
CHAPTER 4. Some Aspect of Roof Design in Sabah.pdf

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CHAPTER 4

SOME ASPECT OF ROOF DESIGN IN SABAH

4.1 General

This chapter describes roof design and roof thermal issues in traditional houses and in contemporary houses in Sabah. Photographic survey is conducted and recommendations are made.

4.2 Roof Design in Sabah

4.2.1 Roof Design in Traditional Houses

Traditional houses in Sabah are mostly rural housing, very famous with their steep roof and low thermal capacity building materials, fabricated with reeds and grass and considered as a part of the building heritage, incorporating various cultural aspects of the ethnic group. Figure 4.1 shows a model of Malay house.

Figure 4.1: Model of Traditional Malay Rural House (Sabah Museum)
The traditional houses in Sabah are built on stilts to avoid the floods and to ensure the ventilation through the floor area as can be seen in Figure 4.2 which provide a better security and the elevation taking advantage of the air movement with the increased wind velocity one meter or two above the ground (Kheong, 1991).

![Figure 4.2: Floor Ventilation in the Traditional House (Sabah Museum)](image)

The Kampung houses of fishing villages are mainly detached houses and they are generally constructed with various types of timber materials and could be found mainly on the coastal area of Sabah. Generally, interior spaces are defined by changes in floor level with less walls repartitions allowing the house to lodge larger number of people. The repartitions in some traditional houses could be removed during daytime, which create good ventilation. The kitchen and toilet are often located on the exterior. The size of the house depends mainly on the family budgets with the possibility to extend their house gradually. The thatch roofing material provides good insulation and could passively cool the building by the evaporation of moisture from rain and early morning dew (Kheong, 1991) and (Koenigsberger, 1973). The bamboo has many qualities that make it superior as building material for creating a healthy living environment (Akaike, 2003). A model of Malay bamboo house is shown in Figure 4.3.
Figure 4.3: Model of Traditional Bamboo House (Sabah Museum)

Gable roof is a main traditional roof design that can be found in several regions in Sabah as shown in Figure 4.4, whereas a hip roof is limited in few regions such as in Brunei.

Figure 4.4: Gable Roof in the Traditional Houses in Sabah (Sabah Museum)
Roofs in the traditional houses are protected by trees, which create a pleasant microclimate and minimize the outdoor temperature. The main traditional roofing materials in Sabah are: the attap (a thatch made from nipah and other palm trees found in the local natural vegetation), sago leaves, bamboo, and rattan, whereas, a grass called in Malay Lalang is used as flashing system to protect roof from leakage. Roof systems in traditional houses are built in general without ceiling. In some traditional houses roof ventilation is well provided such as in Brunei house as shown in Figure 4.5.

Figure 4.5: Ventilation in Traditional Brunei House

Figure 4.6: Ventilation in Vernacular Malay House

The minimum ventilation in this traditional house is always ensured even when the doors and windows are closed by the free space under the roof. This system of ventilation could be also found in several vernacular houses in Sabah as shown in Figure 4.6. The sizes of windows vary from region to region and depend on the location of the house and the microclimate climate of each region. Very small and fixed windows could be found in some houses located in windy or cool areas “upland areas” and a large and several movable wooden windows could be found in coastal areas. The durability of roofs in the traditional houses depends of the quality of the material used. The part of roof damaged by rot as shown in Figure 4.7 could be replaced
to extend the durability of the material. The smoke from the kitchen increase the durability of roofs and walls in traditional houses as reported from Sabah museum.

![Figure 4.7: The Rot of Nepah in a Traditional Roof (Sabah Museum)](image)

The long houses in Sabah are generally very large wooden houses and could lodge several families and most of these houses could be found near Kudat town. A large corridor is used as a common space for cooking, weaving and even practicing some special games. The other part of the space is divided in several small compartments as a dwelling for families. The walls are very shorts and permit air to pass through gaps whereas the roof takes a larger area compared to walls to cover all floor area included the corridor as can be seen in Figure 4.8.

![Figure 4.8: Typical Traditional Long House (Sabah Museum)](image)
The main issues in using traditional building materials could be numerated as follows:

a. The System of day lightning is not sufficient due to the architecture design.
b. Traditional building materials have bad fire resistance.
c. The rot of nepah is the main cause of the reduced durability of roofing in comparison to the modern building material.
d. The dust could penetrate easily inside the house.
e. The attap should be renewed periodically due to its bad quality and has bad fire resistance.
f. Sufficient quantity of traditional building materials are not available corresponding to the increase of the population and good quality of wood is considered a very costly alternative.
g. The durability of the house is very limited in comparison with the modern house.
h. The thatch is considered as a suitable place for insects, and the entire structure made of wood and vegetable matter gives easy passage to termites (Koenigsberger, 1973).

4.2.2 Roof Design in Contemporary Houses

Several regions in east and south of Sabah have been visited from 25 until 29 November 2003, starting from Kota Kinabalu, Ranau, Telupid, Sandakan, Lahad Datu, Tawau and Semporna as shown in Figure 4.9. Photographic survey was carried out in order to have a better understanding of roof design and roof thermal issues in Sabah.
A majority of population in rural areas in Sabah lives in moderate low-cost houses and mainly wooden unpainted houses with pitched metal roofing. Malay vernacular houses are widely distributed throughout Sabah. Figures 4.10, 4.11 and 4.12 show typical Malay houses in Sandakan, Tawau and Simpurna respectively.
Figure 4.11: Typical Malay Vernacular House (Tawau)  
Figure 4.12: Typical Malay Vernacular House (Sandakan)

The heights of these houses are around 5 to 9 m with high ceilings. The elevation of house above the ground ameliorates the breeze velocity and therefore increases natural ventilation under the house and keeps it safe during periodic flooding. The colours chosen for their roofs are based on the availability of pre-painted roofing material and for aesthetic and economical reasons. The main colours of roofs found in these regions are red, blue, green and metallic bright colour. However in many dwelling, the metallic bright colour and some painted roofing as shown in Figure 4.13 are corroded, which reduces the service life of the roof. The corrosion is largely observed in unpainted metal roofing in several low cost houses.

Figure 4.13: Corrosion of Metal Roofing (Ranau)
Overhang is an important element of roof design in Sabah in reducing unwanted solar radiation. It is also used to protect walls from slashing rain and to keep windows open for ventilation while it rains. Overhang is good design for thermal performance. This is used at every level. Thereby reducing the large size had if a single overhang been used. Nevertheless the narrow overhangs could be also complemented by landscaping near house for shading walls and even the roof as shown in Figure 4.14. In several dwelling third overhang are added in gable roof to protect the porch as shown in Figure 4.12 or to create a porch, which serve as outdoor room. It is clear that all facades in a tropical climate need protection from sun and heavy rain through the year. For that reason, the construction of porches or open space in front seems to be the best design in Malay architecture.

Figure 4.14: Protection of Roof and Walls from Sunrays with Trees

In Sabah, gable roof and hipped roof are more common compared to other roof configurations like the clerestory and shed roof. Roof’s ventilation is nearly less diffused in several rural houses, which may increase air temperature into attic and just under the
roof. In spite of this, they usually have numerous large windows to ensure natural air circulation.

Other roofing specification in Sabah and mainly in rural areas is the configuration of roofs in their mosques as shown in Figure 4.15. A flat roof and large dome with minaret, which are largely diffused in almost Arabic mosques, are replaced with hip roof in a pyramidal form. A very small dome is added on the top of the hip roof as an important symbol of mosques and the building is square in shape. This is especially impressive and seems to be very common in many rural areas in Malaysia to facilitate the run off and steep roofs for churches are still provided all over Sabah.

![Figure 4.15: Typical Mosque in Rural Region (Around Lahad Datu)](image)

### 4.3 Roof Issues under Sabah Climate

Roofs in Sabah are exposed to external causes such as air movement, atmospheric pollution, heavy rainfall and incoming and outgoing heat radiation all year round and chemical action. Roofing material and insulation are also influenced by location and orientation (Osbourn, 1985). The use of more appropriate material may reduce
or eliminate certain maintenance at source pre-planning. This could be ensured with the utilisation of adequate roof system for maximum energy efficiency for long period of time.

There are several symptoms of moisture problem on roofing material in Sabah, which could be detected in several ways. The variation in relative humidity could be detected in the separation of paint from support. This problem is more relevant when building is located in coastal areas. Further, the corrosion of roofing near the sea occurs more rapidly by salt deposits from the flow of salt by wind. Paint systems act as physical barriers to any substances, which could accelerate corrosion (Briffett, 1995). Primers applied directly to the cleaned steel surface slow down corrosion and create adhesion for later layers, the last layer is important in terms of colour and gloss (Mills, 1994). It is necessary to mention that the adhesion of paint to new galvanised steel is difficult since the paint generally peel off after a short period of exposure (Rosen and Heinemann, 1996) as can be seen in Figure 4.16. This could also affect the thermal performance of the roof in case the colour - such as white roofing - is chosen for the thermal efficiency of the roof.

Figure 4.16: Separation of Paint from Support (Kota Kinabau)
The designer in Sabah should take a special attention to wooden battens, which could decay and may create much greater risk on roofs system and the insulation could loose its ability to insulate once fungi, dust and humidity penetrate into attic. This problem was observed in several building in Kota Kinabalu as can be seen in Figure 4.17. For that reason, it is important to avoid utilising damaged and wet wood as a building material. It is also good practice to use non-ferrous nails for fixings (Mills, 1994). This is because the contact of two dissimilar metals in the presence of moisture creates galvanic corrosion. The more active metal corrodes by protecting the more passive metal. The corrosion occurs more rapidly when the separation between two dissimilar metals in electromotive force (EMF) series is important. For more details (Harold & Heinemann, 1996) is suggested.

Figure 4.17: Damaged and Wet Wooden Battens (Kota Kinabalu)

Fungi are also noticed on ceiling board as can be seen in Figure 4.18. Their presence is evidence of dampness due to rain penetration, leakage from pipes or to condensation (Briffett, 1995).
Clay, concrete and metal tiles (curved tile) habitually allow air to circulate between tiles helping remove solar heat through numerous small openings between the tiles. However, the horizontal rain due to air movement can penetrate the gap in the overlapping roof tile (Davis et al., 2002). For that reason, it is important not to orient tile in the direction of the prevailing wind as illustrated in Figure 4.19.

Curved tile may perform better under dry hot climate since the climate is most often dry through the year. It is also necessary to mention that discoloration of roof covering is also more observed on clay tile than on coated metal roofing material as can be seen in Figure 4. 20. This situation will also decrease a reflectivity of roofing once it gets dirty.
Other deficiency of roof tiles is the mortar used for ridge tiles, which have a tendency to deteriorate over the years and could also increase the leakage problem. Attention to flashing details is an important aspect of roof selection. Flashing is applied in general in valleys, at vents, at wall/roof junction and near gutters as illustrated in Figure 4.21.

Figure 4.22 shows leakage at wall and roof junction. Moisture surveys of roofs reveal that most entry of water beneath the roofing is through flashed area
(Harold and Heineman, 1996). In addition, the survey conducted by UPM indicates that nearly all the roofs of terrace houses leak at some time (Davis et al., 2002).

Figure 4.22: Leakage at Wall and Roof Junction (Kota Kinabalu)

The form and layout of the roof should be very simple to avoid details, which trap moisture and dirt (Briffett, 1995). This part of work should be done by an expert to prevent any water from getting through (Irwin, 2001). This is one of the most efficient ways to minimize leakage risk and conserve insulation dry. The decomposition of wet insulation once saturated smell mouldy and creates a serious hazard to the entire roof system and even to the electrical system and health. It is also necessary to remove leaves on the roof surface, which cause rot over time and also to remove any debris from metal roofing such as screws and others. Radiant barrier (aluminium foil) is recommended in warm and hot climates and also considered an excellent low-cost vapour retarder (Moore, 1993). However the aluminium foil tears easily. It seems to be important to mention that studies of humidity problem have shown that in a climate with an average of relative humidity of about 50%, the attics with a radiant barrier do not tend to deteriorate. In Sabah, with high rate of humidity this problem could be found in some buildings as shown in Figures 4.23 and 4.24. These figures were taken from one building.
However, Miranville et al., (2003) recommended treating each case individually since aluminium foil could deteriorate even with high rate of humidity. Double side of aluminium foil with reinforcement is the best choice but it is more costly than simple aluminium foil. The accumulation of dust on aluminium foil over time will reduce its effective emissivity, therefore its ability to reradiate (Moore, 1993). It is important do not expose aluminium foil to dust to conserve its efficiency. The use of truss barrier just below fibreglass as can be seen in Figure. 4.24 could be easily damaged. The selection of wire mesh should be considered.
4.4 Summary

Roofs in traditional houses are built without ceiling and roof ventilation is well provided in some regions. Roofs in traditional houses are protected by trees, which create a pleasant microclimate and minimize the outdoor temperature. The thatch roofing material provides good insulation. The rot of nepah is the main cause of the reduced durability of roofing. The traditional building materials have bad fire resistance and enough quantity is not available with the growth of the population. The thatch is considered also a suitable place for insects and gives easy passage to termites.

Gable roof and hip roof are commonly preferred in comparison with other roofs configurations in vernacular houses. The main colours of roofs found in Sabah are red, blue, green and metallic bright colour. The white roofing colour is less diffused but highly recommended under Malaysia climate. This is because a light colour surface (e.g., off white) under tropical climate performed thermally better than an equivalent dark colour surface (Jayasinghe et al., 2003). The discoloration of roof covering is more observed on clay tile than on coated metal roofing. The corrosion of metal roofing is a big issue under Malaysian climate. Coat of metal roofing should be carefully selected in houses located near the sea. The designer in Sabah should take a special attention to wooden battens, which once decay damage the insulation. The form and layout of the roof should be very simple to minimize flashing area, which traps moisture, leakage and dirt. This is also one of the efficient ways to conserve the insulation dry. The saturated insulation looses its ability to insulate and creates a serious hazard to the entire roof system. Double side of aluminium foil with reinforcement is a better choice than simple aluminium foil, which tears easily. Aluminium foil should not be exposed to the dust to conserve its ability to insulate. The reflective face of aluminium foil should be installed facing downward to minimize dust deposit. The selection of wire mesh for insulated roof with fibreglass should be considered.