# Protruding Saddle Roof Structure of Toraja, Minang and Toba Batak House: Learning from Traditional Structure System

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ABSTRACT

Structure system of Nusantara Architecture has been known for its durability. Traditional structure knowledge was passed from generation through folksong, storytelling or old verse. Toraja, Minang, and Toba Batak have similar house roof shape which is gable roof with protruding at the end like buffalo horn. The similarities in structural system need to be elaborate. This paper attempts to seek the structural system of Toraja, Minangkabau and Toba Batak house, especially the roof structure system. The research conducted to discover the similarities of the roof structure system, study the construction and tectonics, and also learn the load transfer. By learning from local knowledge of building structure system, people can learn to build new buildings using local wisdom, instead of only imitate the form.



Keywords: Structure system, Toraja, Batak Toba, Minang house

## 1. Introduction

Nusantara archipelago has thousands of islands which scattered in Pacific and Indian ocean. Indonesia itself has more than 13,000 islands, inhabited by many tribes with different culture, tradition and architecture. Moreover, the beauty and uniqueness of house form represent as identity for each tribe. Every tribe who lives in different location has different form and shape of house, especially the roof shape. The houses are the symbolic center of a web of customs, social relations, traditional laws, taboos, myths and religion (Dawson & Gillow, 1994:10)

Structure system of Nusantara Architecture, which also known as traditional architecture, has been known for its durability. It can stand for years and also endure nature power such as climate and earthquake. Whereas, in the past, the architect built the house without any knowledge about science and mechanics. The building knowledge was passed from generation through folksong, storytelling or old verse. The skill as a builder was passed from the elder to the youth using apprentice system. These methods, according to Rapoport (1969), represent the characteristic of vernacular or traditional building methods.

Toraja, Minang and Toba Batak are ancient tribes who live at different location and island; Minang and Batak Toba tribes inhabited Sumatera Island, Torajan inhabited Celebes (Sulawesi) Island. However, Toraja, Minang, and Toba Batak have similar house roof shape which is gable roof with protruding at the end like buffalo horn. Nowadays, the roof form had been adopted in many modern buildings, especially for government office buildings.

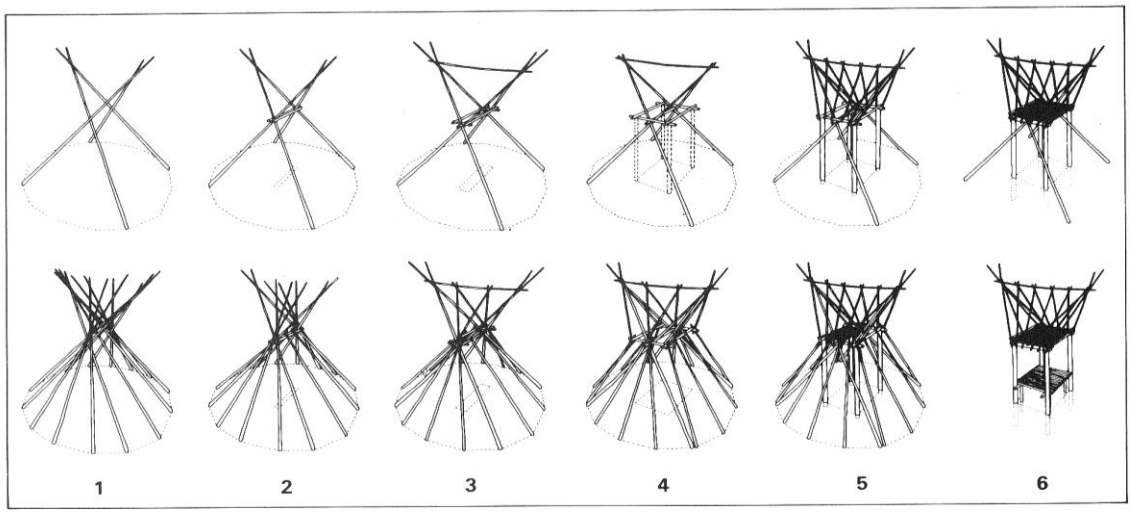
This paper aims are to record and identify structure system of Toraja, Minang and Batak Toba houses, especially on roof system in attempts to preserve the indigenous knowledge of traditional building systems, especially structure systems. By learning from local knowledge of building structure system, people can learn to build new buildings using local wisdom, instead of only imitate the form.

## 2. Literature Review

Macdonald (2001) describe that the function of structure is as the part of building which resist the loads that are imposed on it. And also, a building works as an envelope which encloses and

subdivides space in order to create a protected environment; the surface which form the envelope are subjected to variant types of loads.

Gaudenz Domenig's research on Asia and Nusantara houses had develop a theory about pile and saddle roof house development. The theory is that both pile building and the saddle roof could have developed simultaneously by a progression from a primitive tepee-shaped structure of poles set in the ground and overlapping at the top (Waterson, 1990).




Source: (Waterson, 1990)
Figure 1: The Development of Pile Building and Saddle Roof Based on Domenig's Theory

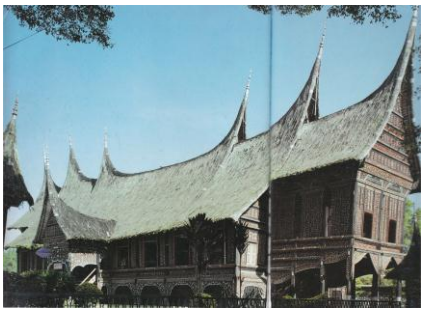
Engel (1977) classified building structure into four structure systems: form-active, vector-active, section-active and surface-active. Form-active structure systems are systems that non-rigid, flexible and can support itself and span space; for examples are membrane and cable structure. Section-active structure systems are systems of rigid surface; resistant to compression, tension and shear.

Veltkam (2007) give brief explanation of structural system based on Engel definition. Vector active structure systems are systems of straight linear members, in which the direction of forces is effected by multi-directional splitting of forces into vectors along compressive and tensile elements. Thus, the material stresses are equally distributed in the members' cross sections. Meanwhile, the surface action systems are systems of rigid surfaces (resistant to compression, tension and shear), in which the direction of forces is effected by surface resistance and particular surface form. Structures acting in surface action consist of a surface as form active structure could be also composed. The difference between both structural systems is defined through the nature of the material surface is made of: form active structures do not resist to compression, tension and shear, whereas material in surface active structures do.

## 3. Methodology

This research is an exploration research through literature study. Qualitative and comparative analysis is used by comparing basic shapes, structural systems and construction of the roof. Each of the traditional houses which observed, have some variety of roof forms; although, basically, they have similar structure system and construction. For example, Kis-Jovak (1988) divided Toraja house into 5 types based on structural development and roof form, from the simple house without curved ridge to the modern house type with long and high protruding roof. To simplify the observation, typical roof forms which can describe the identity of the tribe's traditional architecture were chosen as case study (Table 1).

Table 1: Object Study: Traditional House of Toraja, Batak Toba, Minangkabau

| Toraja: Tongkonan | Batak Toba: Jabu | Minangkabau: Gadang House |
|---|---|---|
|  |  |  |
| Source: (Soeroto, 2005) | Source: (Dawson & Gillow, 1994) | Source: (Dawson & Gillow, 1994) |

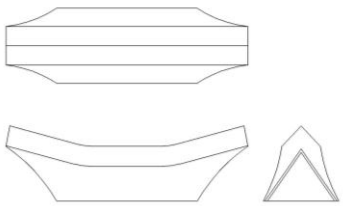
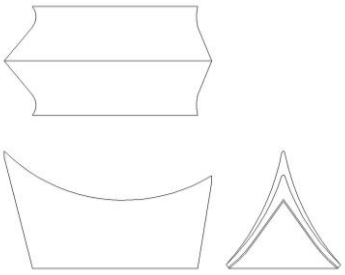
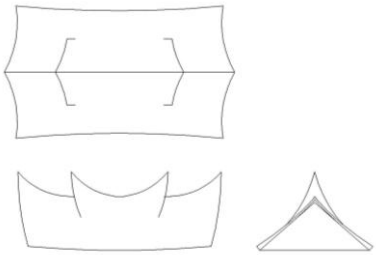
## 4. Results and Discussions

### *4.1 Basic form*

Basic form of Toraja, Minang and Toba Batak houses are prism with triangular gable and protruding shape, curving upward at the end. Those forms are similar to buffalo horn or boat, which both of them have signification. Torajan, Minang and Toba Batak people believe that buffalo is sacred animal and also assume that their ancestor came from north sea India, reached Indonesia archipelago by riding boats (Waterson, 1990). Moreover, curved line and protruding roof give good protection from rain and provide shaded space underneath the cantilever.

The difference between Toraja, Minang and Toba Batak house roof form is the curved ridge. Toraja house roof has symmetry form, the ridge line is curving upward while the side line tilt to the ridge, shape trapezoid plane. The cross section of the roof is triangular. Meanwhile, Toba Batak house roof is asymmetry; the front side of the roof protrudes longer and curves higher than the other side. Those protruding roof provide higher space at the front and back side of the house, which is used as attic and balcony. Then, Minang house roof consist of several curving roofs. Each roof defines the space beneath which is a room called '*anjungan'*. If the house owners need to add more room or '*anjungan'*, they build new room attached to the side of the house and erect new roof. From that reason, some houses have asymmetry form because new '*anjungan'* can be attached to the left or right side. Some houses, especially from Koto Piliang design, have two-direction curved roof. The comparison between Toraja, Toba Batak and Minang roof form can be seen at table 2.

Table 2: Comparison of Basic Form of Toraja, Toba Batak and MinangRoof

| Toraja | Toba Batak | Gadang house |
|---|---|---|
|  |  |  |

### *4.2 Structure system and construction*

The materials are framed together using rattan rope and pin-an-hole joint system. In the past, roofing material of Toba Batak and Minang house were made from sugar palm (*aren*) tree or *ijuk*. Meanwhile, originally Toraja used bamboo as roofing material. Nowadays, those materials become lack and need more times to produces. Thus, people prefer to use new roofing material such as corrugated steel because it is more cheap, light and easy to form. Nevertheless, the changes of roofing material may affect thermal condition inside the house.

Structure elements of the houses roof use timber and bamboo as main frame. These frame hold together using rattan rope and pin-and-hole joint system. Basically, main construction elements which define the roof shape are gable, ridge and barge board. Although those elements can be found at each house, every house has different construction system.

Based on Kis-Jovak (1988) description, Toraja house roof has two ridges; the upper ridge called '*pekadang panuring*' is supported by two free-standing posts called '*tulak somba*'. '*Tulak somba'* posts are placed outside the house, at the north and south side. The upper ridge is also supported by interior posts called '*petuo*'. Meanwhile the lower ridge called '*pekadang para*' has smaller dimension than the upper one. Rafters are placed between upper and lower ridge which means that the ridges clamp the rafters, fasten its. Beside ridges, rafters also supported by another two beams which one act as purlin, placed on the top of the wall while the other beam is placed outside the wall and supported by three or more free-standing posts.

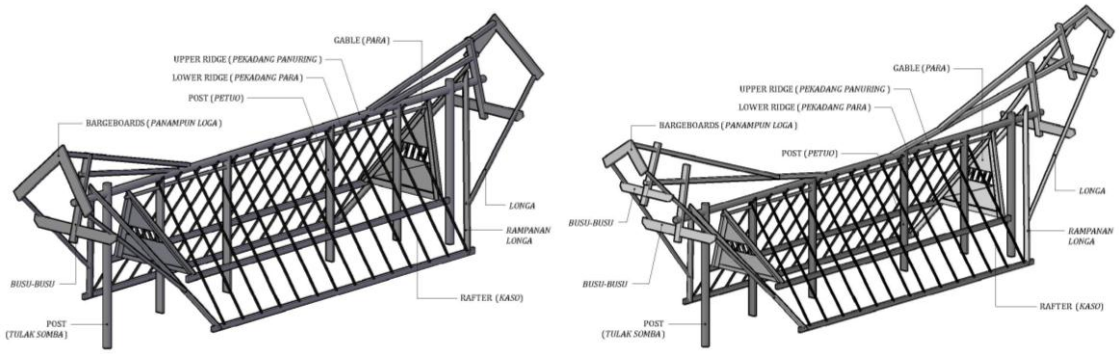



Figure 2: Toraja House Roof; Isometric of Structure Systems

To produce the curve line of the roof, other ridges are added, placed on the straight ridge and slope upward in slanting position. The slanted ridges and slanted beams called '*longa'*, are hold together by a short beam with a plank shaped like a dagger called '*busu-busu*' (fig 2.a). '*Busu-busu*' plank pull the '*longa*' and lock it to the slanted ridges and upper ridge. Another slanted ridges and '*busu-busu*' can be added to make a longer and higher cantilever (fig 2.b).

Even though the curved line of the roof has hyperbolic shape, but the forces distribute by the structure members not by its shape or surface plane. Structure systems of Toraja roof showed that the upper rigde which is supported by '*tulak somba*' posts, sustain the roof and the cantilever. Whereas slanted ridges, '*longa*' and '*busu-busu*' form the protruding roof in triangle shape and transfer the loads to '*pekadang panuring*' or the upper ridge.

Based on Domenig (2003) description about Toba Batak roof construction, gables are placed at the front and back side of the house, slope outwards and upwards. The ridge is rest on the gable to support the long overhang. A barge board called '*bonggar-bonggar'* placed in the front side. Diagonal beams place at the top of gable to the eaves, act as bracing system, help to resist wind forces and others external forces.

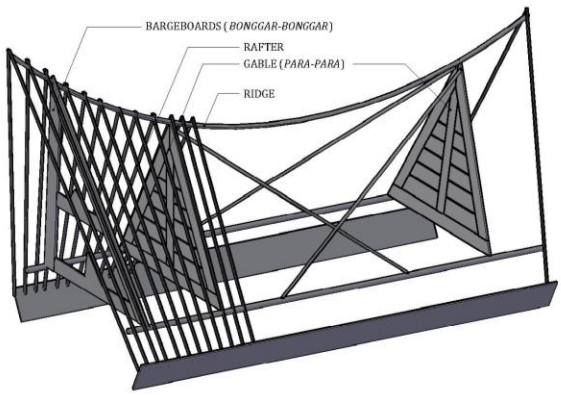



Figure 3: Toba Batak House Roof; Isometric of Structure System

Domenig description has showed that gables and 'bonggar-bonggar' has important role in sustain the ridge. Based on De Boer (1920) description, Batak Toba house roof has about 10 meters base length and if it is measured along the curves ridge, it has about 16 meters length. From fig.3, it

can be seen that the long-curved ridge is only supported by the gables and barge board. Each gable, place in front and back façade, consist of two planks formed triangle and several horizontal planks stacked into triangle plane. While the barge boards consist of two planks form triangle shape like truss, are reinforced by horizontal planks. Then, rafters are placed on the curved ridge and eaves planks.

Even Batak Toba house roof has gables to sustain the roof, but loads are mainly distributed by rafters or roof surface. Meanwhile, gables and roof surface could not stand without others. Roof ability to distribute and sustain loads is affected by the form as well. On the other words, the curved ridge, roof surface and gables shape space structures; like a prism or space frame but in this case, the plane shaped the space structures. This is why Toba Batak house has a spacious space beneath the roof which is used as balcony or attic space. Batak Toba granaries which called sopo, also has the similar system and the attic space is used to store paddies and crops.

Student report of Minang house (1979) gives a comprehensive description on Minang house. In Minang house or *Rumah Gadang*, roof constructions are supported by the house posts. Rumah Gadang consists of several rows of posts which are arranged symmetrically; each row consists of five posts. The center post is higher than the perimeter posts. The posts hold together by heavy beams which also act as purlin. The curved ridges are placed on the top of the center posts. Rafters are place on the ridge and purlins. '*Ijuk*', the roofing materials, are held to the rafters using rattan rope. At the pointed end roof, the '*ijuk*' are stitched and decorated like pinnacle.

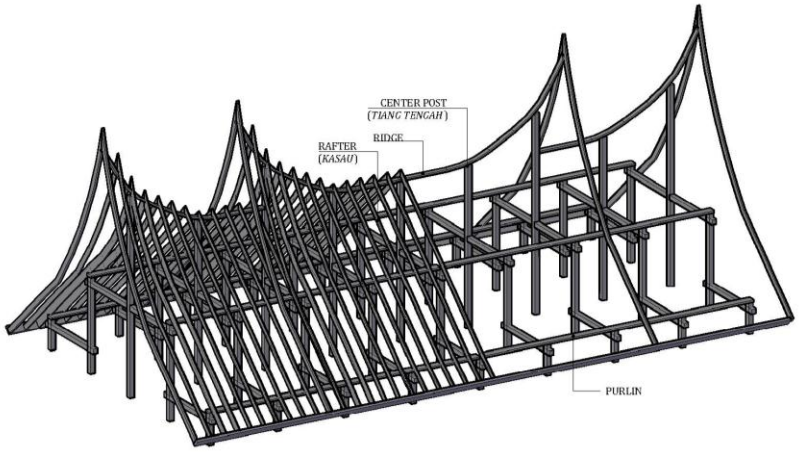



Figure 3: Structure and Construction System of Minang Roof

Minang house from the description has frame structure system. The posts and beams are composed in rigid construction, although it is still have the flexibility to resist horizontal force. Loads bearing and distribution basically are transferred through post and beams. Roofing loads transfer to rafters, rafters transfer it to purlins and then to post. To stabilize the posts, horizontal beams are added between aisle posts.

Some newer Minang house which build after colonial era, using truss systems like modern housing nowadays. It is possible because basically the structure systems was segmented and divided based on room sections.

## 5. Conclusion

Toraja, Batak Toba and Minang house, even though do not have truss systems which based on mechanical calculation, but the structure systems can distribute loads and external forces. Every members or elements of structure systems work together in roof form and loads distribution. If the roof was observed from cross-section, it can be seen that every roof has triangle shape but has different structure systems to achieve the form.

Based on literature observation, Toraja and Minang roof structure systems are composed from posts and beams, the loads are transferred through members. While Batak Toba roof shows the characteristic of surface structure system. Although structurally, the roof consist of members, but the members form surface system that work together to transfer the loads, stabilize and maintain the curve form.

Cantilever system of Toraja Roof is determined by the slanting ridge and *busu-busu*. Minang house doesn't have cantilever such as Toraja's but the high pointed ends are developed by curve

ridge. While Batak Toba roof cantilever system establish due to the roof surface which consist of curve ridge and rafters. The roof surfaces are sustained by the gables.

This results shows that traditional building method can perform complex structure systems that has different systems of form, construction and loads bearing. However, this research result still needs to be explored through field study, also modeling and simulation using structural analysis software to find clearer result and analysis.

## Acknowledgement

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## References

_____(1979). *Laporan Kuliah Kerja Lapangan: Sumatera barat.* Bandung: Departemen Arsitektur ITB.

Amos, R. (1969). *House Form and Culture.* New Jersey: Englewood Cliffs.

Dawson, B., & Gillow, J. (1994). *The Traditional Architecture of Indonesia.* New York: Thames and Hudson.

De Boer, D. W. (1920). Het Toba Bataksche Huis. In G. Sargeant, & R. Saleh, *Traditional Buildings of Indonesia Vol.1: Batak Toba* (pp. 31-41). Bandung: Regional House Centre.

Domenig, G. (2003). Consequences of Functional Change: Granaries, Granary-dwellings, and Houses of the Toba Batak. In R. Schefold, G. Domenig, & P. Nas, *Indonesian Houses: Tradition and Transformation in Vernacular Architecture* (pp. 61-97). Singapore: Singapore University Press.

Engel, H. (1977). *Structure Systems.* Deutsche Verlags-Anstalt: Stuttgart.

Kis-Jovak, J. I. (1988). *Banua Toraja: changing patterns in architecture and symbolism among the Sa'dan Toraja, Sulawesi,* Indonesia. Amsterdam: Royal Tropical Institute.

Macdonald, A. J. (2001). *Structure and Architecture 2nd edition.* Oxford: Architectural Press.

Veltkamp, M. (2007). *Free form structural design: schemes, systems & prototypes of structures for Structures in Irregularly Shaped Buildings.* IOS Press.

Waterson, R. (1990). *The Living House: An Anthropology of Architecture in South-East Asia.* Singapore/Oxford/New York: Oxford University Press.