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Traditional Architectural Tectonics Expression of Sasak Tribe as a Form of Earthquake-Resilient Housing Adaptation

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Abstract— *Destructive earthquakes in the year 2018 in Lombok West Nusa Tenggara province caused many houses damaged and collapse. To overcome the collapsed houses problem, it is very important to do a research, focusing on the traditional architectural tectonic expressions. This focus based on the phenomenon in 2018, when Bale Bayan didn't collapse during the earthquake. This study is aimed at identifying the forms of architectural tectonic of Bale Bayan, describing how the architecture tectonic of Bale Bayan be able to withstand the earthquakes, and formulating the adaptation concepts based on architectural tectonic of Bale Bayan. Research data collected using observation, interview, and literature study methods. To achieve research result, research data were analyzed using Miles and Huberman qualitative data analysis method. It is found that although Bale Bayan was not built with an earthquake-resilient approach, it can be able to withstand the earthquakes, with 22 elements of architecture tectonic, and 6 ways of the architecture tectonic earthquake-resilient. It is also formulated 7 architectural tectonic concepts based on the finding above*.

Keywords— *Architecture Tectonics, Bale Bayan, Earthquake Resistant Housing*.

I. Introduction

Indonesia is a country that often experiences earthquakes. Especially in the southern part of Indonesia (Nugraha, 2014). The number of earthquakes that occurred in February 2021, for example, was recorded 656 times (Badan Meteorologi, Klimatologi, dan Geofisika, 2021). The meeting of the earth's plates and the volcanic activity of the world's ring of fire often cause earthquakes. Therefore, the area along the Sunda arc is an area with a high level of earthquake vulnerability.

Earthquakes that often occur in Indonesia require adaptation by the Indonesian population. Population affected by the earthquake have a great possibility to adapt to the surrounding environment. Adaptation to this disaster is carried by both individually and in groups to reduce the risks that occur (Suryani in Huda, 2016). For example, an adaptation can be done by renovating with an earthquake-resistant approach. This house adaptation is not only done in modern times. Since the first, traditional Indonesians have made active adaptations to their dwellings. This active adaptation can be seen in the architectural tectonics of the Besemah traditional buildings (Rinaldi, 2015), Nias traditional buildings (Prasetyo, 2013), and traditional Acehnese houses (Hairumini, 2017).

Munandar researched traditional housing and its resistance to earthquakes in 2018. The study by Munandar (2018) took two case study locations, namely Lombok island in Indonesia and Kobe district in Japan. The study then compared traditional dwellings and modern units at each study location. The study result founded that the traditional houses of the Sasak tribe were stronger in resisting earthquakes than the modern houses of the people at that time. However, this study by Munandar only focuses on the comparison of strengths but does not delve deeper into the capabilities that exist in these traditional dwellings so that they can withstand earthquakes.

The results of this research by Munandar (2018) are in line with the phenomenon of the traditional housing of the Sasak tribe, Bale Bayan, which did not collapse when the Lombok island earthquake occurred in 2018. The worst effect of the earthquake in 2018 occurred in the North Lombok region. Most of the houses in the community collapsed. Dusun Segenter in the North Lombok district also suffered severe damage to the residential areas of its residents. Modern housing in Dusun Segenter was damaged, while the traditional house was almost undamaged. This phenomenon shows that in the design and construction of Bale Bayan there are capabilities that can be further investigated with a role to enrich knowledge about traditional earthquake-resistant housing. Therefore, this phenomenon is also a strong impetus for research with a focus on the tectonic capabilities of traditional residential architecture in resisting earthquakes.

To find out how Bale Bayan did not collapse during the 2018 earthquake, further observations and analysis are needed. This study aims to identify the tectonic architecture of Bale Bayan and describe how the tectonic capabilities of Bale Bayan architecture withstand earthquakes. It is also formulated earthquake-resistant housing concepts adaptation for future housing development based on Bale Bayan architectural tectonics. The concept of earthquake-resistant housing adaptation based on Bale Bayan architectural tectonics can be an alternative for earthquake-resistant housing development in the future for the residents of Dusun Segenter.

II. Literature Review

Architectural tectonics is the processing of materials, structures, and constructions to carry out the main functions of the structure while providing aesthetic value to the building (Kapiwali, 2019). The origin of the word tectonic is the word tekton or tektonamai (Greek) which means carpenter or

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builder (Frampton in Sir, 2015). The use of architectural tectonics as a design expression has been widely practiced in Indonesia. The house was built by paying attention to the structure that was built by adjusting the contours of the land. The structure is then exposed to provide an aesthetic value to the building by relying on aspects of local craftsmanship.

In this modern era, the ability to withstand earthquakes is implemented in housing that is built by taking into account the rules and principles of earthquake-resistant housing. Earthquake-resistant housing is a dwelling that is built by taking into account the rules and principles of earthquake resistance, both structure, and material, and provides security for its residents when an earthquake occurs (Supriani, 2009). To build earthquake-resistant housing, several principles must be met. These principles include (Fitriani, 2014):

a. When a small-scale earthquake occurs, the structural and non-structural parts of the dwelling must not be damaged or destroyed.
b. When an earthquake of a moderate scale occurs, the structural part of the dwelling must not be damaged even though the non-structural part of the dwelling is damaged.
c. When a large-scale earthquake occurs, residents must have sufficient time for evacuation before the structural and non-structural parts of the shelter are damaged or destroyed.

The government also provides guidelines for the construction of earthquake-resistant housing. The guidelines are written in the guidelines for the Public Works Office of SNI 03-1726-2002 and the Procedure for Planning for Earthquake Resistance for RSNI T-02-2003 Buildings. The guidelines contain three main points, namely:

a. The floor plan used is simple and symmetrical.
b. The building materials used have the lightest possible load.
c. The construction system used in the construction must be adequate.

In addition to principles and guidelines, the construction of earthquake-resistant housing also needs to pay attention to the materials used. The materials used in the construction of earthquake-resistant shelters must meet several principles to give the right effect. These principles include (Siswanto, 2018):

a. The ratio between the strength and the load of the material must be large enough.
b. The material is capable of deformation.
c. The material has a low level of degradation.
d. Uniformity of strength and stiffness of the material.
e. Economical price.

III. Methodology

This research is context-led research. The case of earthquake resistance in the traditional house of the Sasak tribe in Dusun Segenter is the focus of this research. The observation object is Sasak Tribe traditional house called Bale Bayan. Aspects like the architectural tectonic form of Bale Bayan and the capability of Bale Bayan to withstand earthquakes were part of the observation. The strategy used in this research is a qualitative strategy with an ethnographic approach.

Data collection was carried out directly in the field using field observations and interviews with key persons. Field observations were done to collect data on architectural tectonic elements in the Bale Bayan. Architectural tectonic elements like elements that make up the floor-forming structures, structural elements that form walls, roof-forming structural elements, construction joints, and the materials used were observed. The data took in the form of photo documentation of observations and sketches.

The interview method purposed to obtain data related to the history and meaning of Bale Bayan by the community, Bale Bayan construction methods, related traditional activities, and the environment's ability to support Bale Bayan development. Interviewees selection using non-probability sampling method with a purposive sampling approach. This method is used to facilitate in choosing key persons according to the research information needs. Interviews were done with two key persons, namely the traditional leader of the Dusun Segenter and the Bayan customary holder in Bayan Beleq. This study also uses the literature study method to provide additional data needed regarding earthquake-resistant housing.

Data analysis was done using the qualitative data analysis method by Miles and Hubberman (1984). The analysis is divided into three stages, data reduction, data presentation, and data verification. The qualitative data is in the form of interview transcript data, written in alternating format between the questions and answers. Information collected is related to history and meaning, development methods, and traditional activities related to Bale Bayan development. These three pieces of information will become the domain of the respondent's answers. The interview transcripts were later reduced to core points and classified into their respective discussion domains. This qualitative data analysis facilitates the interpretation and discussion process by collecting information scattered on interview transcripts to similar discussion domains.

Discussion of the analysis results was done using an interpretive descriptive discussion method. In this process, the results of the interview transcripts analysis and field observations will be used to describe the tectonic capability of the Bale Bayan architecture to withstand earthquakes. The description of this capability is based on the researcher's interpretation of how the architectural tectonic of Bale Bayan works. The results of the capability interpretation are then compared with the earthquake resistance rules and principles to answers the questions of whether Bale Bayan was built based on an earthquake-resistant approach? Does Bale Bayan have the ability to withstand earthquakes? And can Bale Bayan be classified as a traditional house with architectural tectonic expressions that can withstand earthquakes? The concept of earthquake-resistant housing was then formulated based on the discussion and interpretation of Bale Bayan's tectonic architecture capabilities.

IV. Result

Bale Bayan is a traditional house of the Sasak tribe with a shape and structure unique to the Sasak tribe. Inside Bale Bayan is divided into three house sections, namely the floor of

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the building, the building envelope, and the roof of the building (Fig. 1). The room in Bale Bayan is divided into three physical rooms, namely sesirap, dalem bale, and inan bale (Fig. 2). Other spaces such as bedrooms, kitchens, and storage are only distinguished by function and furniture placement in Bale Bayan.

Sesirap is an area in front of the house that functions as a terrace, agricultural tools storage, and firewood storage. Dalem bale is the inner room of the house with the outer building envelope as the border. Inan bale is a room created inside Bale Bayan as the most sacred place for Bale Bayan. Inan bale is built on a platform located in the middle of the dalem bale (figure 2). Inan bale serves as a place to store the property and heirlooms of the owner of the house.

Fig. 1. Bale Bayan

In Bale Bayan, twenty-two architectural tectonic elements make up the bale. Each of these elements has special terms from the community (Fig. 3 and 4).

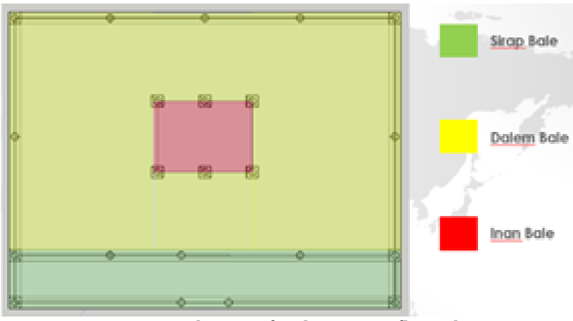

Fig. 2. Distribution of Bale Bayan's floor plans

These terms include:

- Bataran; rows of stones planted and emerging from the ground as high as 15 cm serves as column foundations and the base of the building envelope.
- Teken; intact wooden or bamboo beams serve as building columns.
- Belandar; Whole wooden beams function as ring beams and a resting place for the roof structure.
- Sangkauang; diagonal beams between the columns and the ring beams.
- Aton; 2 m long, solid wood beams for the outermost floor beams inan bale.
- Apit saka; 1.5 m long, solid wood beams for the outermost floor beams inan bale.
- Jejait; 1.5 – 2 m long, solid wood beams for the second layer of floor beams inan bale.
- Jelikar; 1.5 m long, wooden beams for the floor beams in the middle of the inan bale floor.
- Gegolok; 2 m long, whole bamboo for the floor mat inan bale.
- Malak; woven bamboo slats for inan bale flooring.
- Bedek; woven bamboo as a building envelope.
- Lampen; 2 – 2.5 m long, wooden beams for ring inan bale beams.
- Peratepan; 2.5 m long, wooden beam placed on an inan bale ring beam as the roof structure support.
- Karang Lamin; 2 m long, wooden beam placed on an inan bale ring beam as the roof structure support.
- Tunjang Langit; 1 – 1.5 m long, wooden beam, placed perpendicular to the ring inan bale beam as the base for the rooftop.
- Semboko; 2 m long, wooden beam at the top of the roof.
- Permetan; bamboo straps.
- Pemasek; pegs of wood or bamboo.
- Pager Goleng; woven bamboo as high as 1 m for the fence.
- Usuk-usuk; the Whole bamboo serves as a rib in the roof structure.
- Lidi; bamboo slats serve as battens in the roof structure.
- Sepeqan; reeds as a roof covering.

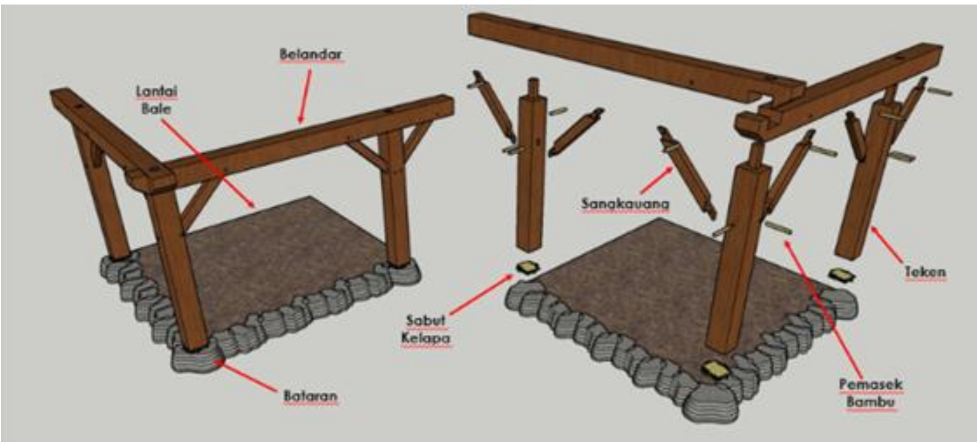

Fig. 3. Dalem bale architectural tectonics

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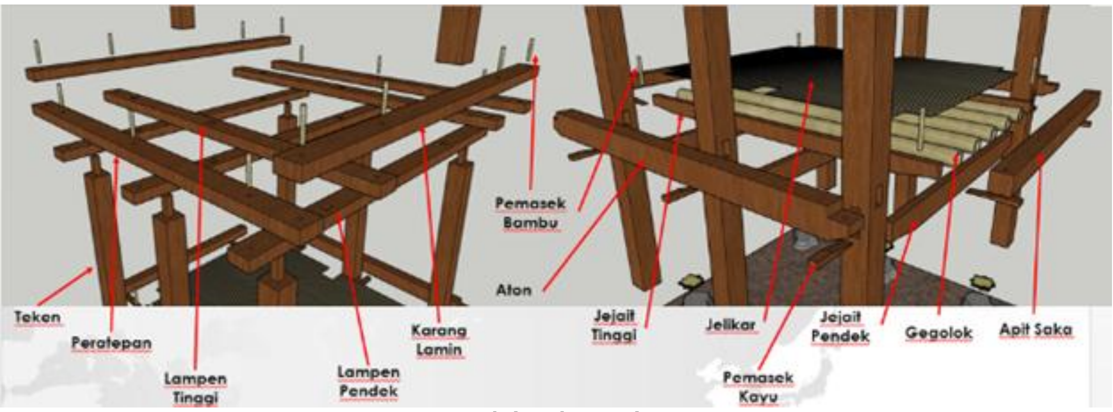

Fig. 4. Inan bale architectural tectonics


Fig. 5. Bataran and teken

The entire Bale Bayan floor measures 6m x 7m and uses soil as the floor material. On the outer side of the floorplan, the bataran is placed as teken's foundation and bedek base for the building envelope. Between the bataran and teken, a layer of coconut coir is given (Fig. 5). Inan bale's floor uses bamboo slats tied with permetan. These bamboo slats are called malak (Fig. 6) and tied on the floor beams of inan bale. The inan bale's floor is raised 1 m from the dalem bale's floor.

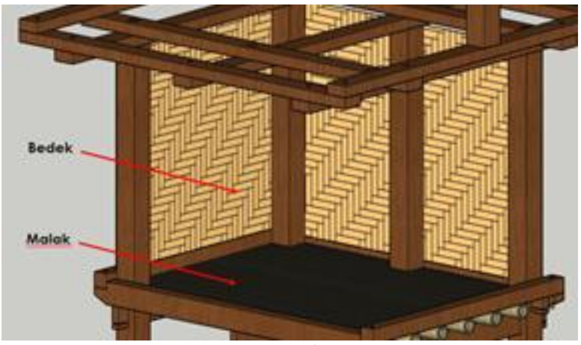

Fig. 6. Inside of inan bale

The building envelope structure of Bale Bayan uses a combination of teken, belandar, sangkauang, and pemasek. The teken and belandar are installed using the slot method and are bolted using a pemasek. The teken and the belandar are connected by a diagonal beam in the form of a sangkauang, which is also bolted at each end using a pemasek (Fig. 7). The Bale Bayan's building envelope uses a woven bamboo material called bedek. This woven bamboo is used for pager goleng, dalem bale walls, and inan bale walls. Pager goleng are made just 1 m high to cover the sesirap area. The dalem bale wall is made as high as 1.5 m high. Meanwhile, the walls of the inan bale are also made with bedek as high as 1.5 m. Bale Bayan building envelope material can last for a long period. According to the key person, Bale Bayan, which was used as the object of observation has never changed the building envelope material since it was first built.

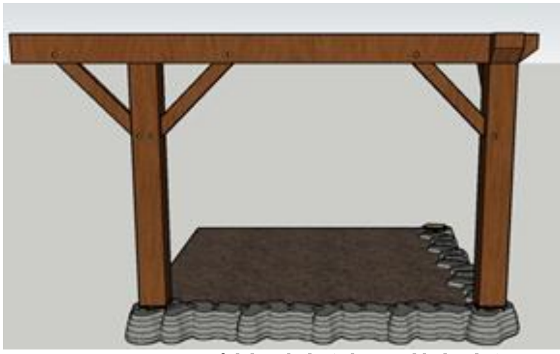
Fig. 7. Structure of dalem bale (teken and belandar)

Bale Bayan roof uses a pyramid roof. The material used is the whole bamboo as ribs and bamboo slats as battens. The roof structure was placed over belandar and fastened using permetan. The roof structure leads to the top of the roof called semboko. Roof covering materials used are dry reeds (re) bound using permetan through the menyepeq process. In the menyepeq process, the re are arranged horizontally and then tied to bamboo slats. The result of this menyepeq process is called sepeqan (Fig. 8). This sepeqan can last up to 10 years.


Fig. 8. Structure of Bale Bayan's roof

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The analysis results of interview transcripts and field observations found that Bale Bayan was not built with an earthquake-resistant approach or consideration. The use of materials, construction methods, and the meaning of Bale Bayan's design focus more on the link between Bale Bayan and the traditional activities of the Sasak tribe. In addition, the meaning by the community also focuses on the relationship between Bale Bayan and religious values. The selection and use of materials are based on the easiness of material obtaining from nature and the surrounding environment. Some material selection decisions are also based on the need to provide thermally comfortable shelter. The meaning and design consideration is then transformed into the architectural design and tectonics of Bale Bayan. Some examples of the manifestation of this meaning in the design include the number of columns, the selection of construction sites, the selection of materials used, the height of the roof, and the construction process of Bale Bayan.

The meaning that is expressed in the form of a design includes three main meanings. The first meaning is respect for the house and the owner of the house. This meaning is expressed in the design of roof height and the entrance size to the house. The second meaning is as a place to carry out daily activities and store property. The results of the hard work and prosperity of the homeowner must remain in the house. This meaning is implemented in the design by building a Bale Bayan with only one entry point. The third meaning is that the Sasak tribe people must be aware of any situation that can be dangerous in their environment. The implementation of this meaning can be seen from the selection of materials and the location of the kitchen inside the house.

In addition to traditional meanings, several meanings related to religion are also implemented in the Bale Bayan's design. Religious meanings are dominated by Islamic meanings and symbols. This religious meaning includes the number of teken, the location of construction, and the selection of materials. The number of teken on Bale Bayan adjusts to the number of rukun iman and rukun Islam. In addition to the number of teken, Bale Bayan was also should not be built on the same type of land for the houses of worship. Bale Bayan may not be built on Tanaq tiwoq. The term tanaq tiwoq is used for the location for the construction of houses of worship. It is also decided that the materials used in Bale Bayan should not match the materials used in houses of worship.

To cope with environmental conditions, the design determination of Bale Bayan also prioritizes the selection of materials that are suitable for the surrounding environment. One of the environmental problems in Dusun Segenter is thermal conditions. For this reason, the Sasak community in the Dusun Segenter uses a design solution in the form of a bedek wall as a cover for the Bale Bayan building. The use of the bedek provides a gap in the wall for air exchange.

From the results of the analysis of the meaning and purpose, it can be seen that Bale Bayan was not built with an earthquake-resistant approach in mind. Although there is no focus and approach to earthquake-resistant housing in the construction of Bale Bayan, the phenomenon of Bale Bayan not collapsing during the 2018 earthquake provides information that Bale Bayan can become earthquake-resistant housing. There are several possible reasons for not finding the meaning or purpose of earthquake resistance at Bale Bayan at this time. This lack of meaning and purpose can be caused by not properly transmitting information during the development process for the next generation. Several things that indicate this reason are the information from the interview that in continuing the ability to build bale, the younger generation is invited to participate in building Bale Bayan but it is not explained directly about the meaning and purpose of Bale Bayan architectural tectonics. Meaning and purpose are only expected to be passed down to the next generation through everyday life experiences. For this reason, in the interview process, the interviewees also carried out interpretations of Bale Bayan's methods and abilities to withstand earthquakes.

To produce a statement that Bale Bayan is classified as a house with earthquake-resistant capabilities, an interpretation, and discussion of Bale Bayan's capabilities is carried out. The results of the interpretation find that there are six earthquake-resistant capabilities of the Bale Bayan architecture tectonics based on earthquake-resistant rules and principles. These capabilities include simple floor plans, open plans concept, rigid but flexible construction systems, lightweight material choices, high material deformation capability, and economical materials.

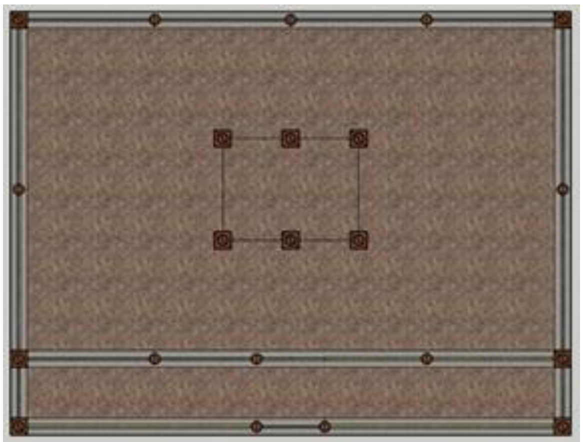

Fig. 9. Bale Bayan’s simple floor plan

In the context of earthquake-resistant buildings, a simple plan is a floor plan that is symmetrical and has a maximum width to length ratio of 1:2. The simple plan for Bale Bayan can be seen from the use of a square floor plan measuring 6 m x 7 m for the dalem bale and 2 m x 1.5 m for the inan bale (Fig. 9). The square plan minimizes the amount of bending and structural joints in Bale Bayan. Reducing the number of bends and structural joints will provide more consistent stiffness. The simplicity of this plan is also supported by the use of the open-plan concept or minimal partition. Bale Bayan plans are formed from the function of space only. There are no physical boundaries from the floor plan. The space boundaries are only formed based on the use of space such as the kitchen area. The kitchen area is marked by the presence of jangkih (earth stove) or the sleeping area which is marked by the

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presence of amben beleq. The lack of partition in Bale Bayan also contributes to the rigidity of Bale Bayan's structure. The concept of a simple floor plan which in this context means that it is symmetrical to the axis of the building and the ratio of maximum length to width is 1:2, and the concept of minimal partition with an open plan approach can be an earthquake-resistant adaptation concept.

Fig. 10. Reinforced structure of inan bale

Bale Bayan construction is rigid but flexible. The rigidity of Bale Bayan's structure stems from the lack of partition, resulted from the open plan concept on the floor plan. The rigidity of the Bale Bayan construction is also the result of the connection between the dalem bale construction and the inan bale construction. The inan bale structure is the most rigid construction of all Bale Bayan. Inan bale has an area of not less than $3m^2$ and several columns and beams reinforcing it. Inan bale is located in the middle of the dalem bale and can function as the core of the building (Fig. 10). The reuse of the inan bale concept in future houses does not have to be in the form of inan bale that already exists in Bale Bayan nowadays. The concept can be adapted by using several parts of the house structure that are reinforced as the core of the building. The rigidity of Bale Bayan's construction is further enriched by using sangkauang. Sangkauang functions as a diagonal beam, connecting the teken and the belandar. The use of sangkauang is seen as a wall bracing method, which increases the rigidity of the construction (Fig. 11). The concept of bracing the building envelope can be adapted through the use of a diagonal frame.

On the other hand, Bale Bayan's construction is also flexible. The flexibility of Bale Bayan construction is obtained from the use of bamboo pegs in construction joints. In addition, flexibility is also obtained from the teken that was not locked on the Bale Bayan foundation. This causes the entire Bale Bayan to move along with the vibrations when the earthquake occurs. This is intentionally done to give the Bale Bayan structure the freedom to move when a shock occurs. The addition of coconut coir (Fig. 11) between the teken and the bataran also contributes to dampening vibrations and structural loads during an earthquake. This separation of structures can be adapted to provide the same capability to future houses. This concept can be applied by using a local slab foundation, and the superstructure is built on a damper layer.

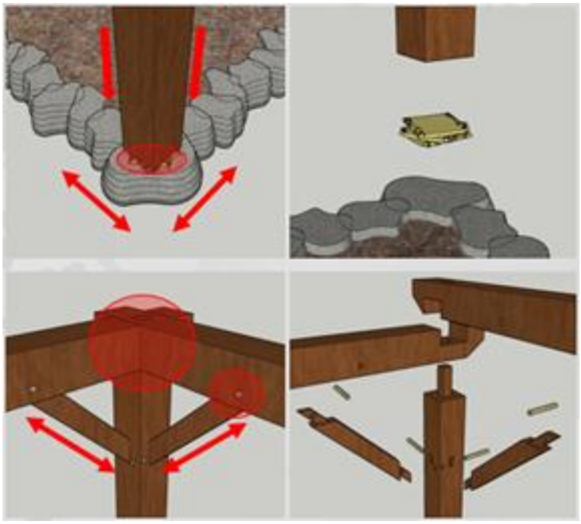

Fig. 11. Reinforcement of the building envelope structure

Bale Bayan's next earthquake-resistant ability is Bale Bayan's material. In the construction of Bale Bayan, the materials used are wood, bamboo, rattan, and reeds. Wood as a building material is lighter than materials that are widely used for modern housing such as masonry or reinforced concrete. This is following the load list for the type of material under construction. The density comparison of wood and masonry is 1000 kg/m3 compared to 1700 kg/m3. In conclusion, masonry has higher loads compared to wood material with the same area. In addition, wood, bamboo, and rattan materials have good deformation ability. So that when an earthquake occurs, these three materials can change and maintain their shape after the earthquake is over. Lastly, Bale Bayan building material is an economical material. The material is said to be an economical material because it can be found in the surrounding environment. In carrying out the construction of Bale Bayan, materials were taken directly from the surrounding environment. This makes Bale Bayan material easily replaceable in the event of a breakdown. The building concept that pays attention to the materials needs to be used to relieve the load borne by the structure during a shock. Reducing the load of this material has been widely carried out with examples of the use of wooden frames and multiplex or drywall as building envelopes.

From the discussion and interpretation above, it can be said that Bale Bayan can withstand earthquakes well. The ability to withstand earthquakes stored in Bale Bayan's

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architectural tectonics should be used as a good earthquake-resistant residential concept for the people of Dusun Segenter. To apply this adaptation concept in future construction, it is necessary to have a general formulation of the concept of earthquake resistance which is extracted from the tectonic capabilities of the Bale Bayan architecture. There are seven concepts formulated, such:

- A simple floor plan.
- Using the open-plan concept.
- Separation of substructure and superstructure.
- Added dampen layer between substructure and superstructure.
- Addition of bracing to the building envelope structure.
- Maintain or use the inan bale structure concept as the building core.
- Reducing material load used.

V. CONCLUSION

Bale Bayan is a traditional house of the Sasak tribe which is rich in meaning in its design. The rich meaning of Bale Bayan is also equipped with its ability to withstand earthquakes. This was proven when the earthquake occurred on Lombok island in 2018. Although not built with an earthquake-resistant residential approach, Bale Bayan managed to survive the earthquake disaster. In contrast to Bale Bayan, houses built with modern materials suffered severe damage when the earthquake occurred. Bale Bayan's ability to outperform this modern residence needs to be investigated further to obtain earthquake-resistant housing concepts that are suitable for the surrounding community.

From this research, several concepts of earthquake-resistant housing adaptation can be formulated which are extracted from Bale Bayan architectural tectonics. The concept of earthquake-resistant housing adaptation includes the form of a simple floor plan with an open plan concept, the separation of the substructure and the superstructure, the addition of a damping layer between the substructure and the superstructure, the addition of bracing to the building envelope structure, maintaining or using the inan bale structure concept as the building core, and reduce the load of the material used.

REFERENCES

[1] Fitriani, T., 2014. Analisis Bahan Bangunan Pada Daerah Rawan Gempa dan Tsunami Di Pesisir Pantai Teluk Palu. *Journal Teknik Sipil Dan Infrastruktur*, *4*(1).

[2] Hairumini, H., Setyowati, D.L. and Sanjoto, T.B., 2017. Kearifan Lokal Rumah Tradisional Aceh sebagai Warisan Budaya Untuk Mitigasi Bencana Gempa dan Tsunami. *Journal of Educational Social Studies*, *6*(1), pp.37-44.

[3] Huda, I.A.I.S., 2016. Bentuk-Bentuk Adaptasi Masyarakat Dalam Menghadapi Bencana Banjir (Studi Kasus di Desa Pelangwot Kecamatan Laren Lamongan)

[4] Kapilawi, Y.W., Nday, R.U. and Hardy, I.G.N.W., 2019. Kajian Tektonika Arsitektur Rumah Tradisional Sabu di Kampung Adat Namata. *GEWANG: Gerbang Wacana dan Rancang Arsitektur*, *1*(1), pp.8-13.

[5] Munandar, A., 2018. Analisis Fenomena Kerentanan Rumah Tradisional Masyarakat Kobe Dengan Rumah Tradisional Masyarakat Lombok Terhadap Bencana Gempa Bumi. *Mimbar: Jurnal Penelitian Sosial Dan Politik*, *7*(2), pp.5-11.

[6] Prasetyo, F., 2013. Manufacturing Genius loci of Indigenous Nias Architecture.

[7] Rinaldi, Z., Purwantiasning, A.W. and Nur'aini, R.D., 2015. Analisa Konstruksi Tahan Gempa Rumah Tradisional Suku Besemah di Kota Pagaralam Sumatera Selatan. *Prosiding Semnastek*.

[8] Sir, M.M., Wunas, S., Parung, H. and Patanduk, J., 2018, August. Tektonika Arsitektur Tongkonan Toraja (Tinjauan Sistem Struktur, Konstruksi dan Tektonika pada Bagian Sallu Banua, Kalle Banua dan Rattiang Banu*aton*gkonan). In *Prosiding SENTRA (Seminar Teknologi dan Rekayasa)* (No. 1).

[9] Siswanto, A.B., 2018. Kriteria Dasar Perencanaan Struktur Bangunan Tahan Gempa. *Jurnal Teknik Sipil*, *11*, pp.59-72.

[10] Supriani, F., 2009. Studi Mitigasi Gempa di Bengkulu dengan Membangun Rumah Tahan Gempa. *Inersia: Jurnal Teknik Sipil*, *1*(1), pp.8-15.

[11] https://www.ilmusipil.com/daftar-berat-jenis-atau-bobot-isi-material-bangunan (diakses 29 Juni 2021).

Lalu Nata Tresna Hadi, Purwanita Setijanti, and Vincentius Totok Noerwasito, "Traditional Architectural Tectonics Expression of Sasak Tribe as a Form of Earthquake-Resilient Housing Adaptation," *International Journal of Multidisciplinary Research and Publications (IJMRAP)*, Volume 4, Issue 2, pp. 46-52, 2021.