



Earthquake Resilience of Traditional Nias Island Houses: Lessons from the 2004 and 2005 Earthquakes

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ABSTRACT

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For the past two centuries, Nias, an island located in the Indian Ocean on the west coast of Sumatra, has been regularly rocked by earthquakes. It was recorded that devastating earthquakes occurred in 1843, 1861, and finally in 2004 and 2005. Facing this situation, the people of Nias Island have taken the initiative to respond to earthquake disasters in the form of cultural heritage to avoid and save themselves from various possible risks of earthquakes by building traditional earthquake resilience houses. This article aims to explain the existence of these traditional earthquake-resilience houses in the face of earthquake natural disasters. The method used is a combination of historical and architectural by utilizing various kinds of past data from earthquake resilience houses. The results of the research show that this earthquake-resilience house has been built for centuries and has a unique architectural model and resilience so it does not collapse easily even when shaken by a strong earthquake. Traditional houses are made of strong wood and built based on the local wisdom of the local community. Throughout its history, this house has been able to save many people living in these houses from earthquakes.

1. INTRODUCTION

As a maritime country, the Indonesian archipelago is prone to natural disasters such as earthquakes. Many places in Indonesia, especially on the islands in contact with the marine waters of the Indian and Pacific Oceans, including Nias Island, often experience earthquake shocks. Some of these earthquakes have a large scale, so rising tsunami waves to the mainland sometimes follow them. Consequently, the Indonesian archipelago is traversed by a route that is also a meeting place for three tectonic plates: the Indo-Australian, Eurasian, and Pacific.

Nias has a historical record as an island that often experiences earthquakes. The available sources indicate that the island has been periodically shaken by earthquakes followed by tsunami waves since several centuries ago [1]. Of the many events, a terrible earthquake shock occurred on December 26, 2004, with a magnitude of 9.3, followed by a tsunami. After lying dormant for around a thousand years, a sudden shift of a 1,600 km long section of the Sunda megathrust fault caused an uplift of the seabed between Aceh and Myanmar, resulting in a massive earthquake and Indian Ocean tsunami. Not to mention the suffering of the people was over; three months later, on March 28, 2005, an earthquake again rocked Nias Island with a magnitude of 8.7. This time the quake was just to the south, a sudden shift of the 350 km megathrust fault beneath the islands of Simeulue and Nias

causing a large destructive earthquake with smaller tsunami waves [2].

The two earthquake and tsunami events devastated Nias Island physically and mentally. Many public facilities such as residential houses, office buildings, hospitals, houses of worship, schools, roads and bridges, and even agricultural land and residential areas were damaged and destroyed. In addition, the earthquake and tsunami on Nias Island also claimed thousands of lives and injuries [3]. Most of the victims who died were residents who lived in Gunungsitoli and Teluk Dalam, the two main towns as political and economic centers on Nias Island. As a town built since the Dutch colonial government in the 19th century, Gunungsitoli has a lot of infrastructure in the form of residential houses and office buildings, as well as others that were built in a modern way using concrete and brick materials. The victims who died and were injured were generally caused by being crushed by collapsed buildings, both public facilities and private houses as residences.

Compared to the incidents in Gunungsitoli and Teluk Dalam, the number of victims was minimal for rural residents living in rural areas throughout Nias Island. This is because residents live in traditional earthquake-resilience houses. The house is an ancestral heritage of the Nias people in the past and has evolved in its development. The house was built as a result of adaptation to environmental conditions, including in terms of the house's resistance when shaken by earthquakes that

regularly hit the island.

Nias traditional houses are built using strong and good quality wood materials. During two devastating earthquakes in 2004 and 2005, the severe damage to this type of house was almost nothing, as was the case for concrete houses. Several houses were tilted except for those caused by partial landslides and permanent slope movements. Some houses built around a cliff toppled into a ravine and moved places because they could not withstand the earthquake's force but did not cause any casualties [4]. The death toll is minimal. For the entire island, only one person was recorded. Even according to Gruber and Herbig in the 11 villages they visited in 2005, nobody was killed during the earthquake on March 28, 2005 due to the breakdown of a traditional house [5]. At the same time, others suffered minor injuries such as abrasions and broken bones. These facts show that Nias' traditional houses, as earthquake-resilience houses that have been tested for their strength, can withstand earthquake shocks that have often shaken the island for centuries, up to the 2004 and 2005 earthquakes. Figure 1 below shows the epicenter of the earthquakes around Nias Island in 2004 and 2005.

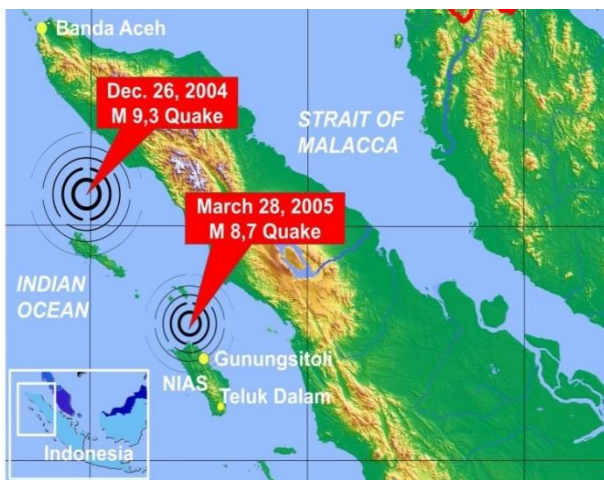


Figure 1. The epicenter of the earthquakes and major towns on Nias Island

In architecture, local wisdom works on many parts such as façade, structures, and ornaments which are born from the specific value of indigenosity. Many articles, reports, as well as personal observations, show that the local wisdom secures the building successfully against disasters such as earthquake [6, 7]. The architecture of traditional houses on Nias Island was built based on the philosophy of local wisdom. As part of the culture, local wisdom can be understood as a human effort by using his mind to act and behave towards an object or event that occurs in space and time. Local wisdom is obtained from the accumulation of past events experienced by a community, then the community draws experience and lessons from it to maintain and continue their life. From local wisdom, local genius or genius loci emerged.

From this experience, the knowledge of Nias people in the form of local geniuses related to the architecture used in building the traditional houses generated. There are three elements applied in forming the genius loci of an architectural creation, logos (knowledge), ethos (character, identity, culture), and pathos (spirit and emotional dimensions). Traditional residential traditions on Nias Island logos have used elements of pathos with a local flavor so that they have character and stand upright based on the ethos of people's lives

that can be seen in real terms and also felt. Following are some aspects of local wisdom in building of traditional houses on Nias Island [8].

Second, the construction of traditional houses on Nias Island does not use nails. The wooden poles are connected in an assembled way. The wood is assembled in such a way by builders using technology based hereditary knowledge from generation to generation as stated in the Nias proverb "*aro ni tuwömoroi ba ni osö.*" This means that it is stronger or more resilience to assembly than nails. This technology is also related to the so-called plastic joints in modern buildings. For buildings that are too rigid, when shaken by an earthquake, plastic joints form to release the earthquake energy they receive. This release of energy is to save the building from collapse. The strong impulse energy from the earthquake is converted into movement or displacement, thus avoiding the building elements from being destroyed or damaged by the energy. This wood assembly technology is a second defense against earthquake hazards if the energy transmitted still escapes from the supporting stones to the body of the building.

This article aims to reveal the existence of earthquake-resilience traditional houses on Nias Island before and after the 2004 and 2005 earthquakes. The main issues focused on in the discussion include the background of the construction of the house, its form and the stages of construction, and efforts to rehabilitate or preserve houses after the 2004 and 2005 earthquakes.

2. METHODOLOGY

This article results from qualitative research using historical methods covering four steps: heuristics, criticism, interpretation, and historiography [9]. Historical data or sources collected in the heuristic step were obtained in three ways: library research, focus group discussions, and oral history interviews. Historical data earthquakes related to earthquake resilience in traditional houses in the past is available on Nias Island. Therefore, this methodology is suitable for the topic.

Through library research, several written sources were obtained, such as manuscripts, books, journals, and others relevant to the condition of traditional earthquake-resilience houses on Nias Island, including the earthquake itself. Meanwhile, sources in the form of information were also obtained from relevant and competent experts regarding the existence of earthquake resilience Nias traditional houses before to after the 2004 and 2005 earthquakes through focus group discussions. The third is conducting field research by visiting several locations on Nias Island. Three areas were visited: Gunungsitoli town in East Nias, Mandrehe in West Nias, and Teluk Dalam in South Nias; apart from witnessing firsthand the condition of the earthquake resilience traditional houses during field research as well as conducting interviews with several key informants.

3. RESULTS AND DISCUSSION

3.1 Earthquake resilience houses in various countries

There have been several studies on earthquake-resilience traditional houses in various countries that have been carried out. First, Khasi house in India. Similar to Nias, Khasi houses are built on stilts. The roof is made of lightweight material

using thatch leaves while in Nias the roof was thatched (sago) leaves. The walls of the house are also made of stone masonry with lime and mud walls made of lime. Mud and rock walls are common in areas with heavy rainfall. While walls in traditional Nias houses were made of wooden planks. The main structural system consists of a wooden frame of columns and beams which have pillars sunk into the ground. The floors are supported at intervals by limestone or wooden pillars. Some characteristics of traditional Khasi houses in Shillong are that they are not built on hilltops and have a symmetrical oval shape that has no sharp corners, thus avoiding stress concentrations. Nails were not used in the construction, and the grooves and tongues used made it possible to eliminate seismic loads [10].

Furthermore, Zagelli's house is a traditional community house in Guilan Province, North Iran. The foundation of the house is called Shikilli. The foundation structure consists of wooden beams arranged overlapping. Similar to traditional earthquake-resilience houses on Nias Island, Zagelli's house uses a vernacular architecture made of logs, so it is relatively light. The foundation and the house will sway when there is an earthquake and make the house well defended against seismic excitation. This was proven by the Manjil-Rudbar earthquake (June 1990) with a magnitude of 7.3 on the Richter scale, the Imperial Valley earthquake (May 1940) and Northridge (January 1994). There is another aspect of the Zagelli house in Iran. The owner and occupant of the house are involved in designing the construction. The "inhabitants as designers" shows that the Zagelli people always maintain a sustainable human-environmental balance. In addition, the existence of Zagelli's house shows that nature is an intermediary element in the cycle between "lifestyles" and "patterns of form". Thus, Zagelli's house is not only resilience to earthquakes, but also makes its residents feel comfortable, both in summer and in winter which alternates in one year in the Guilan area, Northern Iran [11].

Next, the resilience of traditional wooden frame house buildings in Turkey. Earthquakes frequently hit Turkey, as happened in 1894 in Istanbul, 1970 in Gediz, and 1999 in Kocaeli. Modern buildings made of concrete frames that have sprung up in Turkey since the 1960s due to urbanization and modernization, were badly damaged by the earthquake. Timber-framed houses, on the other hand, were more resilient in the earthquake, sustaining little damage. As earthquake-resilience houses on Nias Island, wood-framed houses have survived for 300 years in Turkey. Likewise, in Nias, traditional houses in Turkey were abandoned because many modern buildings made of concrete emerged. The 1999 earthquake sparked discussions about the importance of reusing timber-framed houses, which account for 80% of the total number of houses registered as cultural property in Turkey. The article also discusses construction techniques, material properties, and earthquake resistance features. Timber is widely used for load-bearing masonry and as a building frame. Wooden buildings are more earthquake-resilience, but have limited use for high-rise buildings, and have inadequate resistance to fire and damage by biological organisms [12].

Furthermore, Japan is a country that maintains traditional culture in various fields. Minka house architecture is one of the cultures that is still maintained today so in every region in Japan one can still find Minka style houses. Even modern houses in Japan incorporate some elements of Minka houses so that you will feel a blend of modern style and traditional Minka style. The Minka house has many characteristics that

are unique in its own way that other types of traditional houses do not have. One of the most prominent things about the uniqueness of traditional Japanese Minka houses is the distinctive elements in the house plans that are not found in other traditional houses. This uniqueness is the main attraction of Minka's house so that the existence of Minka's house is maintained and sustainable.

Minka's house contains a philosophy that reflects the wisdom of their local culture. Minka is a model of a house in Northern Japan, where the climate is very cold in winter with abundant snowfall every year, so the architect of Minka's house is adapted to these climatic conditions. The southern part of Japan does not have long winters and as much snow as in the North, so the architects of the Minka houses in the South are different from those in the North. Minka houses in the south generally consist of a group of relatively smaller, lower houses with raised floors to provide maximum ventilation and reduce the danger of typhoon winds. This house is designed to reduce earthquake shocks. The southern region of Japan is often hit by typhoons and earthquakes so that Minka house architects in the southern region are adapted to their natural conditions. Many Minka houses in the southern region of Japan make stilts for safety reasons during an earthquake [13].

3.2 The background of earthquake resilience house construction

Before entering the 17th century, the name Nias Island was not as it is known today. The name Nias was given by people who came from outside, namely the Dutch VOC (*Verenigde Oost-Indische Compagnie*) who went to the west coast of Sumatra, built a fort in the city of Padang, and then paid a visit to Nias Island [14]. Nias people themselves call Nias Island *Tanö Niha*, which means human land. Apart from that, they also named Nias Island as *hulo solaya-laya*, which means an island that sways or an island that floats. The naming identity shows that since ancient times the island of Nias has been frequently shaken by earthquakes so that local residents feel that they are swaying or as if they are floating in the sea.

In the local language of Nias, the house is called *omo*. Nias folklore or oral tradition says that *omo* comes from the word *owo*. *Owo* means small boat or ship. The change from *owo* to *omo* was due to the association of the house as another form of boat, both as a place of refuge. The difference is, *owo* is in the ocean while *omo* is on land. Also, the two terms underwent a metamorphosis into the word Gomo.

Gomo is the name of a settlement in central Nias, believed to be the first village founded by the Nias people. The change of the word *owo* to *omo* to become Gomo can be traced through the story of the arrival of the Nias ancestral group who first arrived in Nias. The group came to Nias by sea using a boat as a means of transportation. They sailed from faraway places thousands of miles away. Recent findings about the area of origin of the Nias people were obtained through research Acid Deoxyribose Nucleic (DNA) samples. Based on this research, the ancestors of the Nias people came from East Asia, specifically Formosa Island (Taiwan). From Taiwan, they migrated southward to the Philippines, then continued their journey westward into the waters of the Indian Ocean and anchored and set foot on Nias Island [15, 16].

After arriving on the east coast of Nias, the group moored their boat at the mouth of the Susua River. All the passengers got off and went ashore in the highlands, making the place a residential area later known as Gomo. There they built a house as a place to live and named the house as *omo*. The choice of

vocabulary and pronunciation is similar to the word *owo*, a boat used for transportation during a voyage. The use of the word *omo* was inspired by the life experiences of the ancestors of the Nias, who were very close to the sea or the maritime world. This was then implemented by building and naming their dwellings on land similar to those at sea.

Not only the naming but the shape of the traditional house that was built also resembles a boat. This has something to do with earthquakes. When their ancestors settled on Nias, they began to feel earthquakes frequently occur on the island. The house they built and lived in at that time felt like they were on a boat, rocking every time. The difference is the swaying in the boat is caused by wind and ocean waves, while on land is caused by an earthquake. Therefore, the idea arose to build a safe and comfortable place to live or house, safe from earthquakes, just as in the sea, they board a boat and survive the shocks of waves, storm winds, etc. The structure and architectural models of houses built in rural areas must adapt to environmental conditions [17]. Thus the function of the house is not just as a place to live or shelter during the day and night together with family but at the same time built to withstand earthquake shocks that come at any time suddenly.

The idea of building earthquake-resilience traditional houses first emerged from the thoughts of one of the ancestors of the first generation of Nias people named Hia. Then Hia's descendant, Ho, and his grandchildren spread the earthquake-resilience house model throughout the territory of Nias Island. The spread started from the location of the first settlement of the Nias people, namely Gomo in Central Nias, then spread to South Nias, namely in Teluk Dalam, Maenamölö and Tölamaera, and Central Nias. From Tölamaera, the Nias people spread again to North Nias, West Nias, and East Nias. In line with this, traditional houses are also scattered throughout Nias Island, covering the four cardinal directions: south, north, east, and west.

Until the mid-19th century, villages in Nias, including the oldest village of Gomo, were an essential part of the community's life system. The villages are a unit of traditional government that is scattered autonomously. In the regional language of Nias, the village is called *banua*, inhabited by a group of people led by a village head (*salawa*). Above it is *öri* which means the country consists of a combination of several *banua*. Each *öri* was headed by a *tuhönöri* (*öri* head) and each *banua*. Before entering the initial phase of Dutch colonial rule on Nias Island, all *öri* on the Nias archipelago were defended by the Dutch and then united into *Afdeeling Nias* led by an *Assistant Resident* [18].

As has been explained, since the beginning, villages on Nias Island have often suffered severe damage from earthquakes. As a result, many ground surfaces cracked and experienced movement, causing the collapse of various facilities, including residential houses. At the end of the 18th century, a large-scale earthquake occurred in 1797. This earthquake was centered on the southern part of Nias waters, including the Batu Islands to the west coast of Sumatra [19].

During the 19th century, at least four earthquakes were recorded to rock Nias Island in 1843 and 1861, respectively. The 1843 earthquake occurred on January 5-6 with a magnitude of 7.2. Meanwhile, the 1861 earthquake occurred thrice each month in succession, namely February 16, 1861, March 9, and April 26, 1861. Rising tsunami waves followed the first earthquake on February 16, with a magnitude of 8.5 [20].

As earthquakes occur consistently, the construction of

traditional earthquake-resilience houses on Nias Island, which began when the earliest Nias people arrived around 1500 years ago, continued into the 19th and 20th centuries. The existence of traditional earthquake-resilience houses in the 19th century was revealed by Elio Modigliani, an Italian adventurer who visited Nias Island in 1886 and lived there for six months [21]. In his notes, Modigliani witnessed firsthand the condition of the traditional anti-seismic houses that were already there and the construction of new houses by local residents whose models exactly resembled the old ones. He also obtained information about the use of the house directly from local residents. Modigliani notes that traditional model houses on Nias are rare and built with unique skill and ingenuity. The places are in the form of stilt houses with a height reaching up to 4 meters from the ground level supported by sturdy supports to prevent and reduce damage to the body of the house caused by earthquake shocks [22].

3.3 House type

Traditional houses in Indonesia, including traditional houses on Nias Island, are works that represent the philosophy of life and traditions of the local community. There are various names for the naming of traditional Nias houses in the local community. In addition to earthquake-resilience houses, these houses are categorized as customary house (*omo hada*) and large house (*omo sebua*). Customary houses in the category of traditional houses are Nias traditional house inhabited by ordinary people. In contrast, house in the big house category are only inhabited by certain groups, such as heads of state (*tuhönöri*), village heads (*salawa*), or the nobility. Usually, large houses are built in bustling village centers.

In addition to the traditional house types, other types of houses were introduced to Nias Island centuries ago, built by migrants who came to live on the island. In general, these settlers came from Sumatra Island such as Aceh and Minangkabau as well as the Chinese and Dutch. They established their settlements in the coastal commercial towns around Nias Island such as Gungsitoli, Lahewa, Sirombu and Teluk Dalam. The houses they built were called coastal houses (*omo pesisir*) or *omo ndrawa*.

There are two main types of earthquake-resilience traditional houses on Nias Island. The first type is rectangular and has two sides, like a boat. This traditional house is generally found in the southern part of Nias, as shown in the following picture of the house in Figure 2 below:



Figure 2. The painting of earthquake-resilience traditional house on southern Nias in 19th Century

Source: Modigliani, 1890

Meanwhile, the second type of house is round or oval. This

house is generally found in northern Nias, as shown in Figure 3 below:

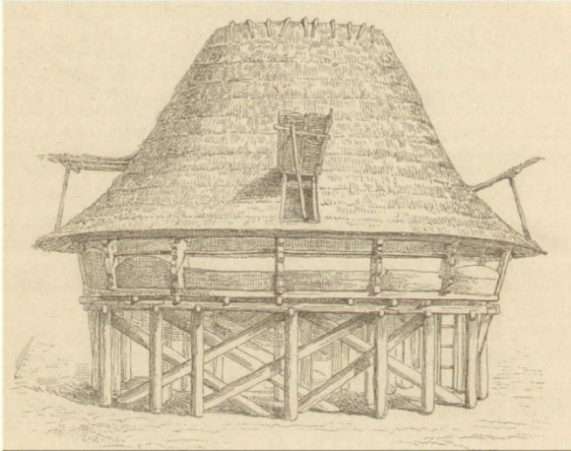


Figure 3. The painting of earthquake-resilience traditional house in 19th Century on northern Nias
Source: Modigliani, 1890

Earthquake resilience traditional houses in southern Nias and northern Nias or other places throughout Nias Island are in the form of stilt houses. The shape of this house is a wise and intelligent attitude built to anticipate conditions that endanger his life by making a simple residence and the floor is high from the ground.

Earthquake-resilience traditional houses are built using a vernacular architectural model based on the local population's creations and wisdom. Specialists do not produce this architecture but through the spontaneous and ongoing activity of entire societies with a common heritage, working within a community of experience. The beauty of this "primitive" architecture is often not overlooked by accident, but today we recognize it as an art form resulting from uniquely applied human ingenuity. This architectural style was born and grown by the people of their own area, depending on the design skills and traditions of local development carried out by the people without the intervention of professional architects. They do it self-taught by looking at their environment. This architecture can also be said to be a building style that appears according to the community's needs and the availability of building materials. This is what makes the shape of the building vary according to its function. With vernacular architecture, one can see the natural conditions of an area, such as climate, local culture, environment, and building materials in that area.

From the results of vernacular engineering, the Nias' traditional house is a stilt house made of wood supported by oblique (diagonal) pillars at the bottom of the house. This is due to the natural conditions of Nias, so they think of a safe and comfortable place to live from the disturbance of other living things and the threat of an earthquake. The pillars of the house are made to stand and be crossed so that the house has strength and flexibility when an earthquake occurs. The poles are not buried in the ground. Still, they sit on flat stones as wooden bases so that the bottom of the poles is more flexible to move and shift during an earthquake that occurs in modern buildings [23]. The plinth stone acts as a vibration barrier so that when an earthquake occurs, the damage to houses is not as severe as that of modern buildings. The ancestors of the Nias people knew that earthquakes often hit the island of Nias, so to reduce the earthquake's strength, the pillars of the house were not planted but placed on flat stones.

The roofs of traditional Nias houses are tall, steep, and curved from the top of the ridge to the tip of the lower roof. The roof of the house is made of thatch leaves which can last a long time, although nowadays, many roofs have been replaced with zinc because thatch leaves are rarely processed. The steep and curved roof is intended so that it is not easily torn apart and is not easily blown away by the wind because it is tied to the roof frame. From inside the house, the roof frame does not use a ceiling and is open, so air circulation runs well, and the house is not stuffy. Windows are made to facilitate air circulation and allow sunlight to enter. There is a window in the form of a lattice or net at the front of the house which functions as an air vent and can see into the yard [24].

3.4 Room division and addition

The division of rooms are divided into two, the front room, which functions as a living room or family room, and the back room, which functions as the bedroom and is private. While at the bottom (under), the house is a building (room) used for the bed, dining room, kitchen, and bathroom. The front room has three levels of floors. The difference in floor levels reflects the respect for people who have a degree, position or age that is older. People with older positions or ages have the right to occupy the top floor.

The levels of traditional Nias houses from the ground floor, the second floor, and the upper floor are the level of customs and the level of behavior. The person sitting on the upper floor is not the same as the person sitting on the second floor, likewise, the person sitting on the second floor is not the same as the person sitting on the lower floor. The seat in the house shows everyone's social status. If there is a meeting in a traditional house, the nobility sits on the upper floor. Other parents sit on the next floor, while the children sit on the lower floor.

Several traditional Nias houses have had additional rooms, especially the additions at the house's bottom (under) and back. Most of the building additions have used brick and concrete construction, no longer using the original construction of traditional houses. Even though there are additional buildings or rooms, the original characteristics of traditional houses are still maintained, both those in the front of the room and the back room. The addition of buildings or spaces to traditional houses is due to inadequate size and division of rooms, which only consist of front and back rooms in the main house to accommodate the occupants' needs.

The addition of a room that the original traditional homeowner often does is the need for a bedroom. The need for private bedrooms with a large number of family members is not fulfilled in the pattern of division of the main house's rooms. Besides that, the modern lifestyle influences many Nias by wanting private bedrooms. Likewise, the needs of the bathroom and kitchen cannot be accommodated in the main house, so additional buildings or rooms are added. Adding buildings, especially those under the house, can also have consequences for the resistance and structure of the building against earthquakes. With the addition of facilities (rooms), there is a reduction or elimination of diagonal and vertical columns if the space below is made into a bedroom, kitchen, or bathroom. Vertical and diagonal pillars have a function to strengthen the robustness of the main house so that reducing the pillars can cause the building's resistance to earthquake shocks. Additional buildings using bricks will be damaged when an earthquake occurs [25].

3.5 Development stages

The construction of traditional houses on Nias Island must follow customary rules and rituals, including slaughtering and corporating pigs at every stage of the construction process. In building houses, traditions are practiced and developed, both physical and intangible. Implementing customs and rituals which are always marked by slaughtering pigs and paying respects and banquets in the form of pork, money, and gold, are simultaneously a challenge and an obstacle in the construction of traditional houses in the future. The process of constructing traditional houses in Nias also varies between West, North, South Nias, and Gunungsitoli.

According to key informants: Arozanolo Gulo and A. Efrida Laia, the process of constructing a traditional house has the following stages [26-28]:

1. *Otomosa zi darua niha* means to plan an agreement between husband and wife. After their debt affairs at the time of marriage are completed, there is an intention in the heart to build a house. This shows that they agreed to build a house, and for that, they have to work hard (*lö simörö-mörö ira*). Due to various obstacles, these plans and agreements may not be successfully completed into a house. For example, the owner's family is sick or lacks sustenance. They know what causes the disease if they ask the shaman. If the *ere* prays for it, the disease can be cured.
2. *Fangombakha ba dalifusö faoma ba zitenga bö'ö* means that you have to tell your brothers and uncles to build a house.
3. *Fogaoni tuka* to call a handyman. To call a builder, the owner of the house pays a wage to the builder and to build a house there must be one skilled craftsman.
4. *Famaigi naha nomo* (home spot check)
5. *Folobö eu* (chop down a tree)
6. *Famaigi silalö yawä* (major pillar)
7. *Fangai mbaha tuo* (main pillar powder taking)
8. Installing wood (installing other poles)
9. *Mamedadao* (establish)
10. *Fame'e boto mbumbu* (installation of the top wood as a support for the roof frame / ridge beam)
11. *Manaba ahe mbulu zaku* (roof cutting)
12. *Fosaitagö mbawa ndrühö sebua* (installation of main door)
13. *Manawa omo* (occupy the house)

Nias traditional houses are in the form of stilt houses, building materials made of wood supported by pillars. This traditional house building does not use a foundation, while the joints between the frames use pegs, and the roof soars high. The room of the house consists of the front for the living room and the back for the owner of the house.

The condition of traditional Nias houses is relatively reasonable and quite sturdy, even though the buildings are old. The wood materials used are of good quality. The style of building traditional Nias houses shows distinctive traditional architectural characteristics. It proves that the ancestors of the Nias people had far more advanced knowledge of building materials and patterns. The Nias' traditional house is a stilt house made of wood supported by oblique (diagonal) pillars at the bottom of the house. This is due to the natural conditions of Nias, so they think of a place to live that is safe and comfortable from disturbances by living things and natural threats. The shape of the house on stilts is a wise and intelligent

attitude to anticipate conditions that endanger their lives by making a simple place to live.

3.6 Post 2005: Rehabilitation and preservation

Earthquake-resilience traditional houses are built with good materials and good workmanship. The superstructure uses high-quality cylindrical wooden beams with a frame-type construction method. However, the earthquakes in 2004 and 2005 resulted in some of the earthquake-resilience traditional houses being damaged. This was triggered by the strong vibrations and shaking of the earthquake that rocked the house many times.

Not many houses collapsed, but some parts of the building were also damaged. Several factors causing the damage include wood's decreasing quality and strength as the primary building material. Then the structure of the central part of the building wobbled so that the house tilted; it also affected the roof of the building. In addition, the damage to these traditional houses was also caused by the widening of the superstructure caused by subsidence and lateral spread of soil liquefaction as well as partial landslides and permanent slope movements.

Luckily, not long after the 2004 and 2005 earthquakes and tsunamis were over, Nias Island and Aceh received financial assistance from the Indonesian government and international donor agencies to reconstruct and rehabilitate the various damaged facilities that were experienced during the disaster. In organizing this assistance, the Indonesian government established an official institution, the Aceh-Nias Reconstruction and Rehabilitation Agency (BRR). This agency is responsible for post-earthquake and tsunami reconstruction and rehabilitation and managing financial and material assistance from these international donor agencies. Many facilities, especially public facilities on Nias Island, were reconstructed and rehabilitated during the post-earthquake and tsunami periods. Without exception, the traditional houses damaged by the earthquake were also rehabilitated. However, because most traditional houses are still intact, there is no need for reconstruction; only rehabilitation is enough.

In an effort to rehabilitate traditional houses on Nias Island, the Nias Heritage Museum, as the initiator, did it using a three-stage work method? The first is to conduct a field survey. At this stage, the museum staff visited areas that had traditional houses throughout Nias Island. The aim is to review and see the condition of traditional houses damaged after the 2004 and 2005 earthquakes, which deserves to be rehabilitated. The field survey was carried out secretly without notification to villagers and house owners. This was done to avoid turmoil in the community, especially for homeowners who want their homes rehabilitated.

After all the field data from the survey results were obtained, the second stage was studying and identifying these data. All data were analyzed in such a way by the team, and then a decision was made to determine which houses were damaged by the earthquake and deserve to be rehabilitated. In the third or final stage, the museum contacts the house's owner to be rehabilitated by the museum and donor agencies. The aim is to notify them that their houses are receiving rehabilitation assistance officially. In addition, the museum also involves and asks for the active participation of homeowners who directly participate in the rehabilitation process for their homes. Figure 4 is an example of a traditional house being

rehabilitated due to the earthquake disaster.



Figure 4. A traditional house damaged by the earthquake is in the process of being rehabilitated

The financing for rehabilitation is carried out under the Direct Community Assistance (BLM) scheme. Rehabilitation assistance funds were directly handed over to the owners of traditional houses. With the help of these funds, the homeowner directly manages the rehabilitation process or can be said to be a contractor for repairing his own house. Implementing a scheme like this is carried out to maintain the values of the local wisdom of the people who have the rule that the owner of the traditional house has the right to manage and rehabilitate his traditional house. Apart from that, with such conditions, it is hoped that the aid funds will be used as well as possible to avoid deflection of funds because later, it will be detrimental to the house's owner. In this case, the Nias Heritage Museum itself positions itself as a distributor of donations, directing and participating in supervising the homeowner's rehabilitation process.

The effort made by the Nias Heritage Museum Foundation based in Gunungsitoli to obtain funds for rehabilitating earthquake-resilience traditional houses was by carrying out a campaign to save earthquake-resilience traditional houses on Nias Island, whose condition at that time was apprehensive. The campaign was aimed at various donor agencies and members of the international community. The long struggle carried out by the museum finally bore fruit.

A number of donor agencies and communities from various countries and multi donor fund of International Labour Organization (ILO) have also paid attention to saving these traditional houses [29]. Donor agencies from within or outside put their trust in the Nias Heritage Museum as a partner to carry out rehabilitation with the community to preserve one of Nias' historical and cultural heritage [30]. From the results of this collaboration, within eight years after the 2004 and 2005 earthquakes, 372 Nias traditional houses were successfully rehabilitated, as illustrated in Table 1 below.

In line with the rehabilitation process, the Nias Heritage Museum Foundation then collected data on the number of traditional houses on Nias Island, both rehabilitated and not. As a result, until 2010, there were 1,142 traditional houses scattered throughout Nias Island, covering four districts and one city. The highest number was found in South Nias Regency, namely 887 units, as shown in Table 2.

Apart from being earthquake resilience, the presence of traditional houses is a symbol of life and the survival of the Nias people's customs. Therefore, where there are traditional houses, there are also traditions that are preserved. The traditional house is the center for maintaining traditions and

social life practices. A traditional house is not just an ordinary house but a traditional one for Nias's ancestors, which must be preserved and passed on to posterity.

Table 1. Number of earthquake-resilience Nias traditional houses rehabilitated by the Nias Heritage Museum in collaboration with international institution donors and communities

No.	Year	International Institution Donor and Community	Number
1	2005-2006	Kindernothilfe.e.e.V, Germany	108
2	2006	Embassy of the United States of America, Jakarta, Indonesia	2
3	2006	Neustadt SchleswigHolsteiin, Germany	9
4	2006	Residents of Konstanz city, Germany	18
5	2007	The Johanniter, Gemany	26
6	2007	Brigitte Ott, Austria	1
7	2008	Residents of Munster city, Germany	10
8	2008-2010	Caritas Italiana, Italy	31
9	2009	Muslim Aid & BPPI, Jakarta, Indonesia	2
10	2009	Turnstone Tsunami Fund, UK	5
11	2010	Governor of South Tirol, Italy	1
12	2009	Multi Donor Fund of ILO, Jakarta, Indonesia	149
13	2010-2013	Tirto Utomo Foundation, Jakarta, Indonesia	10
Total			372

Source: Processed from the Nias Heritage Museum

Table 2. Distribution and number of earthquake-resilience traditional house units on Nias Island in 2010

No.	District/Municipality	Number of Units
1	Gunungsitoli	94
2	Nias	40
3	North Nias	18
4	South Nias	887
5	West Nias	103
Total		1,142

Source: Processed from the Nias Heritage Museum

Figure 5 shows several traditional Nias houses that have been rehabilitated after the 2004 and 2005 earthquakes.



Figure 5. Rehabilitated traditional houses

For this conservation effort, apart from the Nias Heritage

Museum, which has collaborated with donor agencies and the international community, due to the large number of houses that need to be saved, the regency and city governments on Nias Island are also paying attention. Through the Department of Tourism and Culture, the local government annually rolls out an assistance program to rehabilitate as many as six traditional houses. After ten years since the program was first launched, from 2010 to 2019, the local government on Nias Island has succeeded in rehabilitating as many as 60 earthquake-resilience traditional housing units.

4. CONCLUSION

The condition of Nias Island, which earthquakes have shaken for centuries, has awakened the local population to adapt to disasters while at the same time creating simple mitigation strategies to anticipate and reduce the risks caused by the earthquakes they experience. The strategy is to build a model of a residential house resilience to earthquake shocks. The idea of building earthquake-resilience houses has emerged from the beginning, starting with the ancestors of the Nias people and then being implemented by subsequent generations.

Earthquakes occurred twice in a row in just three months at the end of 2004 and early 2005, significantly impacting the existence of earthquake-resilience houses on Nias Island. First, even though it faced two large-scale earthquake shocks, this traditional house remained sturdy and did not collapse so that it could protect its inhabitants from earthquake shocks. Second, even though it did not collapse to the ground due to the very strong shaking, some parts of the house, such as the pillars and the roof, were still damaged, so this house was not habitable after the earthquake.

Responding to the condition of earthquake-resilience traditional houses on Nias Island, both their skill in dealing with earthquakes and the conditions after the earthquake, has raised the level of public awareness, both the Nias people as direct owners and users of these traditional houses and the international community who are concerned about the earthquake and put the condition of the traditional houses. Planning for the construction of a new traditional house, the superiority and strength of the structure possessed by traditional Nias houses is a building that can still be used today with the value of pride in ancestral heritage. The location of Nias Island, which is above the ring of fire-prone to earthquakes and tsunamis, makes it a reason that deserves preservation. In essence, these houses are immediately repaired or rehabilitated with the hope that they will be good again so that they can continue to be occupied by their owners and be passed on to future generations. And in efforts to rehabilitate earthquake-resilience traditional houses, the Nias Heritage Museum has a very large role. Apart from the local government, the Nias Heritage Museum is the only private institution on Nias Island concerned about the existence and sustainability of traditional earthquake-resilience houses by seeking and establishing cooperation with donor organizations and the international community. The results were extraordinary. Within eight years, from 2005 to 2013, the Nias Heritage Museum and partners have rehabilitated more than three hundred earthquake-resilience traditional houses on Nias Island.

Although traditional houses still exist, the construction of modern houses cannot be hampered. Therefore, the implications for future research include efforts to combine

elements of earthquake-resilience traditional house architecture with architectural elements of modern house construction on Nias Island. There must be a policy to combine traditional elements with modern elements. In this case, it is important to do research on the aspects that will be combined. Building material in the form of wood is the main material. It is necessary to cultivate strong wood that grows on the island such as *afoa* and *manawa danö* as one of the important elements in the construction of earthquake resilience houses. Technology to avoid the shock of an earthquake has been applied by using supporting stones at the base of the building to release the remaining earthquake energy that enters the building body. Finally, it is important to ensure the availability of builders who are able to combine the construction of traditional houses with modern ones.

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