International Studies in Vernacular Architecture
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Lecture: 17
Learning Disaster Mitigation from the Vernacular

Hi everyone, welcome to international Studies on Vernacular Architecture. In this lecture, we are going to learn about Disaster Mitigation from Vernacular Architecture. We will begin with a context of disaster in the world generally and in Indonesia specifically, then I will show you how vernacular society responds to disaster. A lesson learned from Indonesia's vernacular architecture.

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Tectonic plates are gigantic segments of pieces of Earth's crust. Tectonic plates are not fixed, but move and when they come into contact, tectonic plates form either divergent transform or convergent boundaries. Such boundaries are highly susceptible to earthquake and volcanic eruptions. Tectonic plates are defined as major and minor plates depending on their size. The world consists of seven major tectonic plates, which cover nearly 95 percent of Earth's surface.

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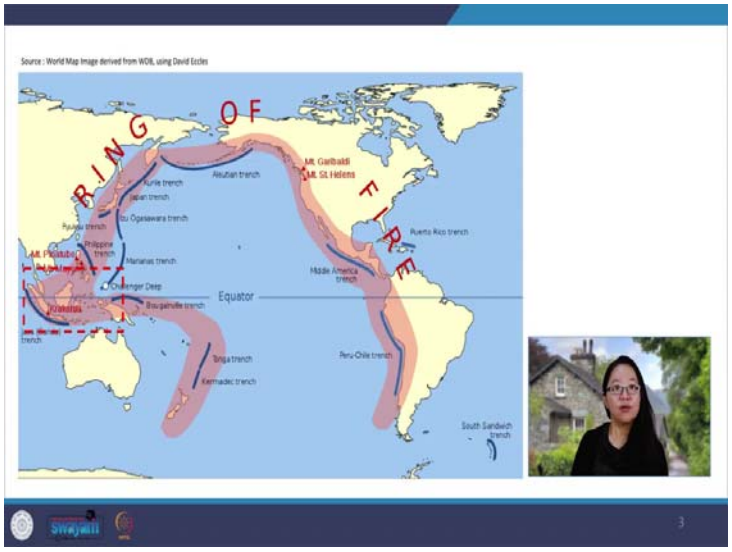

Ring of Fire is a seismically active belt of earthquake epicenters volcanoes and tectonic plate boundaries, spanning up to 40,000 kilometers from Pacific Island, Indonesian archipelago going to the north to the Philippines, Japan, and then to the western coast of North America and the Andes Mountain. Most of the world's earthquake and approximately 75 percent of world volcanoes occur within this Ring of Fire. Indonesian archipelago located in the Ring of Fire belt. These posts the islands constantly at risk of earthquake, landslide, floods and tsunamis and volcanic eruptions. One of the 12 World's largest volcanic eruptions is Mount Tambora on the northern coast of Sumbawa island, Indonesia. It exploded in 1851 and the eruption lasting up to 3 years.

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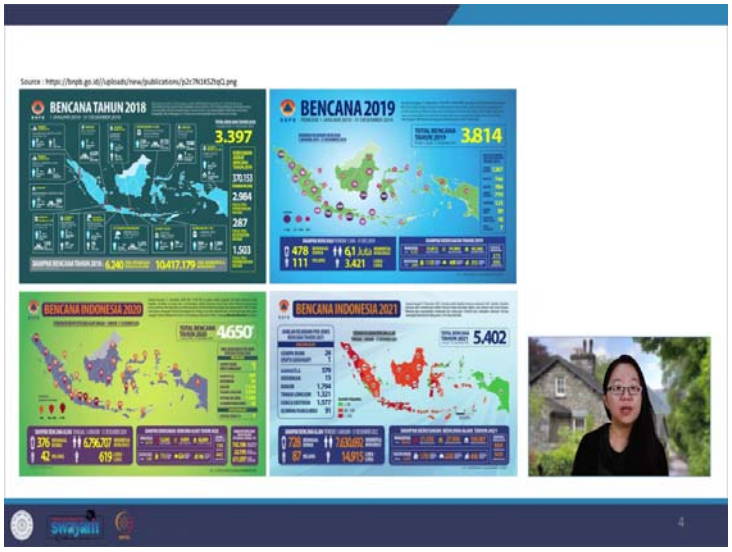

Many vernaculars society have learned how to live with natural environment including hazards. They have the knowledge of how to minimize disaster risk, and handed it down to the next generations. But rapid urbanization, industrialization and globalization, as well as the lack of awareness and documentation has made vernacular society forgot the vernacular knowledge of disaster mitigation. As a result, each year Indonesia's next National Disaster Management Agency recorded an increase of disaster 3800 in 2019, 4600 in 2020 and 5400 in 2021, with building damage up to 158,000.

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In this lecture, we will look at some knowledge of vernacular society in responding to natural hazards, especially earthquake, which occur in many forms song poetry and in the physical form of vernacular architecture. In Phang Nga province, there is an island in the West called similar island. They have warned people of the danger of tsunami, known as Smong in their language. The warning is distributed among themselves and is handed down to the younger generation in the form of poetry called Nandong. The poetry contain warnings as follows.

If the earthquake is strong, followed by low tide, hurry up and find a higher place. That is Smong and in Mentawai island where Sumatra province the warning of earthquake is handed down in the form of song lyrics. The earthquake is known as Teteu in their language. The song is about thunder, landslide and destruction.

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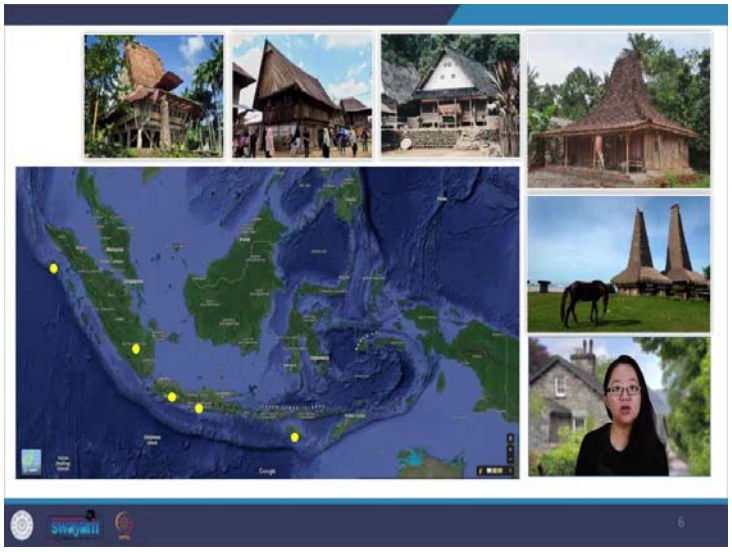

The knowledge of Disaster Mitigation also found in Indonesia vernacular architecture along the Ring of Fire Bell, the ones that will be discussed here is those of Mia's in North Sumatra, Baggy in South Sumatra, Sunda, Jaffa and Sumba.

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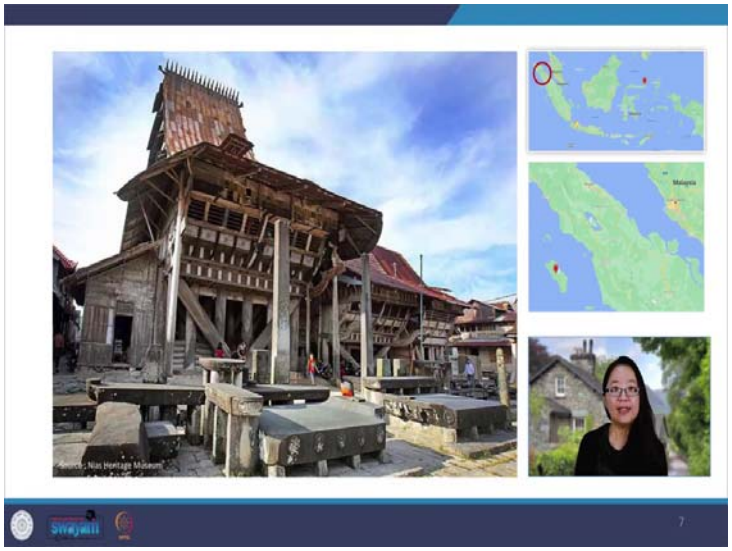

This island is located in between two plates, the Indian, Australian and Eurasian plates, so the island often experienced earthquake with a high magnitude from seismic data on March 2005, the island was affected by a devastating earthquake that caused many houses to collapse. And more than 1000 people died and thousands more were injured. But in the 2005 earthquake, Nias vernacular architecture is still standing strong considering the earthquake that was felt

by the community in the city is very high. This is of course related to the adaptation strategy of Nias community in dealing with the earthquake disaster.

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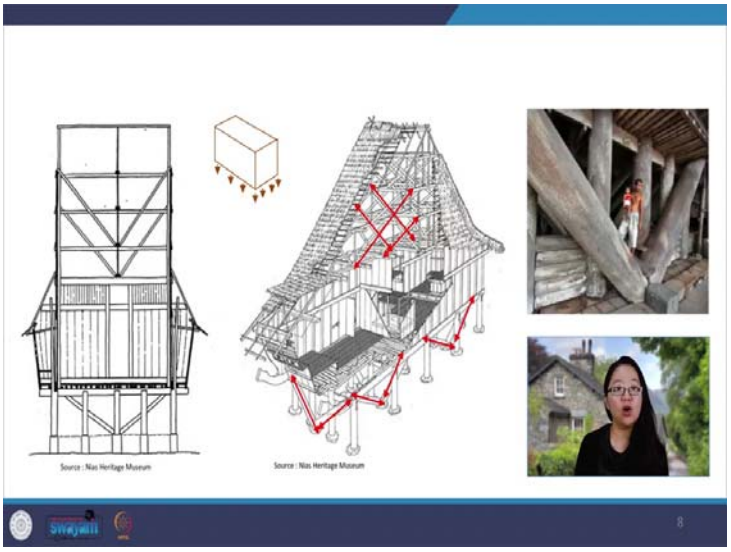

All Nias vernacular architecture are built on stilts with gigantic wooden pillars placed on top of a rock. The main structural system is like a box placed on top of the ground. So, the box itself has to be self supporting. Each structural component bounded in a way to form a unity. The bottom area of the pillars is strengthened by a diagonal support structures as bracing. This bracing support structure is also found in the top at the roof structure, the function of the support are to counteract the earthquake lateral forces.

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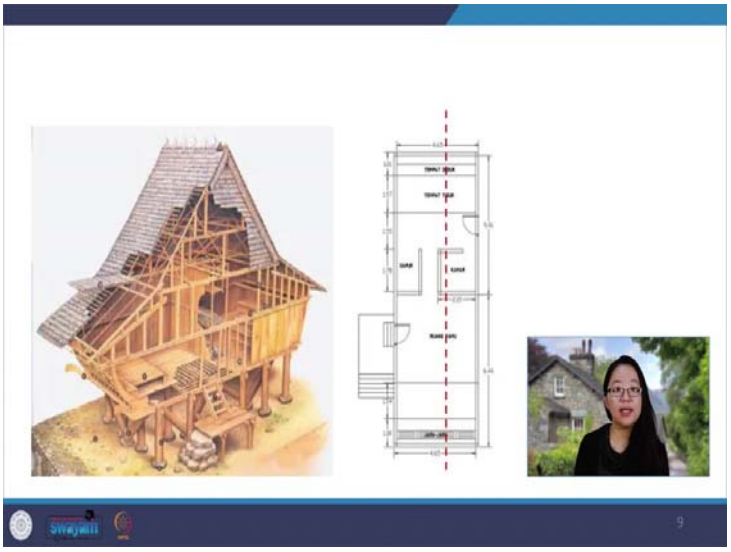

Nias vernacular house plan is symmetrical whether it is consciously or unconsciously, the symmetrical shape actually makes it easier to spread the load that occur in the building, both horizontally and vertically. The symmetry of this plan the overall shape, the structural and construction system makes the Nias vernacular architecture highly earthquake resistant.

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From the northern part, now we look at South Sumatra, which is located close to the subduction zone precisely along the southwest side. So, the area is also a high-risk area to disaster. The seismic condition of South Sumatra are influenced by the activity of collision of two plates, also the Indian Australian ocean plate and Eurasian plate. In the southern part of Sumatra, there is a Bugis vernacular house. It is a rectangular wooden house on stilts, different from their neighbor, the Nias people who use these diagonal bracings in the bottom.

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Bugis house mitigate earthquake by creating flexible building behavior against the direction of the earthquake force. The concept of box with a wood top down system without nails is used in bugis house. The box used to be square, 6 x 6 meters, 7 x 7 meters or 8 x 8 meters with a symmetrical columns structure configuration, but nowadays, there was an addition to the house form such as upper terrace or room addition at the back.

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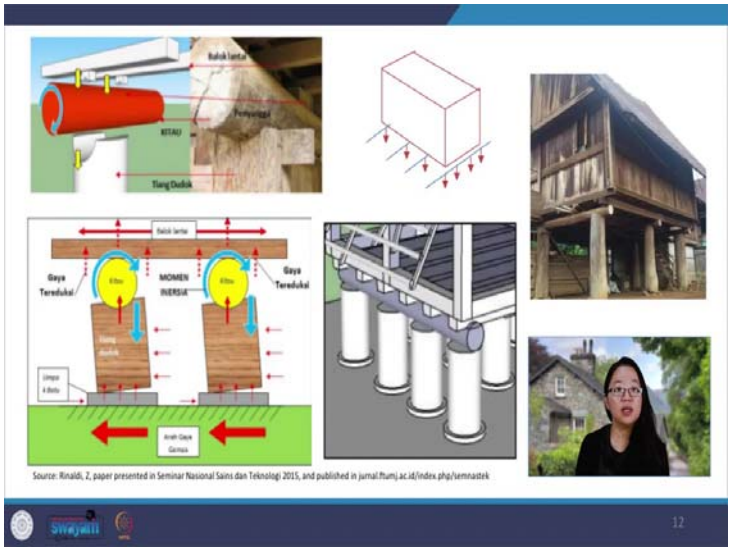

The most essential part is in the kitau. The horizontal beams connecting the box and the pillars below the connection the kitau is a roller pedestal function to reduce earthquake forces. Another unique feature of this house is that they do not use solid rock. Instead, they use crushed stone or cobblestone compiled and slightly immerse into soil as foundation of the

house. This creates a certain elasticity for the house when earthquake happen that each structural element plays a role in maintaining the position of other elements allowing the structure to move simultaneously.

When vibration occurs, the roller function to reduce a force which will rotate on the holder so that vibration reaching the upper structure will be reduced. The lightweight upper structure will then make it easier for this mechanism to work. This means that bugis house has fulfilled the principles of elasticity in earthquake resistance construction. It is interesting to note that these vernacular society have known roller support system long before the technology is developed. Nowadays, the roller pedestal is commonly used in bridge construction to create elastic joinery, which functions as an earthquake reducing agent.

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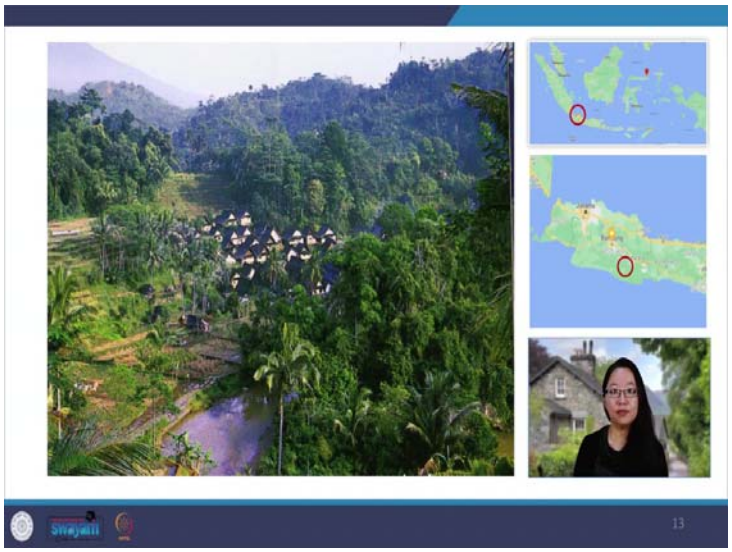

From Sumatra, we move to the island of Jaffa, which is located adjacent to the actives arc subduction zone precisely on the south side of the island. So, the area on the south side of the island will often be shaken by earthquake and landslides. One of the area of the South is where the Sudanese community reside. We will look at an old vernacular village called Kampung Naga that still exists today.

They are able to maintain their unique culture until now. The village is located in the valley. It is close to the main road connecting West Jaffa and Central Jaffa, so the road is quite busy. To reach Kampung Naga from the main road, one must go down hundreds of stairs, which also means to get to the main road one must go up hundreds of stairs.

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As you can see in the picture, the village is located in the middle between river and mountain is left and right is rice field. This location is specific to the Sundanese culture. They believe mountain is where God resides. It is also the future life after death and heaven. While the river what is water, it is evil, death, hell and lots of bad spirits were in the middle is where human live. The house is lying towards the water in accordance to the contours of the land. The Sundanese ideology, respect nature and wants to live in harmony with nature. They have a rule that related to the capacity of the ground to accommodate human activity, meaning they restrict the number of the house and people that can live in the village.

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They also have a unique recycling food culture. It is a closed cycle so there is very little waste. Sundanese are rice farmers. After harvesting rice, the unhulled rice is pounded at saung lisung, the bran is thrown into the pond. The fish consumed waste from saung lisung and toilets as we can see in the picture. Saung lisung and toilets are built on the pond. The villagers caught and eat the fish when the villagers use toilet the fish then consume human waste. So, the cycle is a simple method of recycling similar to that in current technology.

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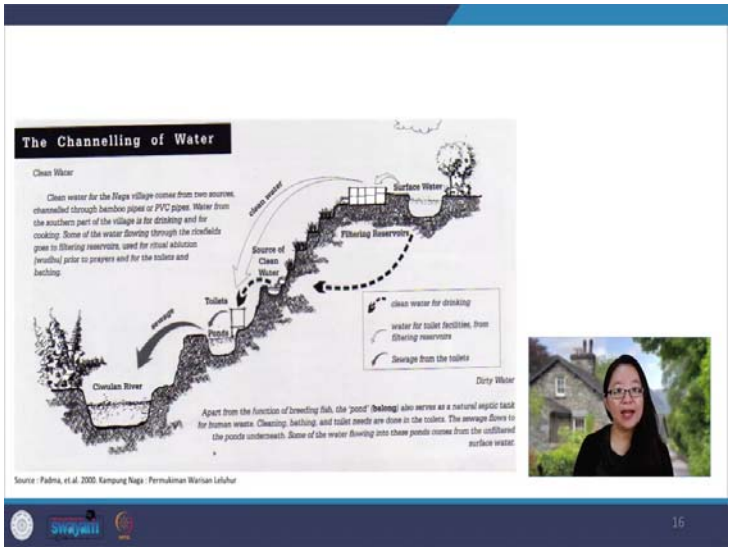

And the other interesting thing about Kampung Naga village is how they channel water. Clean water from the Naga village come a channel through bamboo pipes. Water from the southern part of the village is for drinking and cooking. Some of the water flowing through the rice field goes to filtering process used for ritual ablution or wudhu prior to Islamic prayers and for toilet and bathing.

Apart from the function of breeding fish, the pond also serve as natural septic tank for human ways. Cleaning, bathing and toilet needs are done in the toilets. The sewage flows to the pond underneath. Some of the water flowing into these ponds also comes from the unfiltered surface water.

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This thinking sustained environment from landslide, climate change and reduce the impact of natural hazards. In the sense, this ideology related to sustainable thinking. For the earthquake the sundanese houses are lightweight. The walls are thin made from bamboo weaves and thin woods. The concept of box also present in this village. The box is placed on top of stone there are no stilts.

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The lightweight house box can be moved to another place as you can see in the picture. The moving of the house is a Gotong Royong process. Villagers come together so the structure of the box is in unity. When the earthquake happened the house can shake more freely in

different direction. In this sense, the sundanese vernacular architecture of Kampung Naga is highly disaster resistant.

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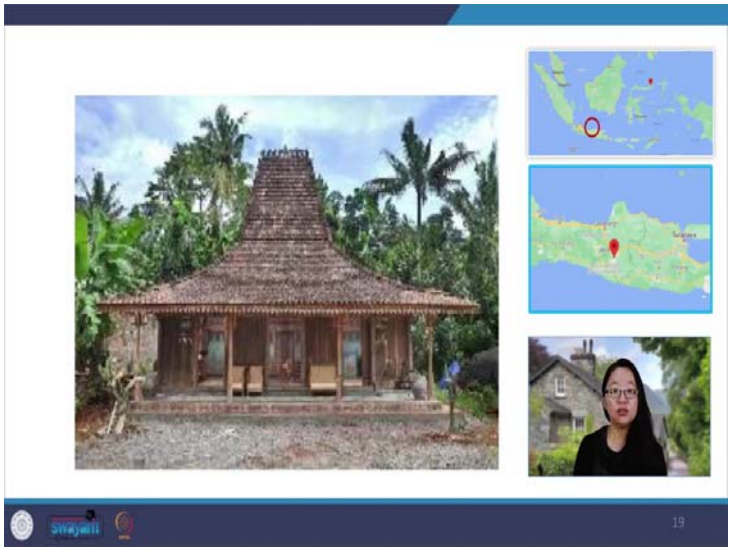

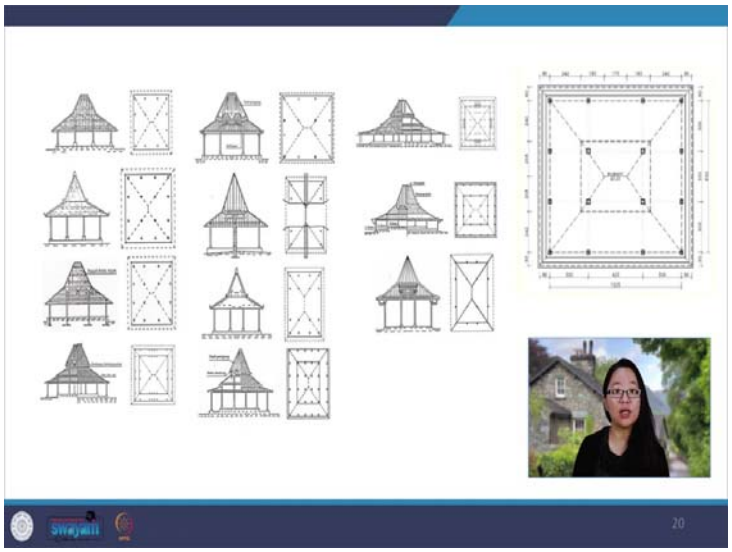

The Sundanese neighbor the Javanses people has a different response to earthquake. The response is apparent in joglo house type it is a rectangular wooden house type with tower like roofs. Joglo is commonly used in Central Jaffa, there are many variety of roofs shape and dimension. One of them is called limasan which we will discuss further towards the end of the lecture. But all joglo variants have a common structural system the plans are square or rectangular. The main structure is very specific which start from the middle of four main column called soko guru expanded to the left, right, front and back.

The soko guru is bound by double beam on top, usually highly decorated called Tumpang Sari. The weight of the double beams strengthen joglo structure. The structure of the pillar that surrounds soko guru called saka parang follows the main symmetrical structural system. Saka parang has more than a smaller dimension than soko guru serve and serves as pedestal beam pedestal that support the additional roof structure.

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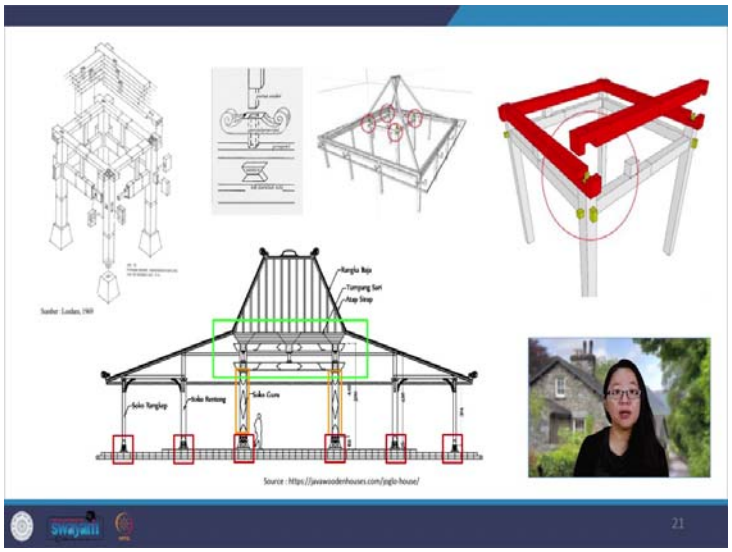

The connection system at the bottom of the main structure between soko guru and the ground called tumpang which act as insulating base for the structure above it and also functions to reduce earthquake vibration in the soko guru. Tumpang has a trapezoid form made of stone or cement. Tumpang foundation is slightly submerge to withstand the shearing force. Then the top is given a hole the size of soko guru dimension. The connection system at the top of the main structure between soko guru, the beam and the roof is a knockdown system with complex three axis X, Y, Z connection that blocks each other.

The connection makes the roof act as a counterweight pendulum, so when the, so the building can remain stable when receiving earthquake force. The flexible building behavior of soko guru and tumpang act as a lateral load bearing system arranged symmetrically. The four pillars the soko guru will bear the same balance vertical and horizontal loads to reduce the effect of torsion caused by unbalanced loading when the building receive earthquake forces. This means that joglo vernacular house is an earthquake resistant building.

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The island of Sumba is last example discussed in this lecture. Because of its location, the island is a high-risk earthquake zone. In the case of Sumba vernacular architecture, tower like roof shape is similar to that of joglo. However, the structural system is completely different.

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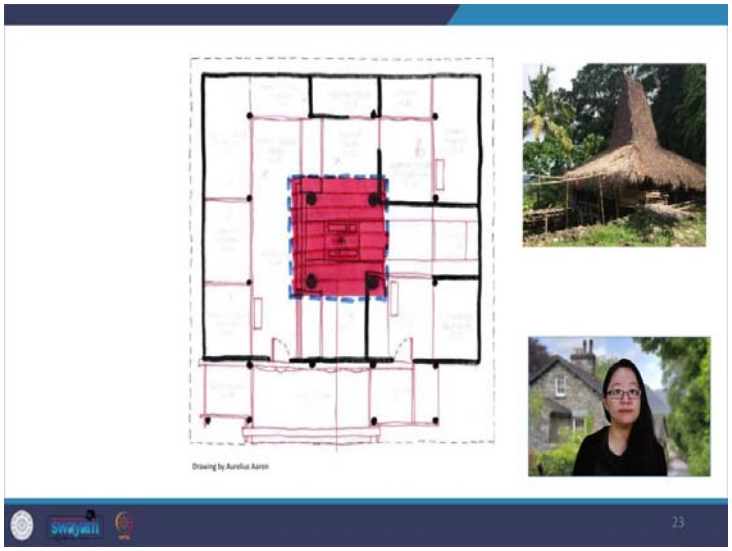

The house is on stilts, the house plan is also square or rectangular with four main columns or pillar. In the middle of the four main wooden pillar, there is a hearth that has to be lived when there is people inside the house.

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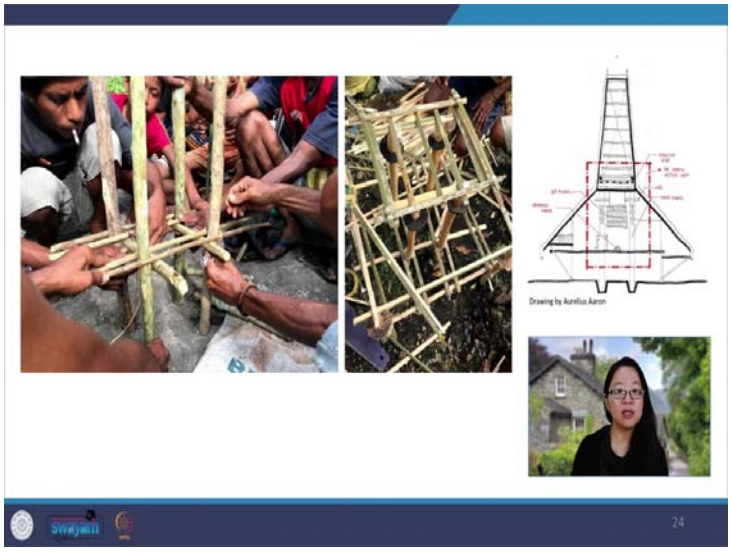

The picture shown here is the Sumbanese community in Wee Levo village demonstrating the construction of the house through a model. The four main column or pillars are planted one meter below the ground, while the other pillars are placed on top of stone. The construction process begins from the center from the four main pillars. From there, the beams for the floor are made and then ceiling on top of the pillars are made to hang foot and separate objects. It is important to note that the ceilings are only placed on top of the pillar without joinery. The Wee Levo villagers believe that the main pillars have to be pure, free from any kind of wood joinery.

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From the ceiling, the tower like roof structure is erected. It is important to note that all wood joinery is flexible. There are no mortise tenon join, on the left join bound by rope. The way they knot the rope depends on where and which building components are tied. So, there are at least four knot types with three different rope materials rattan, coconut husk and jungle roots.

The roof is itself is like a head placed on top of the building. The roof then tied by rope made of a weave coconut husk only at the edge or fringe of the house all way around. In this sense, the joinery, the knot and the pillars that is buried one meters in the ground, create a unique building responds to earthquake, the house can shake in different direction, but it is still tied to the ground and is still tied by the knot. This demonstration made it clear that the main reason Sumba vernacular house is earthquake resistant. It is because the way it is constructed.

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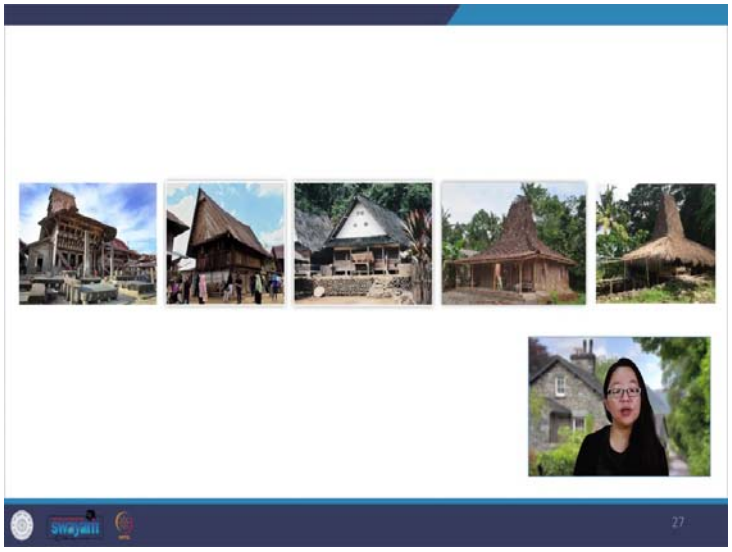

So, if we look at the example of vernacular architecture above, we can conclude two basic principles that makes the Nias, Bugis, Sunda, Jaffa and Sumba vernacular architecture, highly earthquake resistant. The principles are a symmetrical plan of the house and a flexible building behavior in responding to the forces of earthquake.

This is done in varied ways. But we have to see the building behavior as a whole, to understand how it is stand against the forces of earthquake. We have also learned several knowledge of Disaster Mitigation from vernacular society that which takes the form of poetry, song and ideology about how they maintain their environment.

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So, what can we do after we learn Disaster Mitigation from vernacular architecture? Here is an example of the role of architect in post disaster reconstruction and why the people in Yogyakarta region shifted from modern house using brick back to limasan type house in post disaster reconstruction.

On May 2006, an earthquake hit Indonesia in the region of Yogyakarta, in the southeastern portion of central Jaffa, the village of Nijmegen, located less than 10 kilometers from the quake's epicenter was destroyed. More than 5000 people died, and more than 140,000 homes in the immediate region were damaged. Due to the village location post disaster aid is low.

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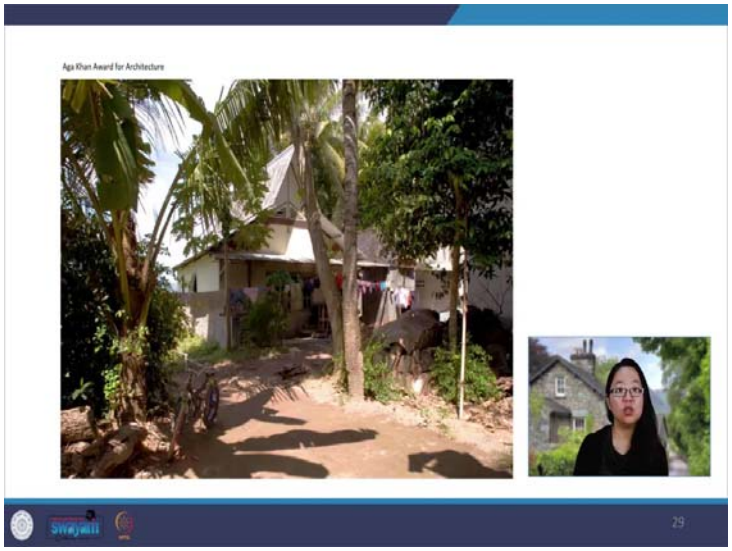

So, Eko Prawoto an architect, artist and educator, takes the initiative to help the villagers. His mission was not only rebuilding the house, but also rebuilding the community. He saw the wooden vernacular house of limasan a variant of joglo strength stronger against earthquake than the modern brick house.

So, his design input is to make a modified within limasan structural system. The modification aim at faster rebuilding process. So, after explaining the design and discussion with the villagers and with financial assistance from local newspaper, the villagers of the Ngibikan led by community leader Mariano reconstructed 65 homes in less than 90 days. The new homes are based on vernacular building type the limasan house with innovative modification to keep wooden structures lightweight, but at the same time resistant to future earthquake.

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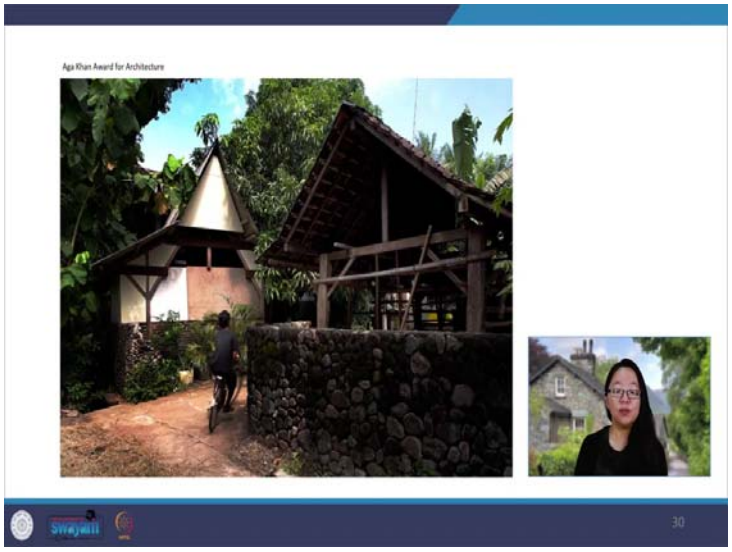

The community rebuild the physical fabric of their environment, which in turn, helped to rebuild gotong royong or togetherness in this agrarian village. As such, the Ngibikan village, reconstruction provides an alternative model for post disaster reconstruction projects that demonstrate the enormous positive impact of a grass root rebuilding process. This project is shortlisted in the Aga Khan award for architecture.

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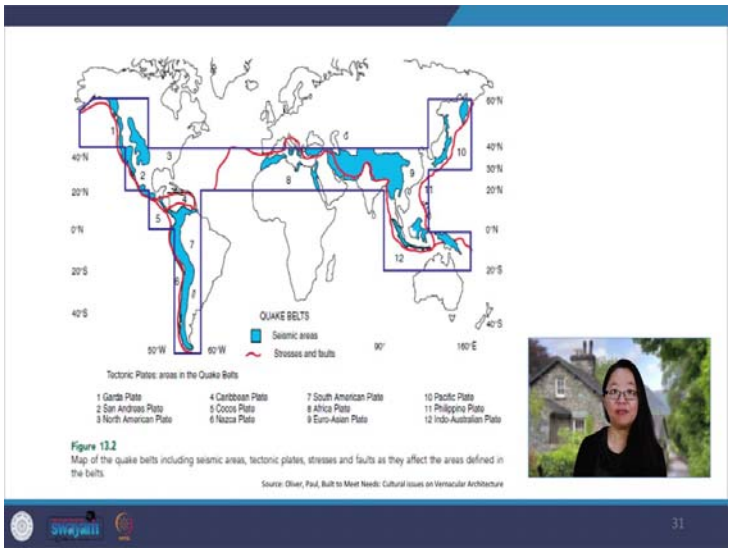

We have come to the end of this lecture. Throughout the lecture, we have discussed the context of disaster, how vernacular society mitigate disaster embedded in their culture, ideology and vernacular architecture. And we have also seen the examples of a post disaster reconstruction project. Hopefully, this lecture can inspire all of us to have a deeper look at

disaster mitigation knowledge from vernacular society, all over the world and take on the role of architects in rebuilding architecture after disaster with a respect of vernacular tradition. The example shown here is multiple research done in collaboration with many people, the vernacular community of Wee Levo and Kampung Naga, Construye Identidad of Peru, Marianne Trauten, Justin Coupertino Umbu, Arsitektur Hijau, Pele Widjaya, Takeuchi Ken and students of architecture Aurelius Aron, Gabrielle Mark Heybert Malangkay, and Jovita Christy.

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Here are some references of the lecture that you might be interested to look further. Thank you. See you in the next lecture.