

Daylighting and architectural concept of traditional architecture: The Tongkonan in Toraja, Indonesia

Parmonangan MANURUNG

monang@staff.ukdw.ac.id • Department of Architecture, Faculty of Architecture and Design, Universitas Kristen Duta Wacana, Yogyakarta, Indonesia

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Abstract

Indonesia has more than three hundred tribes distributed in various islands. Since each tribe is divided into several traditions, this means Indonesia has hundreds of traditional architecture. One of the traditional architecture which has a unique design and a representation of Austronesian style is a traditional house Tongkonan. Tongkonan, built by the ancestors of the Toraja people, is based on their belief which called Aluk Todolo. This belief arranges the orientation of Tongkonan, sun has a great influence in the arrangement of exterior and interior space in Tongkonan.

The aim of this study is to find the relationship between the spatial patterns generated through Aluk Todolo belief and the quantity/quality of daylighting obtained based on light measurements and the review of the various theories on daylighting. The method used in this research is quantitative by measuring the quantity of daylight. This is supplemented by a review of theories about Aluk Todolo belief and architecture of Tongkonan within the framework of the theories of daylighting.

The results of the research show that although designed by ancestral belief, the architectural design of Tongkonan has already met the rules of daylighting design. The quantity of daylight inside Tongkonan has accommodated the needs of functions and activities. Design of Tongkonan's roof has an important role in optimizing daylight and reducing solar heat and ultraviolet. In conclusion, traditional architecture designed based on Aluk Todolo belief has provided good quality and quantity daylight and can support the functions and activities of the building.

Keywords

Traditional architecture, Tongkonan, Ancestral beliefs, Daylighting, Orientation.



1. Introduction

Indonesia is a country with hundreds of tribes and has a variety of cultures. Such cultural richness makes Indonesia has a variety of traditional architecture inherited from generation to generation. Ronald (2002:5) says Indonesia has more than three hundred tribes which can be further divided into several customs. Each custom has its own house so that Indonesia has hundreds of diverse customary houses. Meanwhile, Sefold, et al. (2004:4) argue that it is not difficult to choose architecture in Indonesia as a research object because most of the houses in the archipelago are interesting and important objects, not only the traditional houses but also the transformation of the modern houses. Furthermore, Sefold, Nas and Domenig (2004:4) say many ethnic groups in Indonesia have a wide variety of traditional houses and settlements with their specific history.

Figure 1 shows a map of Indonesia and the geographical location of the Tana Toraja Regency. Tana Toraja is located in South Sulawesi Province which is geographically located on the Sulawesi Island. Built for generations by the Toraja in South Sulawesi, Tongkonan house is a traditional house which is very important in Indonesia because it represents the history and development of architecture in Indonesia. According Wuisman (2009: 26), traditional and vernacular architecture in Indonesia is considered as a very important constituent element in highly diverse and complex architectural heritage. Furthermore, Wuisman (2009:27-33) says that building which is the most important and most often built and included in the vernacular architectural tradition in Indonesia is house. Buildings constructed by communities in the interior are considered to show greater similarity in various Austronesian buildings than houses of communities living in lowland or coast, and the houses built by the Toraja people in South Sulawesi and the Batak people in North Sumatra are closest representation to the diversity of vernacular architecture of their ancestors.

Rudofsky (1965:1) describes vernacular architecture as “architecture without architects”, arguing that the

vernacular architecture does not follow fashion cycle. This shows that the vernacular architecture is oriented to local needs by utilizing potentials of nature and existing context, so that it is not influenced by flourishing trend, style or fashion. The architecture of Tongkonan in Toraja is built based on belief and faith of the Toraja people oriented to the direction of the wind because north-south axis and east-west axis are very important in their belief, as Koentjaraningrat (2004) states that every form of manifestation of cultural object reflect perspective, thought, belief and social system. This shows that the traditional house of the Toraja people as a work of architecture built without architects is a manifestation and reflection of their perspective, thought, belief and social system, and not a work oriented to the development of particular architectural style or fashion.

Before the 15th century, the Toraja region was called *Tondok Lempongan Bulan* or *Tana Matarik Allo* which means a country which has an integral unit of belief and culture as the full moon (*bulan*) and the sun (*allo*), as stated by Tangdilintin and Syafei (1977:13). This shows that light (moon and sun) is an important element in the belief of Aluk *Todolo* embraced by the ancestors of the Toraja people. Said (2004:33) explains that in the belief of Aluk *Todolo* the traditional house of Toraja (Tongkonan) is regarded as microcosm and is a part of macrocosm (universe), and *Puang Matua* (God) is associated with *allo* (sun).

It is clear from the aforementioned explanation that the house of Toraja people, Tongkonan, is an important architecture because it represents the belief and culture of ancestor and is an important part in the Austronesian architecture. The belief held influences settlement arrangement and design of



Figure 1. Map of Indonesia. (Source www.visittoraja.com)

Tongkonan traditional house because of the importance of the orientation to the axis of north-south and east-west, as the appreciation and respect for the Creator (*Puang Matua*), which is associated with the sun.

Based on the aforementioned background, the study was conducted at Tongkonan house because it is a traditional architecture that is important in the development of architecture in Indonesia and has a concept of design oriented to the belief and culture of the Toraja people. The belief and faith, which are oriented to *Puang Matua* associated with the sun (*allo*) affect the planning of exterior, architecture and interior of the building. This study is aimed at obtaining the correlation between the spatial pattern resulted from the belief of Toraja people and the quantity and quality of daylight obtained based on the measurements in the field and the review of various theories of daylighting.

1.1. Research methods

This research employed quantitative method done by directly measuring the quantity of daylighting in the Tongkonan house and studying theories of Tongkonan and daylighting. According to Gordon (2014:74), in order to determine the quantity of light entering the building, we need to know the size and position of windows as well as data concerning the average daylight at a certain location and orientation. The Commission of the European Communities Directorate-General XII for Science, Research and Development (1993) explains that measuring light in the room can use two very important tools, namely *Illuminance meter* and *Luminance meter*, both of which use sensitive light detectors that convert light hitting the detector into the lumen. Phillips (2004:219) states that Illuminance is light that falls on a surface, while Luminance is light reflected by a surface. Illumination level is the amount or quantity of light falling on a surface in units of lumen per square meter (or Lux). Light meter, according to Bradshaw (2006:279) and Viridi (2012), can be used to measure the illumination level.

The quantity of daylight was direct-

ly measure at the site by using the light meter at 27 spots in the three rooms in the Tongkonan house, which are front room (*tangdo*), middle room (*sali*) and back room (*sumbung*). The measurements were taken directly at the site in order to obtain more accurate results because the topography of the site is exceptional and is in the mountain. Each room was divided into 9 point of observation in order to see the distribution of light and the difference in the quantity of light existing in these rooms. In order to complete the data, in addition to using a light meter, measurements were also done using computer simulations. According to Hopper (2007: 41), computer simulation can be used to determine the position of the sun and shade locations. Measurements were made using computer software DIALux Evo 6.2. DIALux Evo 6.2 is a computer software that has the ability to measure and analyze the natural lighting of light into the building.

According to Livingston (2014:169); Tregenza and Wilson (2011:63); Viridi (2012:257), and Lechner (2015:141) the position of the sun changes every day and throughout the year and its highest angle occurs on June 21 in the summer and the lowest angle occurs on December 21 in the winter. Although Indonesia has only two seasons, i.e. dry season and rainy season, and lies along the equator which causes the circulation of the sun is relatively stable throughout the year, but June is the dry season and has a greater quantity of solar light. The measurements were taken since June 21. But, on June 21 and June 22 the sky was dull and cloudy, so that the measurements started again on June 23.

In addition to taking measurements, literature study was done on the theories of Tongkonan traditional house, particularly on the belief of the Toraja people that affects design, orientation, arrangement of interior, as well as the implementation of the traditional ceremonies. The study on the theory of daylighting was done to find the correlation between the belief of Toraja people and the theories of the quality and quantity of daylighting and the factors that influence them.

1.2. Difficulty of research

There were several obstacles related to the stages of object observation selection and measurement processes for the study, such difficulties were partly because:

Not all Tongkonan could be entered, some were considered sacred or had been emptied;

Measurement could not be taken full day; Tongkonan could only be entered for short period of time. Meanwhile, the research had to be conducted throughout the day from morning until evening; and

The sky was often dull or cloudy, so that some measurements were considered invalid and should be repeated in the next day.

1.3. Research object

After encountering some obstacles above, a representative observation unit was finally obtained. A Tongkonan located in Lembang (village) Turunan, Sangalla' Subdistrict, Tana Toraja Regency (as shown in Figure 2), is the biggest Tongkonan in the village. Owned by a royal family, this Tongkonan is important in Lembang Turunan and is the first Tongkonan built by the first generation that came down from the mountain. Lembang Turunan is one of the Lembangs in Sangalla Subdistrict as a result of the proliferation of Lembang Bulian Massa'bu. Lembang Turunan is located on the mountain and at an altitude of ± 800 masl (meters above sea level).

Being studied, the Tongkonan plan has dimensions of 8.70m long and 3.60m wide. The front and the back room have the same dimensions, 2.60m x 3.60m, while the middle room has the dimensions of 3.50 x 3.60m. On the north, south and west sides there are small windows for ventilation and daylighting with dimensions of 30 x 80cm. Meanwhile, on the east side there is a door with dimensions adapted to the functional needs, namely 60 x 170cm.

2. Theoretical review of Tongkonan

2.1. Belief and settlement of Toraja people

Toraja is a native tribe that inhabits Tana Toraja Regency and Toraja Utara

Regency of South Sulawesi, Indonesia and is located at 2⁰ and 3⁰ South Latitude and 119⁰ and 120⁰ East Longitude. According Tangdilintin and Syafei (1977:13), the name *Toraja* was given by the Sidenreng people, *to* (meaning people) and *riaja* (meaning north up); and also given by Bugis people in Luwu from the word *to* (people) and *rajang* (west) because they are in the west area of Luwu.

The ancestors of the Toraja people embraced the belief of *Aluk Todolo*, and until now most of the Toraja people still embrace this belief. According Tangdilintin and Syafei (1977:22); and Said (2004:27-29), the belief of *Aluk Todolo* believes the three elements of power, namely: *Puang Matua* (the Creator); *Deata-deata* (Gods), consisting of *Deata Tangngana Langi* (God in Heaven), *Deata Kapadanganna* (God on Earth), and *Deata Tangngana Padang* (God of the inner part of the earth; and *Tomembali Puang* (spirit of ancestors) in charge of controlling and blessing humans and their descendants. Meanwhile, Kis-Jovak, Nooy-Palm, Schefold, & Schulz-Dornburg (1988:36) and Said (2004:33) say that *Puang Matua* maintain the balance

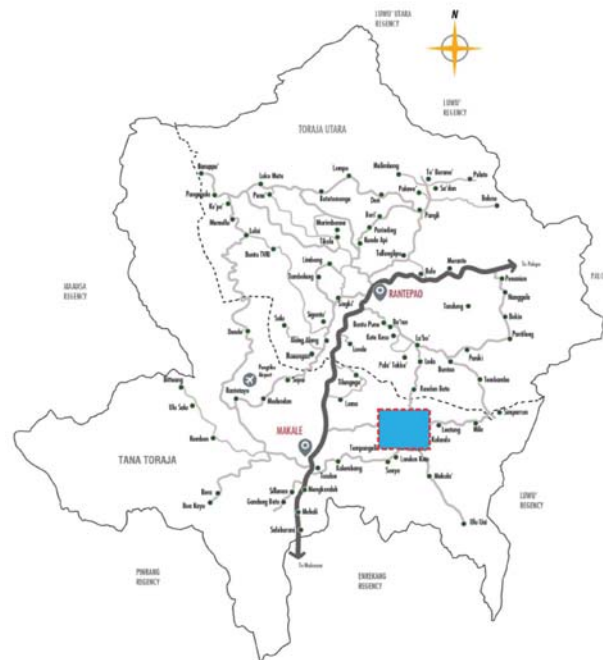


Figure 2. Location of district Sangalla. (Source www.visittoraja.com)



Figure 3. *Ke'te' Kesu, a traditional village of Toraja people built hundreds years ago.*



Figure 4. *Rock tombs a place where the body of deceased is placed.*

of the day and night and is associated with the 'sun' (*allo*) and is not dependent on anything.

The belief of the Toraja people, *Aluk Todolo*, affects the development of art and culture, including architectural works. This is in line with Koentjaraningrat (2004:7) that a physical aspect of a religion as a cultural element is building (or a place to worship). Kis-Jovak, et al. (1988:74) states that the traditional architecture of Toraja can be divided into in five categories based on their function, namely: dwelling house; rice barn; house of rice field guard; livestock sheds, and tomb. Dwelling house and rice barn are a unity that is always present simultaneously, while the tomb is one of the important elements in the belief of the Toraja people. In addition

to functioning as a dwelling, the dwelling house of the Toraja people also serves as a place to hold traditional ceremonies. Wuisman (2009:36) says that the Toraja people who live in the mountainous regions have a tradition which is very close to the vernacular architecture of the Austronesia, which can be seen from the shape and features of Tongkonan functioning for family gathering and rituals.

The smallest territory of the Toraja community is *tondok* (village), which is usually divided into several districts. The style of the settlement changed when the Netherlands arrived. In the 19th century, most of the settlements were located on hilltops and some were built on the cliffs for survival. Access to the location of settlements is very difficult with stairs and tunnels made by punching holes in the rock (Kis-Jovak, et al., 1988: 20-23). Some of these settlements still survive until present day, and show that the structure system and the materials used can last for hundreds of years. Adams (2006: 30) says that Ke'te' Kesu is one of the oldest traditional village areas and the most visited and built adjacent to the cliffs of burial site. Figure 3 shows the settlements of the Toraja people in Ke'te' Kesu which with the back faces a hill and with the front faces the rice fields.

Funeral and tomb are very important in the Toraja society which is influenced by the belief of *Aluk Todolo*. Although most of the Toraja people have embraced Christianity, Catholicism and Islam, to date the funeral is still held as a tradition. According to Said (2004: 39), the funeral is called *Rambu Solo'* or *Aluk Rampe Matampu* and held in the west of Tongkonan by offering pigs and buffaloes to the spirits of the dead. While Tangdilintin (1977:25) says that the function of the ceremony Signs Solo is as a preparation for the souls of the dead to the next life; as the social status of the deceased; as an opportunity repay those who died; and as the basis for allocation of heritage.

The belief of Toraja people affects burial procedures of Toraja people who died. According Handini (2006:554) the Toraja people are very good in utilizing natural resources around them to meet their needs, including funeral

activities. In the past when jackfruit wood was widely available, they made wooden coffin (*erong*). Then, when the jackfruit wood became scarce, they used stone cave as an ideal burial place because, according to their belief, the deceased should be placed in a high (sacred) place. In addition to using stone cave as a burial place, the Toraja people also use cliff or rock hill which is first hollowed as tombs of Toraja people who died. Figure 4 shows one of the rock hill used as a tomb in Toraja. The wall of rock hill is hollowed with the size of a coffin, and then the coffin containing the deceased is inserted into the hole.

The use of caves and rock cannot be separated from the traditions and culture of Toraja and their expertise to process rock, as Handini (2006:549) says that Tana Toraja has long been known as an area in which megalithic tradition still survive until today; the types of megalith like menhir, rock chamber, and stone mortar are still used and utilized. The expertise of Toraja people to process the rock can be seen from the neatness and precision of the hole in which the coffin is placed as shown in Figure 4. The hole in the hard rock is made longitudinally to the inner part and in accordance with the size of the coffin that will be inserted. Such architecture, according to Rudofsky (1969:22) is called "architecture by subtraction".

The dwelling and tomb of the Toraja people are architectural works which represent the belief of *Aluk Todolo* and still survive to this day. Handini (2006: 556) argues that although most of the indigenous people of Toraja have abandoned the belief of *Aluk Todolo*, the megalithic tradition still survives because the concept of worship and honor to the spirits of ancestors has become an integral part in the life of the Toraja people.

2.2. Architecture of Tongkonan

The smallest unit of Torajan social organization is the single-family household or *banua* (house). The member of *banua* trace their descent bilaterally to the male and female sides of the family, back to the ancestral house (*Tongkonan*) constructed by the commonly

acknowledged founder of the family branch (Bigalke, 2005:10). Meanwhile, according to Said (2004:50-52), *Banua* is a term to describe house in general, while the house which has custom function is called *Tongkonan*.

Tongkonan is a traditional house of the Toraja people who live in Tana Toraja Regency and Toraja Utara Regency of South Sulawesi Province, Indonesia. According to the Kis-Jovak, et al. (1988: 8), "The houses represents much more than just a roof over the head, its three functions, house as home, house as microcosm and house as social symbol." For the Toraja people, the house has very important role and function in their lives, the house functions as a place to stay and a representation of the macrocosm.

The word *Tongkonan* comes from the word *tongkon*, which means sitting. Definition of 'sitting' is to sit in the community and to deliberate (Kis-Jovak, et al., 1988: 34; and Said, 2004: 54). *Tongkonan* also serves as an administrative center and the residence of the king, so that the role of *Tongkonan* for the Toraja people is very important. The existence of *Tongkonan* cannot be separated from the belief of the Toraja people, *Aluk Todolo*, in terms of building orientation, shape, distribution of interior space, as well as the system of building structures and ornaments used. In regard to the building orientation, *Tongkonan* always faces north and is opposite the rice barn.

The orientation is greatly affected by the belief of *Aluk Todolo*, which believes that the Creator, God Almighty dwells in the North. This belief affects the distribution of space in the building, as stated by Kis-Jovak, et al. (1988: 37) that on *the ground-plan, the house can be divided into north and south, east and west*. Meanwhile, Said (2004:32) says that the northern part of *Tongkonan* is called *Ulanna lino*, which means front, top, respected part and is regarded as a sacred place, a place where *Puang Matua* dwells. Meanwhile, the southern part is called *pollo 'na lino*, which means 'tail of the world', dirty place. The spirits of those who have died are believed to make a voyage to a place called *Puya*, located to the southern part, guarded by *Pong Lalondong*.

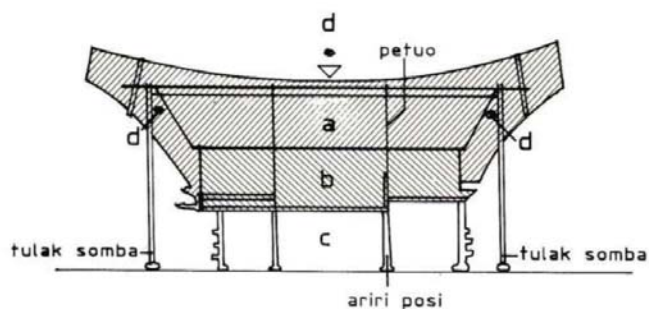


Figure 5. Tongkonan House presents three worlds. (Source: Kis-Jovak, et al., 1988)

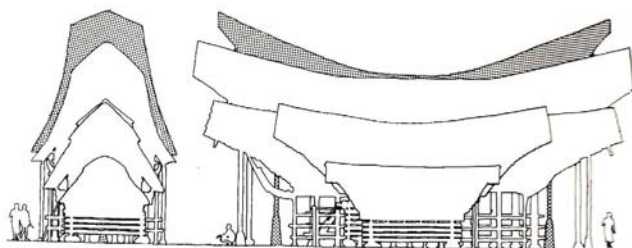


Figure 6. A comparison of five houses. (Source: Kis-Jovak, et al., 1988)

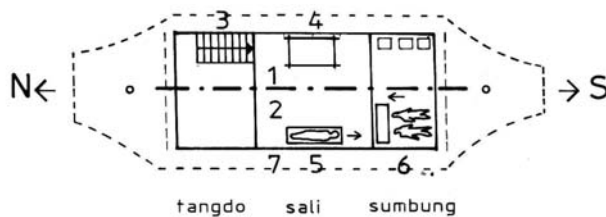


Figure 7. Ground plan of a Tongkonan. (Source: Kis-Jovak, et al., 1988)

The belief held by the Toraja people affects the distribution of vertical hierarchy of the building as shown in Figure 5. As the microcosm and representation of the macrocosm and, vertically *Tongkonan* is divided into three parts, upper, middle and lower. According Kis-Jovak., et al., 1988:34; and Said, 2004:54, the roof space (Figure 5:a) describe the upper world which is considered sacred, a space on the top floor is considered as the middle world where people live (Figure 5:b), while the space under the floor is described as the lower world where evil spirits dwell (Figure 5:c), upper part (Figure 5:d) a roof that can be opened for particular ritual purposes.

According to Kis-Jovak, et al. (1988:74-103) in the course of time, *Tongkonan* has five types of shape and size that are influenced by size, shape and social status of the owner. These five types are:

- Blockhouse structure – low type with one level (Figure 6 – front)
- Blockhouse structure – high type with several level (Figure 6 – number two on the front)
- Archaic type on polygonal piles (Figure 6 – number three on the front)
- Intermediate type on polygonal piles (Figure 6 – number four on the front)
- Modern type on square piles (Figure 6 – rear)

Blockhouse structure is the oldest *Tongkonan* (Tangdilintin, 1978:3-7). Some types of building with Archaic type on polygonal piles aged 350 years can still be found in Toraja. This shows the strength of the structure and the material used. Meanwhile, Intermediate type on polygonal piles is believed about 150 years old, and Modern type on square piles is a new type built by the Toraja people. Although *Tongkonan* has some variation of shape, size and system structure, the spatial composition of *Tongkonan* is relatively similar, namely *tangdo*, *sali* and *sumbung*.

Figure 7 shows the distribution plan oriented north-south and east (Figure 7:1) west (Figure 7:2). The house is divided into three parts, *tangdo*, *sali*, and *sumbung*, with the building orientation to the north. Several variants of the house have two *sumbungs*, but with similar spatial pattern and hierarchy. *Tangdo* is the very front of the house, and serves as the entrance connecting the basement through a staircase (Figure 7:3) which penetrates the floor. In another variant of *Tongkonan* house, the staircase is placed on the west side of the house, while *sali* is divided into two parts, the eastern side functions as the kitchen (Figure 7:4) and the west side is used as a place to put the corpse (Figure 7:5) before being buried and brought through the door on the west side (Figure 7:7), while *sumbung* serves as a bedroom (Figure 7:6) in the southern part (Kis-Jovak, et al., 1988:37). According to Said (2004:33) the east is associated with the place where the sun raises, *rampe mata allo*, connoted as 'life', and considered to represent happiness, light, joy, and the source of life. Meanwhile, the west is where the sun sets, *rampe matampu*, and refers to

‘death’ and represents elements of darkness, grief, and other things that bring grief. The space of the southern part is called *sumbung*, serving as a bedroom with a sleeping position with the head pointing the north direction.

The concept and understanding of the belief of *Aluk Todolo* in the azimuth also affect the locations of ceremonies in outdoor area. Thanksgiving ceremony, *Rambu Tuka*, is held on the eastern side of Tongkonan when the sun rises. On the contrary, funerals, *Rambu Solo*, is held on the west side of Tongkonan. Meanwhile, the ritual of worshipping and glorifying *Puang Matua* is held on the north side or in front of Tongkonan (Said, 2004:37-38). On the north side of Tongkonan, between Tongkonan and rice barn, there is an open space used as a place for the traditional ceremonies as shown in Figure 8.

The roof shape of Tongkonan and rice barn that soar high creates a space with a very firm boundary between these two buildings. This space is used for offering and thanksgiving ceremony to *Puang Matua* who dwells in the north.

3. Theory of daylighting

‘Daylighting’ is a term that refers to the use of solar light and sky-reflected light to light up the interior of the building (Livingston 2014: 167; and Gordon, 2014:73). The history of the use of openings and daylight began together with the history of architecture. The use of openings began to simply allow light and air as well as hot and cold, then developed to produce magnificent interior in cathedrals and churches of Baroque and other buildings (Phillips 2004:3). This suggests that traditional and vernacular buildings built hundreds of years ago had

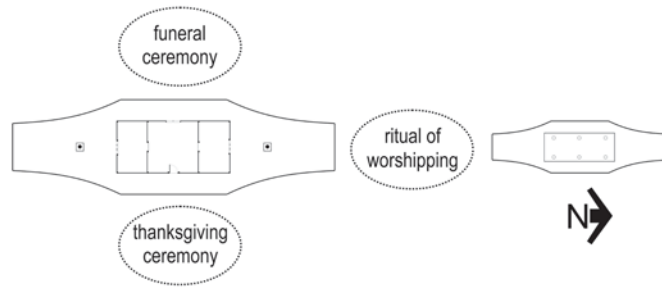


Figure 8. Layout of structure and open space.

considered daylight in their designs in order to meet the needs of the lighting in the interior of the building.

In the utilization of daylight as the light source of the interior of the building, the building orientation plays an important role as Phillips (2004:6-11) suggests that orientation comes from understanding of the relationship with the exterior. The building orientation should be considered since the beginning of design process when architects plan the position of the building on the site so as to optimize daylight and sunlight entering the interior. The building orientation as well as the interior function and interior layout should be considered since the beginning of the design process in order to be able to optimize daylighting.

According to Livingston (2014:170) the north side is a part of the building that receives the most consistent light, easily controls light distribution, and reduces the risk of heat coming from the sun directly; south side provides a diverse variety of light throughout the day and throughout the year; the east side in the morning will receive direct sunlight, direct light can be reduced by using overhang; while the west side receives direct light in the afternoon.

The utilization of daylight should be adapted to the function of rooms

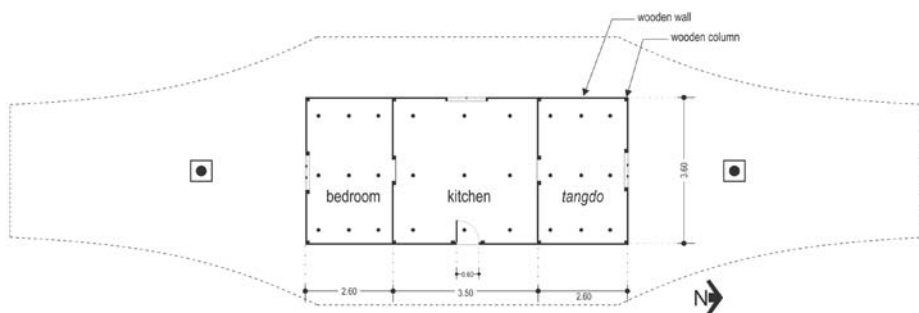


Figure 9. 27 measurement spots in interior space of Tongkonan.

in the building because each room has different needs of daylight. Phillips (2004:10) states that kitchen and bedroom will be very well if placed on the east side because it will get morning sun, while the other rooms often used in the afternoon or night are placed on the south or east side. This statement is very important in the design of buildings, especially dwelling house so that every room in the building can accommodate their functions well.

Meanwhile, according to Posudin (2014), there are three tools that can be used to measure solar radiation, namely: radiometer (used to measure flux radiant or electromagnetic radiation energy); photometer or light meter (used

to measure light received by human eye by measuring the quantity of the luminous flux/lumen, luminous intensity/candela and illuminance/lux); and photon meter or quantum meter. Furthermore, Posudin (2014) and Phillips (2004: 219) say that the illuminance is light that falls on a surface per unit area and is measured in lux. According to Phillips (2004: 219) Illumination level is the amount or quantity of light falling on a surface in units of lumen per square meter (or Lux). According to Bradshaw (2006: 279) and Virdi (2012: 257) light meter can be used to measure the illumination level.

4. Results of light intensity measurements

4.1. Field measurement using light meter

The quantity of light is measured in three interiors at 27 spots (each room has 9 points of observation) as shown in Figure 9. The measurements were taken at three different periods of time on the same day, i.e. at 9:00 pm, 12:00 pm and 03:00 pm. The research was conducted only for measuring the quantity of sunlight entering through openings that exist on the entire building enclosure.

The results of light measurement in interior space of Tongkonan are showed below:

- Measurement at 9.00 am. (Figure 10)
- Measurement at 12.00 pm. (Figure 11)
- Measurement at 3.00 pm. (Figure 12)

The results of by using light meter as shown in Figure 10, 11 and 12 show that the greater quantity of light is found in the north side, or the front part (*tangdo*), while the smaller quantity of light is in the back room, the south side (*sumbung*). The biggest quantity of light occurs at 12:00 pm in the front room; this is influenced by the building orientation facing the north, the position of the sun at its peak, as well as the position of the window on the wall so that light can enter optimally. Meanwhile, the east side receives greater light at 09.00 am (morning), and on the contrary, the west side receives greater light intensity at 03:00 pm (afternoon);

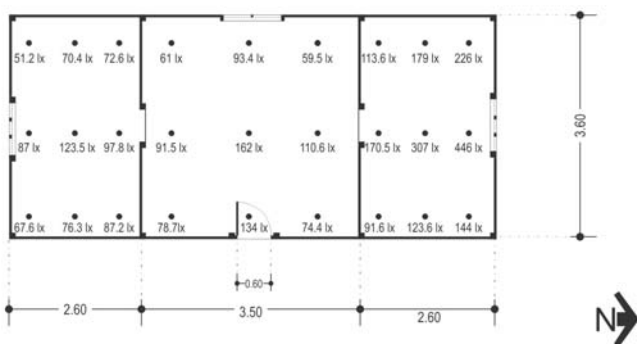


Figure 10. Result of daylight measurement at 9 am.

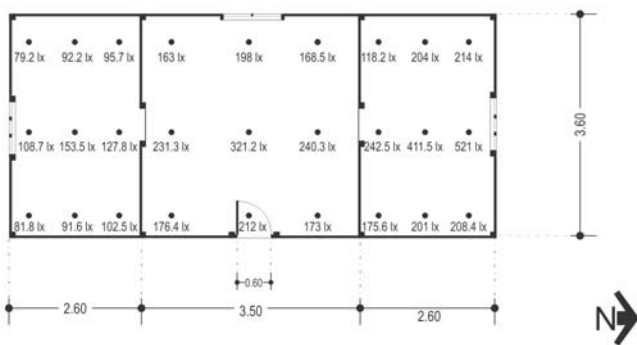


Figure 11. Result of daylight measurement at 12 pm.

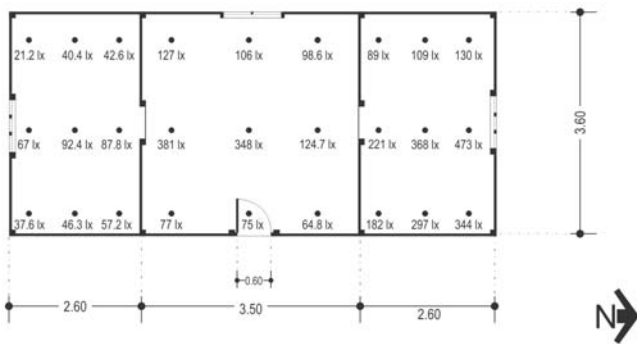


Figure 12. Result of daylight measurement at 3 pm.

this is strongly influenced by the angle of incidence of light. Furthermore, the most southern area, located at the back part (*sumbung*) that serves as a bedroom has a small light intensity in the morning, noon and afternoon.

4.2. Computer simulation

To reinforce the analytical results, the measurement of light intensity is also carried out using a computer software (DIALux Evo 6.2). Measurements were conducted on four different days which were on March 21, June 21, September 21 and December 21. This was done in accordance sun positions as mentioned by Hopper (2007: 41-42) that on March 21 and September 21, has a equal value of time between day and night. Meanwhile, on June 21, a time where the sun shines is longer and midday shade has less time. Instead, on December 21 is the time where the sun shines shortest and the shadows at the noon are longest daylight. Measurements were taken at 09:00 am, 12:00 pm and 3:00 pm. The measurement results (Table 1, Table 2, and Table 3) shows that the light from the north are more stable than the light from another directions. Light coming from the north side has a highest light intensity on June 21, while the light from the south has brightest light on December 21. Meanwhile, light from the east has the highest intensity in the morning, while light from the west has the highest intensity in the afternoon; both have the highest intensity on June 21.

5. Discussion

5.1. The architecture

In the belief Torajanese, Tongkonan house is a representation of microcosm and macrocosm, it affects the orientation, shape and arrangement of interior space. There is a robust link between the architecture of Tongkonan with the belief of Torajanese. According to the Kis-Jovak., et al., 1988: 34; and Said, 2004: 54, the building is divided into three parts, top / roof (holy), center / space in the house (human living space) and lower / under (evil spirits dwell). This belief resulted in houses on stilts with roofs that are lifted up. Roof of the building is a representation of something sacred; it is shown

by soaring roof shape. Roof-oriented north and south, and the building is oriented to the north side which is the dwelling place of God. In proportion, the roof of the building dominates the overall shape; this is done because the roof is associated with the upper world, a sacred place.

5.2. Orientation

The orientation of the building is a very important thing to be considered in the process of architectural design. This has been done since the days of our ancestors when designing their homes. According to Lechner (2015:3), traditional buildings wherever it was built, is normally will consider the climate in the design process. *Tongkonan* house is one of unique traditional architecture in Indonesia. The orientation of the building designed by the trust of the Toraja people who believe that the north is a sacred place (Said, 2004: 32). Toraja people have the belief that God (the creator) dwells in the north (Kis-Jovak, et.al., 1988: 37). Therefore, the whole house of Tongkonan, either single house type or the village type, is always oriented to the north. In addition to affecting the orientation of the building, the belief of Toraja people (*Aluk Todolo*) also affects the orientation of the interior space of the building. The arrangement of the interior space is strongly influenced by the position of the building to the direction of sunlight. Toraja people believe that the east side is the beginning of life as the sun rises on this side, on the other hand, the west regarded as death as the sun sets on this side.

5.2.1. Sunlight and orientation of Tongkonan

Baker & Steemers (2002:72) said that the orientation of the building would influence the natural light both in quality and quantity into the building. Natural light coming from the north is the most constant and cooler light than the light from the other directions. The results of field measurements and computer simulation indicated that the light coming from the north side is more constant compare to the light coming from other directions. From this discussion it can be concluded that

the orientation Tongkonan house is strongly influenced by the direction of sunlight (*allo*) because the sun is associated as God (*Puang Matua*) the Creator. The sunlight coming from the east is the unstable light because the sun will set in the west, while the sunlight coming from the north is very stable and constant. The belief of Toraja people associate sun as God and they believe that God dwells in the north. This then affects the orientation of Toraja house so that it always faces north.

5.2.2. Heating and Cooling

Indonesia is a country located in the hot-humid climate; this indicates that the temperature in Indonesia is quite hot. According to Bainbridge & Haggard (2011: v-vi), orientation of buildings can reduce energy needs of the building heating and cooling significantly, this condition occurs in most climatic conditions. Building design should consider the heating in winter and cooling in summer. Indonesia is located below the equator so that the country does not have summer and winter, and only has two seasons, dry and rainy season. Tana Toraja is wet tropical regions, the average temperature ranges between 15 °C - 28 °C with humidity between 82-86%, the average rainfall is 1500 mm / yr to over 3500 mm / year (<http://www.tanatorajakab.go.id/id/content/klimatologi>). These data show that the temperature in Tana Toraja is cooler compare to temperature in other regions in Indonesia, this is due to Tana Toraja is located in a mountainous area.

In addition to these data, the Toraja people's belief did not mention that the orientation of the building was designed by considering solar heating and cooling. By contrast, in the belief Toraja people, it was mentioned that the orientation of the building was designed based on the direction of sunlight, as the sun is associated as the God. It means, in the concept of heating, cooling and lighting, solar heating and cooling has no influence in determining the orientation of the building.

5.3. Interior space

Tongkonan interior space arrangement is influenced by the direction of

sunlight appropriate to the belief of Toraja people. All of Tongkonan house facing the north, the dwelling place of the Creator that is associated with the sun, while the south is believed to be the tail of the world, a dirty place. Sunrise (east part) connoted as a life, otherwise the west where the sun sinking considered as death (Said, 2004: 32-33). The philosophy of the direction of the sun affects the division of the interior space as Tangdo, Sali and Sumbung.

5.3.1. Tangdo

Tangdo is a room at the very front or at the north, has windows on the north side, and has function as a space to accommodate thanks giving ritual. Tongkonan house is oriented to the north because it is based on the belief that *Aluk Todolo*, God the creator of the universe (*Puang Matua*), that is associated as the sun, dwells in the north. Said (2004:32) states that the northern part of Tongkonan is called *Ulanna lino*, which means front, top, part respected and regarded as a sacred place, a place where *Puang Matua* dwells. The question is, if Puang Matua is associated with the sun (*allo*) as Said (2004: 33) and Kis-Jovak, et al., (1988:36), why does Tongkonan house face the north, and *Puang Matua* is considered to dwell in the north, while the sun rises in the east and sets in the west? The results of measurement of quantity of light indicate that rooms in the north (*tangdo*) has higher quantity of light than *Sali* room which receives light from the east and west as well as *sumbung* room that receives light from the south. This is supported by the statement Livingston (2014:170) and Baker & Steemers (2002:72) stating that the north side is a part of the building that receives the most consistent light. Therefore, it can be concluded that Tongkonan is oriented to the north because the north side provides light with high intensity and consistent from morning to evening, as the belief of *Aluk Todolo* that associate *Puang Matua* with the sun. This is supported by the shape of the roof of Tongkonan that creates a clear access from sunlight entering the structure through north windows. Meanwhile, the east side, direction of the rising sun, gives light with high intensity only



Figure 13(a). Roof design optimizes daylight from north side.

from morning until noon only.

The roof shape of Tongkonan soaring high on the north side plays an important role in optimizing the entry of sunlight throughout the day. The roof shape (Figure 13) does not block access of the sunlight to the building, and does not result in a shadow area which reduces the quantity of sunlight. Although the light entering the building is not blocked by the roof, the light coming from the north is indirect light (Livingston, 2014: 168) so that the radiation coming into the building can be reduced.

5.3.2. Sali

Sali is a middle room at house of Tongkonan and is divided into two sides, east and west. The east side serves as the kitchen and the west side is used as a place to put the corpse before burial (Kis-Jovak, et al., 1988:37). The results of measurement show that the east side receives greater light at 09.00 am (morning), and on the contrary, the west side receives greater light intensity at 03:00 pm (afternoon).

Sali room on the east side of the room serves as a kitchen (*dapo*). The placement of the kitchen on the east side is influenced by the direction of the rising sun. Sunrise associated as a source of life, so the kitchen is also a source of life (food as a source of life) was placed on the east side. Activities in the kitchen are usually done in the

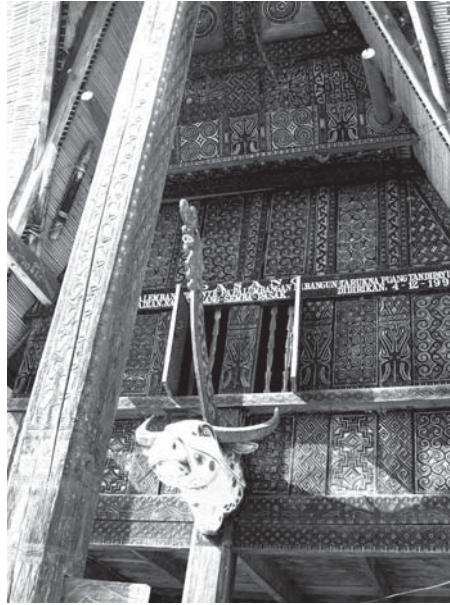


Figure 13(b). Window on north side as a daylight access.

morning and the results of measurement indicate that the quantity of light in the morning coming through the openings on the east side strongly supports the activities of cooking in the kitchen. The placement of the kitchen on the east side is in accordance with the statement of Phillips (2004: 10) about daylighting that the kitchen will be very good if placed on the east side because it will receive morning sun. Baker & Steemers (2002: 25) said that a kitchen needs bright conditions as integrity of character. Furthermore, according to Roberts (2006: 16-17), daylighting will make a kitchen more enjoyable for spending time inside, and east-facing windows are usually considered for a kitchen because the morning light is able to create a cheerful atmosphere. This statement is in accordance with the belief of Toraja people (as Said, 2004: 33) that the light of morning sun is a representation of life, happiness and joy. It is also supported by the results of field measurements that indicate the early morning light of the east have a very good quantity.

Sali room on the west side is used to put the corpse before burial. According to the belief of *Aluk Todolo*, humans do not really die until the funeral ritual held (Said, 2004: 39). The sun sets in the west side and a shift from daytime to the night occurs at sunset. The belief of *Aluk Todolo* as stated by Said (2004:33) describes the place where the



Figure 14. Window on west side of Tongkonan house.

sun sets as *rampe matampu*, and refers to 'death' and represents the elements of darkness, grief, and other things that bring grief, so that the corpse is located on the west side of the *sali* room before burial. Figure 14 shows an opening located on west side of Tongkonan as light access of daylight to *Sali* room.

5.3.3. Sumbung

Toraja people believe that the south side is a dirty place, the graves placed on the south side Tongkonan. This belief is the same as the beliefs of ancient Egyptian society (as mentioned by Kitter, Kocifaj, and Darula, 2012), who worshiped the sun as a mightiest god, most of the graves and pyramids facing south side.

Sumbung is a room located in the southern part of Tongkonan and serves as a bedroom. According to Phillips

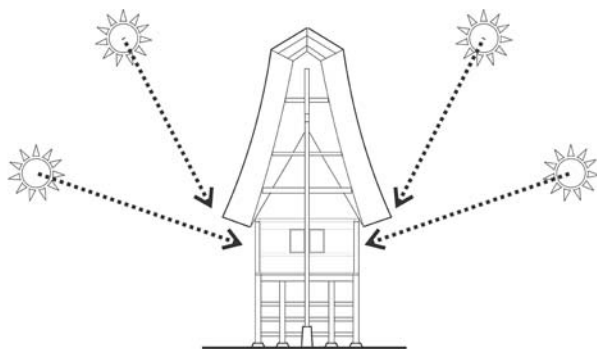


Figure 15. Sun angles from east and west sides.

(2004:10), a room which is frequently used in the afternoon or evening is placed on the south or east. Most of the Toraja people worked as farmers and spent more time in the fields, so the bedroom was more frequently used in the afternoon and evening. Robert (2006:17) mentioned that the light coming from the north will not cause glare or over-heating while the light from the south can be shaded using additional elements. The graves is usually located in the hilly area and is located in the south (behind) Tongkonan so hills and vegetation element is able to shade Tongkonan. This means Tongkonan not require additional elements to shade the south side of the window. In addition, the bedroom is often used at night when the sun goes down.

5.4. Roof shape of Tongkonan

Tongkonan hyperbolic-shaped roof soaring curved structure supported by columns called *tulak somba*. Roof oriented north-south, the north is believed to be the dwelling place of the God Almighty (*Puang Matua*) and the south is regarded as a dirty place, the grave is located on the south side of the Tongkonan house (Sumalyo, 2001; and Said, 2004: 32). Hyperbolic shape of the roof allows light from the north and south illuminates interior of building optimally throughout the day. Rice barn (*alang*) on the north side has smaller dimensions compare to the house, and on the other hand, rice barn has a distance of more than eight meters from the house Tongkonan so it does not shade the sunlight into the building through the openings on the north side. The sunlight coming from the east and west sides are direct sunlight containing radiation and ultraviolet light (Figure 15). The roof design of Tongkonan on the north-south side receiving indirect sunlight is different from the east-west side that receives direct sunlight. On the side of the north-south, the roof soars high and does not block the access of sunlight into the building (Figure 16). Meanwhile, on the east-west side which receives direct sunlight and contain radiation and ultraviolet light, the access of light is blocked by roof, so that the radiation can be reduced (Figure 15).

Tongkonan studied is a single house type, in this type there are no other houses that shaded the Tongkonan; therefore it would create good opportunity for daylighting of the house. The sunlight can get into the building as well. Meanwhile, in the village type, there is an open space between Tongkonan (on the east side and west side) and between Tongkonan and rice barn (on the north side) that serves as a ceremonial space and created a wider distance between one the Tongkonan with another. This distance will also create a good opportunity for natural light as well as on the type of single house.

5.5. The optimal solar orientation

Based on the literature study, the results of field measurements and analysis, the most appropriate orientation to get optimal sunlight is north-facing. The north side is able to provide a stable and constant light. Thus, the orientation of the house Tongkonan very appropriate because it can provide optimum light and it is accordance with their beliefs that associate the Lord as the sun.

The kitchen as a space that accommodates morning activities and needs an enjoyable and cheerful space, laid on the east side because according to the results of a literature study, field measurements and the analysis results, the morning light from the east was able to create a cheerful atmosphere and lively, this is in accordance with the Toraja people's belief that the morning sun is the source of life.

Furthermore, the west side serves as a place to put the bodies before burial, in accordance with the position of the sun sets in the west side and an intermediate transition afternoon to evening. While the south side is an area that is considered dirty and functioned as a bedroom because it is only used at night, this is in accordance with the theory about the layout of the sleeping area associated with daylighting.

6. Conclusion

From the results of this research concluded that the Tongkonan House designed and built hundreds of years ago which is oriented to the ancestral belief of Toraja people, *Aluk Todolo*,

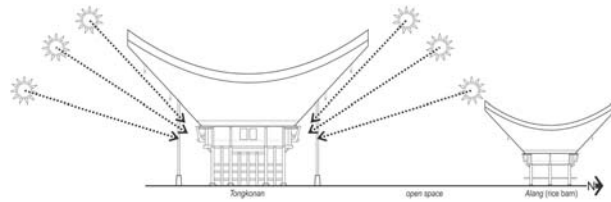


Figure 16. Diagram of sun angles from north and south sides.

indicates conformity with the principles of daylighting design. According to *Aluk Todolo*, *Puang Matua* (god) is associated as the sun and considered residing in the north, this belief has influence to house orientation which is all houses should be oriented to the north. The measurement and computer simulation results show that the quality of daylight in a room on the north side was very good, while the theories of daylighting also argued that the sunlight from the north side is the most stable light all days and years. Results of research on space in Tongkonan also show conformity between function, zoning, and activities accommodated inside Tongkonan with the quantity and the needs of daylight; this means all of activities inside Tongkonan can take place properly.

The results showed that although designed oriented ancestral belief of

Table 1. Results of computer simulation in Tangdo room.

ROOM	DATE	TIME		
		09.00 am	12.00 pm	03.00 pm
Tangdo (South)	March, 21			
		Average 191 lx	Average 188 lx	Average 166 lx
	June, 21			
		Average 1196 lx	Average 1320 lx	Average 789 lx
	September, 21			
		Average 197 lx	Average 197 lx	Average 158 lx
	December, 21			
		Average 143 lx	Average 141 lx	Average 123 lx

Table 2. Results of computer simulation in Sali room.

ROOM	DATE	TIME		
		09.00 am	12.00 pm	03.00 pm
Sali (East-West)	March, 21			
		Average 1329 lx	Average 564 lx	Average 1733 lx
		June, 21		
	Average 999 lx		Average 530 lx	Average 1305 lx
	September, 21			
		Average 1207 lx	Average 741 lx	Average 1635 lx
		December, 21		
	Average 1053 lx		Average 585 lx	Average 1477 lx

Table 3. Results of computer simulation in Sumbung room.

ROOM	DATE	TIME		
		09.00 am	12.00 pm	03.00 pm
Sumbung (South)	March, 21			
		Average 179 lx	Average 172 lx	Average 158 lx
		June, 21		
	Average 140 lx		Average 137 lx	Average 118 lx
	September, 21			
		Average 175 lx	Average 170 lx	Average 147 lx
		December, 21		
	Average 1005 lx		Average 1032 lx	Average 761 lx

Toraja people, all interior space of Tongkonan are able to fulfill the principles of daylighting. The orientation of the building, its slender shape, roof design and zoning are able to optimize the quantity and quality of daylight inside the building and meet the functional requirements of the house. These results also indicate that the vernacular architecture which was built based on traditional culture and ancestral belief is able to optimize the potential of nature to accommodate building comfort and function, including the optimization of daylight.

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