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The First International Conference in Engineering and Technology Development




Universitas Bandar Lampung
20 - 21, June 2012
Lampung, Indonesia

PREFACE

The activities of the International Conference is in line and very appropriate with the vision and mission of the UBL to promote training and education as well as research in these areas.

On behave of the First International Conference of Engineering and Technology Development (ICETD 2012) organizing committee; we are very pleased with the very good responses especially from the keynote speakers and from the participants. It is noteworthy to point out that about 45 technical papers were received for this conference

The participants of conference come from many well known universities, among others: Universitas Bandar Lampung, International Islamic University Malaysia, University Malaysia Trengganu, Nanyang Technological University, Curtin University of Technology Australia, University Putra Malaysia, Jamal Mohamed College India, ITB, Mercu Buana University, National University Malaysia, Surya Institute Jakarta, Diponogoro University, Unila, Universitas Malahayati, University Pelita Harapan, STIMIK Kristen Newmann, BPPT Lampung, Nurtanio University Bandung, STIMIK Tarakanita, University Sultan Ageng Tirtayasa, and Pelita Bangsa.

I would like to express my deepest gratitude to the International Advisory Board members, sponsors and also welcome to all keynote speakers and all participants. I am also grateful to all organizing committee and all of the reviewers which contribute to the high standard of the conference. Also I would like to express my deepest gratitude to the Rector which give us endless support to these activities, such that the conference can be administrated on time.

Bandar Lampung, 20 Juni 2012

Mustofa Usman, Ph.D
ICETD Chairman

 ISSN 2301-4

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Bandar Lampung,Indonesia
June, 20-21 2012

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Universitas Bandar Lampung
Faculty od Engineering and Faculty of Computer Science

Earthquake Resistant House Building Structure

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Abstract— ***Earthquakes are unpredictable when it comes so anticipation is needed as early as possible. One way to anticipate earthquakes is to design buildings or houses that are resistant to earthquakes. After a small earthquake, the building must still be able to fully functional within a short time and repairing costs are not expensive. After a medium earthquake, the building can function again after repairing and strengthening of the main parts of the structure is completed. Meanwhile, after a major earthquake, the building may no longer can be used but the occupants of the building can be saved and the items inside the building can be protected. Any additional security value of a house requires adequate additional cost. Security value is not simply a house that is free from thieves, but natural disturbances such as floods, earthquakes, tsunamis, hurricanes and others. But all of those values are fair price for the security and comfort.***

***Keywords*—earthquake, housing, safety, comfort, structure of building construction**

I. INTRODUCTION

Earthquakes are unpredictable when it comes so anticipation is needed as early as possible. One way to anticipate earthquakes is to design buildings or houses that are resistant to earthquakes.

After a small earthquake, the building must still be able to fully functional within a short time and repairing costs are not expensive. After a medium earthquake, the building can function again after repairing and strengthening of the main parts of the structure is completed. Meanwhile, after a major earthquake, the building may no longer can be used but the occupants of the building can be saved and the items inside the building can be protected.

Definition of structure in relation to the buildings is that the structure is a means to distribute the load resulting from the usage or presence of buildings on the land.

The Function of the residence is a place to rest and shelter, so the house should be able to meet those needs. Any additional security value to a house requires adequate additional costs. Security value is not simply a house that is free from thieves, but natural disturbances such as floods, earthquakes, tsunamis, hurricanes and other factors.

- What are the impacts of earthquake on the residence?
- What are the causes of earthquake-prone house?
- How is earthquake-prone house construction?
- How is anti earthquake house building construction?

Building a house needs quite a bit cost and need not be at once, but it can be done in several stages according to the capability of each owner. And those are fair price for the security and comfort.

There are many books that discuss the techniques to build a building which is resistant to earthquakes, but in reality those book are directed only to the civil engineers (constructors) so it is difficult to be understood, especially for beginners. Basically those books present the science of building techniques that are not for simple buildings.

Recently in mass media, both electronic and printed, there were news about the earthquake that hit several regions in Indonesia. Its impact is significantly influenced the socio ¬ economic community so designated as a national disaster.

Definition of Earthquake

Earthquake is a vibration in the ground caused by earth's surface movement. This movement can cause damage to buildings, bridges, roads, housings, and up to land surface changes, and even resulted in the loss of many lives. Earth's surface is formed from the outermost layer rocks called the earth's crust.

The earth's crust is made up of nickel and iron with solid section in the middle. Crust thickness can reach 70 km.

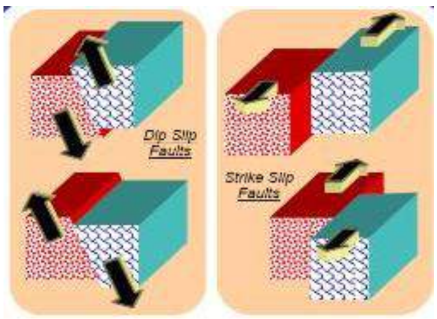

Fig. 1 Image of the Shifting of Earth That Cause Earthquakes
Sources: Website Earthquakes and Earth's Layers

Most of the earthquakes come from the earth's crust which is not far from underground. The broken Earth's crust form large pieces in pairs. Those pieces are called plates. Collision between two plates causes one plate be pushed to the bottom.

Usually the oceanic plate in the sea hits the continental shelf which is thinner on the ground. Oceanic plates that are falling and rubbing with its upper plates cause earthquakes and tsunamis.

On other occasions, when the plates that form Earth's crust move and jostle each other will cause enormous stress, even to break the rock. The place was called a rock burst fracture (fault) and the flow from the rock fragments called fault line. A major fault line can reach the rocks underground and stretch across the continent. The biggest fault line in the world is the same as the world's strongest earthquake and can be found near the edge of the plate.

Several major faults divide the land when it moves, pushing up the land or make it disappear. After the earthquake, when the energy is released, a collection of rocks on both sides of the fault is locked into one new position.

Pressures and stresses that cause the first earthquake are often happen and continue to grow and cause another earthquake. Each year recorded small earthquakes as much as 11 million times, and strong earthquakes as much as 34 000 times. In addition to on the land earthquake, at sea there are also marine seismic.

This earthquake can cause tsunamis, or giant waves that can sweep the oceans and continents. In the Japanese language, tsunami means harbor wave. It is called so because of its destruction power can be seen only when the wave arrived at the harbor or beach. This wave is known as seismic sea waves. Marine seismic which shakes the ocean causes water shock on it.

In the open ocean, tsunami waves move very fast and can reach speeds of 500-1000 km per hour. Once it starts approaching the shore or more shallow areas, the speed will decrease. The height of the waves in the sea is only 30 cm. Then when it is closer to the shore, the wave heights will rise. The tsunami in Aceh, the wave height reaches 36 m. The greatest tsunami wave occurred in Japan in 1771 where its heights reached 85 m.

Tsunami Formation Process

1. The sea floor plate fracture occurred so that the seawater recede because they are attracted to the fracture.

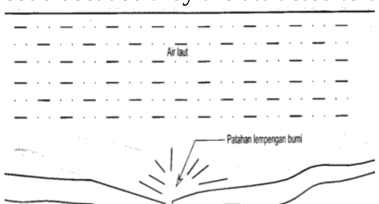

Fig. 2 Sea floor plate fracture
Sources: Mistra, Building Earthquake Resistant Houses

2. Receding seawater near the shore because it is attracted into the sea floor plate fracture.

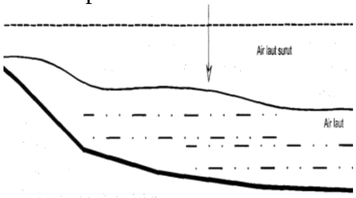

Fig.3 Retreat of the seawater
Sources: Mistra, Building Earthquake Resistant Houses

3. Seawater around the fracture is also flow toward the fault, but the decline in sea level are not visible.

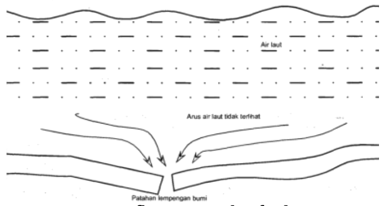

Fig. 4 Water flows into the fault
Sources: Mistra, Building Earthquake Resistant Houses

4. Collision occurred at two different currents meeting at fault.

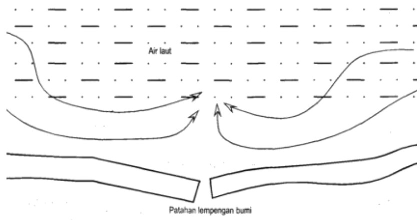

Fig. 4 The collision flow at the fault
Sources: Mistra, Building Earthquake Resistant Houses

5. A strong wave to the beach appeared. This happens because the pressure waves from the center are larger and accompanied by earthquake waves.

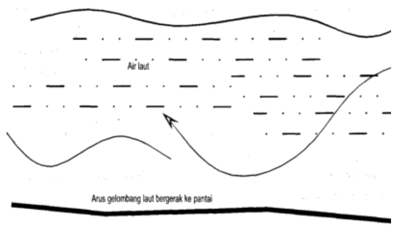

Fig. 5 The ocean wave's current leads to the beach
Sources: Mistra, Building Earthquake Resistant Houses

6. Wave's height depends on the magnitude of the earthquake in the sea and the wave's influence is not very powerful because of the high is only 30 cm to 1 m.

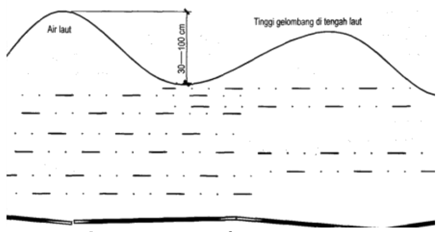

Fig. 6 The occurrence of sea waves
Sources: Mistra, Building Earthquake Resistant Houses

7. The wave begins to propagate to the beach along the ocean floor to the mainland with a permanent wave height.

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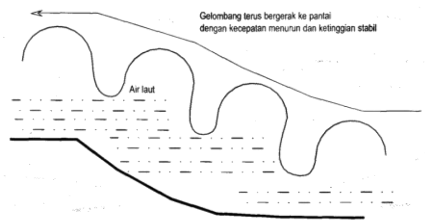

Fig. 6 The flow of the wave continues to move to the beach
Sources: Mistra, Building Earthquake Resistant Houses

Types of Earthquake

Earthquakes generally make the ground moves. If the epicenter was close to the settlement, there would be damage to buildings in the area. Conversely, if the epicenter was far from the settlements, the effect is only minor tremors, and sometimes there is no vibration perceived. The existence of propagation of seismic vibrations in the vertical or horizontal and as well as large or small impact on the building damage is more influenced by the soil condition itself, such as soil thickness, hardness or softness of the soil surface, and soil properties and geological conditions of the land (geological setting).

There are three conditions or characteristics of the soil, it can be concluded that the propagation or spread of the earthquake is a very complex event. Soil can increase or decrease the motion of earthquake waves. Soil conditions under the ground can also determine the extent of damage, which is not only depending on the amount recorded on the Richter scale. If the soil layer below is very hard, predictable existence of an earthquake of 5.9 on the Richter scale and caused major damage due to hard soil will continue and even increase the tremor, an example of the earthquake in Yogyakarta and Central Java. However, if the bottom of the soil is soft, the earthquake will not cause damage. Few months after earthquake in Yogyakarta, an earthquake shook Jakarta on the strength of 6.2 on the Richter scale, but there was no damage. There was just panic. This was due to the part of the earthquake vibrations were absorbed by the soft soil. In addition to soil characteristics, which also enlarge or reduce the vibration is radius of the earthquake epicenter. The closer to the epicenter, the vibration is bigger. In addition to moving horizontally, there is also a quake that moves up and down. It occurred in an earthquake in Kobe, Japan, January 17, 1995.

There are two types of Earthquake known by the experts:
- Tectonic earthquake.
- Volcanic earthquakes.

Tectonic earthquake

In the earth's crust, geological processes are constantly going on resulted in a concentrated and bridled stresses and strain-strain in geological time that will result in changes of the mountains formation. If this condition increased beyond crust limit strength, there was a long shifts in the weakest areas of the so-called slab fracture (fault) or shifting blocks of rock to find a new balance. Tectonic earthquake have a large wave and occur repeatedly and cannot be predicted when it will happen.

Volcanic earthquakes

When a volcano erupts, the eruptions can "drain" waves that can be recorded by seismographs. If the eruption is terrific, the movement or vibration can be felt immediately. Volcanic earthquake is local and has weak vibrations. This is due to the most energy released in the form of an explosion. So, generally the earthquake that causes the damage is tectonic earthquake. Volcanic earthquake can occur repeatedly in a day or even within hours. The intensity of wave's vibration is not big so it does not cause severe damage to buildings. Volcanic earthquake waves are still predictable when it will happen.

There are two types of earthquake waves known by scientists:
- Primary wave.
- Secondary waves.

Primary wave

Primary wave is a wave that arrives first at the earth's surface. This wave propagates longitudinally, just like sound waves, which spread as it solidifies and expands, but does not rotate. Primary wave's speed is from 4.3 to 8.6 miles per second.

Secondary waves

Secondary waves arrive at the earth's surface after the primary waves arrive. This wave propagates in the transverse and the particles spread in the direction perpendicular to the direction of wave spreading. This wave propagates slower than the primary wave, but emits more energy. Wave speeds are at average 2/3 times the speed of primary wave.

Earthquake Intensity

Intensity scale is based on human observation to the degree of damage caused by earthquakes on buildings. Seismology experts measure vibration magnitude on Richter scale (full Charles F. Richter). This unit becomes guidance the general public to know large-small of earthquake vibration. Richter has created a system of measurement magnitude and extent of the damage.

TABEL 1
LIST OF EARTHQUAKE INTENSITY ON THE RICHTER SCALE.

No	Power	Note	Average/year	Epicenter Intensity
1	0-1,9	-	700.000	Recorded, not felt
2	2-2,9	-	300.000	Recorded, not felt
3	3-3,9	small	40.000	Felt by some people
4	4-4,9	light	6.200	Felt by many people
5	5-5,9	medium	800	Bit damaging
6	6-6,9	Strong	120	Damaging
7	7-7,9	Major	18	Very damaged
8	8-8,9	Tremendous	1 in 10-20	Destroying

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			year	

Sources: Mistra, Building Earthquake Resistant Houses

For construction experts, what is considered to affect the construction of the building is earthquake intensity. The earthquake intensity is large-small surface vibration in the building construction area (International Standard Scale or the Modified Mercalli Intensity Scale).

TABLE 2
MODIFIED MERCALLI INTENSITY SCALE LIST

Scale	Damaging Level
I	Not felt
II	Felt by people in resting condition, especially people in up stair or high place.
III	Felt at home, but many people don’t think that there is earthquake. The vibration felt is like there is small truck passing.
IV	Felt at home like there is heavy truck passing or it is like a heavy thing hit the house wall. Hanging things are shaking and stand things are vibrating. Doors are rattling and glasses are clanking. Walls and structure of the house ringing..
V	Can be felt outside of the house. Sleeping person wake up. Fluid rock and spilled a little. Small jewelry moving and falling. Doors open-close. Frames on the wall are moving. Clockwise (Hanging clock) big size will die or change not fit anymore..
VI	Felt by everyone. Many ran out of shock and fear. Pedestrians are disturbed. Window glass, crockery-belch would burst. Small items clan books fell out of place. The pictures fell from walls. Furniture moving and swivel. Weak plaster walls will break or crack, and the trees swaying.
VII	can be felt by drivers who are driving a vehicle. People who walk get difficulty to walk well. Chimney or tower that is weak will fall. Ceiling is broken. Weak wall will collapse. Shifts and grooves on the pile of sand and gravel. Water will be cloudy. Big bell rang. Waterways damaged.
VIII	The driver is impaired. Strong buildings suffered damage and there are parts that collapse. There is damage on the wall that is made resistant to horizontal vibrations. Some parts of the wall collapsed. Chimneys, towers, and water tanks are spinning or falling. Home structure moves from the house wall. Branches of the tree patch from its tree. Wetlands and steep slopes are divided.
IX	Not strong buildings destroyed. Strong buildings suffered major damage. There is damage at the foundation and building frames. Plumbing pipes in the ground breaking. Mud and sand are out of the ground.
X	In general, all walls and houses structure were damaged. Strong wooden building clan bridges damaged. Severe damage to dams, dikes and ponds. A large landslide. Displacement occurs horizontal between the sand and mud. The roads and railways to be bent.
XI	The pipes in the ground are totally destroyed. Crooked railroad
XII	The entire building is destroyed. These stones, great stuff ¬ move goods. Goods are thrown into the air

Sources: Mistra, Building Earthquake Resistant Houses

TABLE 1
The average radius Influence of the earthquake based on the radius of influence of MMI Scale

Scale	Modified Mercalli Intensity at Episentrum (MMI)	Maximum surface acceleration at epicenter	Earthquake effect radius (average)
1	11-111	0,003 g	25 km
2	IV—V	0,01 g	50 km
3	VI	0,03 g	100 km
4	VII—VIII	0,01 g	200 km
5	IX	0,03 g	400 km
6	X—XI	1 g	700 km

g = acceleration of the earth (gravity)
Sources: Mistra, Build Earthquake Resistant Houses

There are two terms in the quake, the epicenter and hypocenter (the epicenter). Epicenter is the point on the earth's surface located directly above the epicenter. While hypocenter is the epicenter of the quake which is as the starting point of the quake, then climbing into the upper reaches the soil surface (the epicenter). The propagation of earthquake waves upward could turn if exposed rock layers. In addition, it could be reflected back into the soil when it reaches the surface.

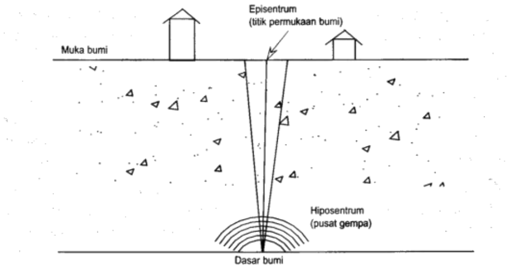

Fig. 7 Quake propagation process from the source towards ground surface (epicenter)
Sources: Mistra, Building Earthquake Resistant Houses

The earthquake design philosophy

- On a more frequent mild earthquake occur, the main parts of the structure that supports horizontal and vertical force must be intact, but the structure which doesn’t have the burden may be damaged which can be repaired.
- In the medium earthquake, the main part of the structure may be damaged which can be repaired while other parts may be seriously damaged which may require replacement.
- On a major earthquake that rarely occurs, the main structure may be heavily damaged (even irreparable) but the building should not collapse.

Fig. 8 : The light, medium and major earthquake design philosophy
Sources: Website Earthquakes and Earth's Layers

- After a small earthquake, the building must still be fully functional within a short time and repair costs are not expensive.
- After the medium earthquake, the building can function again after the repair and strengthening of the main parts of the structure is completed.

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- Meanwhile, after a major earthquake, the building may no longer can be used but the occupants of the building can be saved and the items inside the building can be protected.

1. Building damage was Inevitable

The design of earthquake resistant buildings includes the control of damage to normal levels with an acceptable cost. Unlike public opinion, cracks in buildings after an earthquake are actually natural and inevitable. A variety of damage can happen to the buildings (especially concrete buildings and walls) when an earthquake happens. Several types of cracks can be acceptable (in terms of size and location) while some are not acceptable. For example, in buildings with reinforced concrete frame with filler walls between columns, cracks in the wall are acceptable, but diagonal cracks in the column should not happen. In general, an experienced engineer knows the cause and extent of damage to earthquake resistant buildings.

Fig. 9 Diagonal Cracks in Type of a Column
Sources: Website Earthquakes and Earth's Layers

2. Damage that can be accepted: Plasticity

The designer's task is to identify the damage that can be accepted and the buildings behavior during an earthquake. Earthquake resistant buildings, particularly the main elements must have a high plasticity to be able to withstand earthquake forces, although it is damaged but it is not collapsed. Plasticity is the most important factor affecting the performance of the building. The design of earthquake resistant buildings is trying to determine the location where the damage will occur and make well details on these locations to ensure the plasticity of the building.

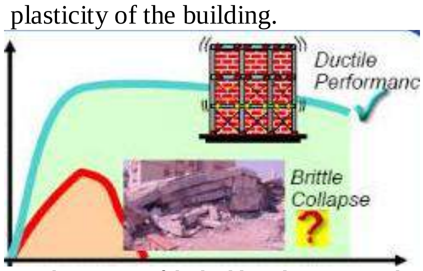

Fig. 10 Achievement of the building during an earthquake
Sources: Website Earthquakes and Earth's Layer

Fig. 11 The failure of reinforce concrete weak column
Sources: Website Earthquakes and Earth's Layer

The Impact of Earthquakes on Buildings

1. Inertia on the building.

The earthquake caused shaking on the ground so that the foundation of the building on it will sway. According to Newton's law of inertia, although the building foundation moves along the ground, the roof of the building tends to remain in his position. However, because the walls and pillars are interconnected with the roof, the roof will be dragged along with the house. Tendency to stick to the original position is called inertia. On the building, as a wall or pole is flexible, roof movement will be in contrast to ground movement. Consider a building whose roof is supported on the pole. When the ground moves, the building moves along and the top has a force called inertia. If the roof has a mass “M” and acceleration “a”, the inertial force will be as mass “M” and multiplied by the acceleration “a” in the opposite direction to the acceleration of ground motion. Thus, the greater the mass of the building the greater the inertia force generated. Therefore, a lightweight building is more resistant to earthquake shaking.

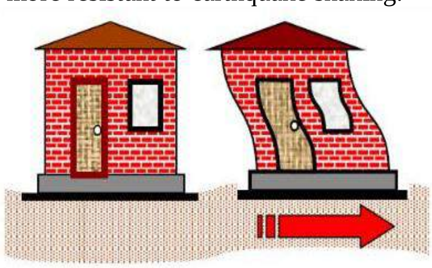

Fig. 11 a result of inertial forces on a building when the shaking on its foundation
Sources: Website Earthquakes and Earth's Layers

2. Effect of Deformation In Building

Inertial forces from the top of the building is transferred to ground through a column (pillar), causing the force on the column. Forces on the column can also be seen the other way. When an earthquake happens, the ends of the column move relatively to one another for “u”. Because of elasticity, the column will attempt to return to its original upright position, in other words, the column against deformation. In the vertical position, the columns do not support a horizontal force, but when it bends occur in the column style. The greater the

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horizontal displacement "u" between the top and bottom of the column, the greater the force of inertia of the column. Magnitude of the force in the column is proportional to the relative displacement between the edges are multiplied by the stiffness of the column.

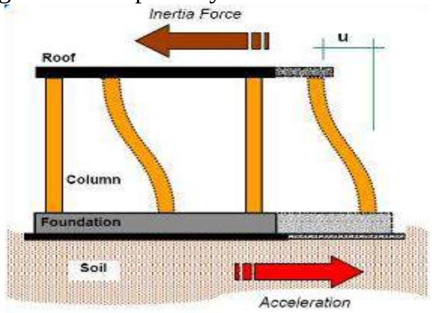

Fig. 12: the power of inertia and slow motion later in a building
Sources: Website Earthquakes and Earth's Layers

3. Horizontal and Vertical oscillation

The earthquake caused shaking in three directions (two horizontal directions X and Y and Z the vertical direction). During the earthquake, the ground rocked back and forth at random in all three directions. Buildings designed to resist gravity (gravity) either its own or heavy weight of the user and the items above it. The magnitude of the gravity of the vertical direction is the product of the mass with the acceleration of gravity in a downward direction (-Z). Downward force is called gravity. Vertical acceleration during the earthquake increases and decreases the force of gravity. Because the number of security forces in planning stage, generally additional vertical force is capable of being held by the structure. However, the sway of the flat directions (X and Y) maybe unable to be holds the structure which is not designed for seismic conditions. Therefore, in the earthquake zone, the structure must be designed to withstand horizontal forces that occur when the earthquake struck.

4. Transfer of inertia force to the foundation

On the condition that soil sway in the horizontal direction, the horizontal inertial forces generated at the center of mass of the building. This horizontal inertia force is transferred by the structure of buildings, floors, walls and columns to the foundation and finally to the ground at the base of the building. Therefore, the structural elements (floors, walls, columns, and foundations) as well as the connections between each element must be strong to continue the inertial forces. Walls and columns are the most critical element in moving the inertial forces. In the traditional building, floor and beam get more attention than the walls and columns. Walls are generally thin and made of materials that break easily (brittle) such as bricks. These materials cannot withstand the horizontal inertial forces during earthquakes. Damage of the wall happens on almost every major earthquake. Similarly, reinforced concrete buildings are not designed or not properly implemented can also be very dangerous. The damage on under the column causes the damage of rise buildings.

Stone Wall's Behavior when Earthquakes Happen

1. Wall's Behavior

Houses with stone walls are brittle building and most vulnerable to earthquake shocks. In Indonesia, the experience so far proves that the houses with stone walls cause most victims. Therefore, it is very important to improve the performance of stone wall houses to be more resistant to earthquakes. A number of repairmen steps to make this kind of building to be more resistant to earthquakes can be done. Soil vibration during an earthquake causes the inertial forces on the mass of the building that propagate from the roof and walls to the foundation. What to be considered is to ensure that the force is reaching the ground without causing severe damage or collapse of the wall. From the three components of stone wall house (roof, walls, and foundations), the wall is the most prone to seismic horizontal force. A wall will be easy to collapse when the top is pushed to the side direction perpendicular to wall side (called the weak), but much more powerful when pushed to the longitudinal wall direction (called the strong direction). Ground is shaking in the vertical and horizontal directions during earthquakes. Horizontal vibration is the most harmful to the simple stone wall. Horizontal force on the roof transferred to the wall in the weak or strong direction. If all parts the walls are not tied together like a box, the wall which is burdened in the weak direction will be easily collapse. To ensure the strength of the wall during an earthquake, the entire wall must be tied up to other wall. Thus the wall which is pushed in its weak direction will be captured by the wall in the other direction. In addition, the wall should be put together with the foundation and roof in order to become a single unit structure.

2. How to improve the performance of stone walls

One easy way to make stone wall be more resistant to earthquake is to make it into a box with a roof on top and foundation below the building. Several things need to be considered to ensure that the box is functioning. First, the connection between the walls should be good. This can be achieved by (a) ensure the connection of the wall at the corner of the wall interlock each other, and (b) installing horizontal ties in some parts, especially on the line above the door frame / window. Second, the size of doors and windows opening should be small. The smaller opening will be the stronger the walls withstand the force. Third, the tendency of a wall to collapse when it is pushed to the weak direction can be reduced by limiting the length and height. Walls that are too high or too long compared to its thickness is very prone to vibration in the weak direction.

3. Selection and quality of material

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The performance of stone wall during an earthquake is very sensitive to the quality of materials and adhesives used. Walls can be made of brick, cement brick, limestone, etc. The bricks are the most widely used material. Brick is porous and absorbs water. Excessive porosity has negative impact on the strength of a brick wall because it absorbs water from the mixture of mortar / adhesive so the bricks and adhesive bond weakened. Brick with a smaller porosity is advisable. Before it is used, bricks must be soaked in water to reduce the absorption of water from the adhesive. In reality, various types of adhesives are used, among others, mud, sand, cement, or a mixture of sand-cement-lime. Adhesives from the mud are the weakest because it will be easy to separate when it is dry and it is not earthquake resistant. Cement-sand mixture with lime is the best. This mixture is easily used to install bricks, it can be stretched without collapse when the quake rocked, and it is strong enough to bind the bricks. Stone wall respond to the earthquake depends on the power of brick and adhesive. The use of too thick adhesives is also not good. Generally, the adhesive thickness of 1 cm has been good enough in terms of practicality and beauty.

Role of Bundle Bar

Bundle bar and sloof have a important role in earthquake resistant stone wall building. Bond obtained from Sloof and bundle bar tightened the walls into a single unit such as a bundled box. In a stone wall house, there are four kinds of horizontal bundles, Sloof bar on the foundation, bundle bar above a door frame, window, roof bundle bar (on the wall), and the horses bundle bar.

Bundle bar above the sill is the most important binder and should be on every earthquake resistant stone wall buildings. Horses bar is only required in buildings with sloping roofs. Buildings with concrete slab roof do not require a roof bundle bar because the plate also functions as a binder from the relationship between plates, bars and columns. When wooden roof, asbestos, or other flat roof is used, roof bundle bar is indispensable. In buildings with sloping roofs, roof bundle bar is very important. Sloof is needed especially in conditions where soil degradation may not be evenly distributed. Bundle bar above the frame serves to unite the walls and withstand the force on the weak direction and pass them on the strong direction. Bundle bar is also split the high walls without reinforcement thereby increasing its stability and strength. On a very large earthquake in 1993 in Latur (Central India) in Killari village, almost all stone houses were damaged or destroyed, but there is one house that uses a bundle bar above the frame and it remain to stand upright without significant damage.

1. Planning bundle bar

When the quake shakes, bundle bar sills experience deflection and attraction. To withstand these forces, bundle bar construction should be considered. Bundle bar can be made of wood (including bamboo split) or with reinforced concrete. Bundle bar from reinforced concrete is the best option. Blocks must be connected firmly in the corner of the building to be able to propagate quake loads in the weak direction into another wall in the strong direction. Wood connections (on wooden bundle bar) and bend reinforcing bars (on the bundle bar of reinforced concrete) tied bundle bar together. On the wooden bundle bar the installation of nail in the bar straight with a connection to the other direction is very important to consider. Similarly, in reinforced concrete, the relations between reinforcement in the two directions must be thorough.

2. Guidance

On reinforced concrete, the minimum thickness is 75 mm with reinforcement of at least 2 pieces of 8 mm diameter tied with bar at least 6 mm diameter at a distance of 150 mm.

Is Vertical Reinforcement Required

1) Stone Wall House's Response

Frame/horizontal binder at stone house is used to increase the strength of the building during an earthquake. Horizontal binder include Sloof, bundle bar above a door frame, window, roof bundle bar (above the wall), and the horses bundle bar. Although it has been reinforced with bundle bar, the power of stone wall house can reduce significantly because of a hole/opening in the wall. When the earthquake shake, the stone walls house can be grouped into 3 sections/panels, wall in the top, middle and bottom part. Consider the pyramid-roofed house with two windows and a door opening in the wall. This house has bar frame and Sloof. Because the roof is tilted, the top bundle bar is also made. When the ground shakes, inertial forces cause the wall panel separated from its top and bottom part. Each panel moves from side to side with the pedestal at the ends of its diagonal. This movement can crush the corner of a wall panel. When the wall is slim and lightweight, the vibration can occur, whereas when the wall is not slim and lightweight, there will be cracks which formed X-shaped and commonly found in stone houses without reinforcement, the broad of wall at the existing wall opening is reduced. When the earthquake happens, the building may be shifted in the bottom part of the roof, under the bundle bar above the sill or near Sloof. The shift location depends on various factors such as construction weight, seismic inertial forces, wide aperture, and type-window frame.

2) How does the vertical reinforcement works

Installation of vertical reinforcement in columns on the corner of the wall and tied it into the foundation and the upper bundle bar will force the building to sway and not shake. At the more powerful pillar, vertical strengthening withstands the horizontal earthquake forces to reduce crack-X. Reinforcement of a sufficient size withstands towards earthquakes force. It also protects the wall of the shift or collapse.

3) Protection of openings in the wall

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Damage due to the shift as described above is rare. However, the damage that most often found in stone house is a crack-X in the wall panel and angled cracks in the door-window corner hole. When the walls with openings are being deformed during the earthquake, the shape of the openings is skewed, the two opposite corner holes moves away from each other and other move closer to each other. At this deformation, the corner which moves closer to each other will crack. The larger the hole, the bigger the cracks occur. Iron rod on the wall which is installed around the hole can reduce the crack in the corner hole. In sum, bundle bar above and below the hole and vertical reinforcement around the hole provide protection to the wall from damage.

Appendix: Earthquake Zonification and its use in planning aspects.

1) Zonification

From the results of document studies from Metrology and Geophysics and the observations in the field to the spatial aspects, architecture, building structures, and utilities there are four basic functions zonification namely:

1. Zonification based on the spatial density of buildings, classified as: Zone I density is very low, Zone II low density, Zone III middle density and Zone IV high density.
2. Earthquake zonification, based on the strength class of earthquakes.
3. Elevation of earth surface Zonification, consider the aspects of the Tsunami disaster, classified at an elevation of less than 5 meters, 5-15 meters and 15 meters above sea level from the lowest ebb (LWS).
4. Radius/Distance from the sea zonification, consider the aspect of the tsunami and hurricane, are classified at a distance of less than 5 kilometers, 5-25 kilometers, and more than 25 kilometers from the lowest ebb of seawater toward land.

2) The use of zones on various aspects of the building code

- Spatial aspect only use density zonification and not following the earthquake, elevation and distance zonification. Determination of the buildings location is decided based on the Zoning Code and Building Code which are created in each region/city.
- Architecture aspect is not affected by density zinification, earthquake, elevation and distance zonification. Determination of the requirements of the building architecture and its reliability in the Building Code in each county/city is determined by particularities of local communities socio-cultural while still provide opportunities for the development of local architecture.
- Structural aspects are determined by an earthquake zonification, soil conditions, and the distance zonification to the lowest ebb of seawater.
- Utilities aspects which include sanitary, mechanical and electrical are generally not affected by the above four types of zonification.

Earthquake Resistant House Planning Analysis

Creating a house or building which resistant to earthquake is not always by using expensive materials on all building elements, but only a few elements only, such as building construction, foundations, walls, stairs, roofs, fences, and others.

Foundation

Continuous foundation

Actually, with this system the building will be spared from severe damage if it is hit by an earthquake. Before going on the planning of earthquake resistant buildings, firstly we must know several terms in the building construction. There are several terms in the building construction such as foundations, Sloof or foundation bar, columns, ring bar, sopi-sopi bar, and the roof truss. There are many types of buildings and different land area. Before discussing further about the foundation, it's good to explain first the processes of making concrete tofu or a concrete shelter.

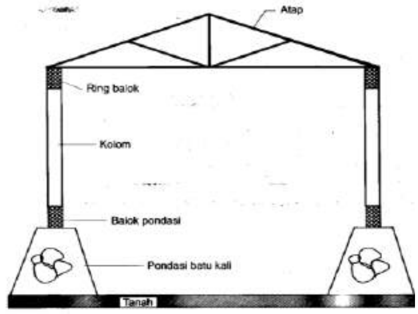

Fig. 13 Picture frame construction. Consisting of foundation, Sloof or foundation bar, columns, ring bar, sopi-sopi bar, and the roof truss.
Sources: Mistra, Jakarta Building Earthquake Resistant Houses

Shelter or tofu concrete is essential requirements of a iron protection system against external influences so that the iron is protected from corrosion due to moisture (concrete cover). The workers or builders prefer to or sometimes underestimate its function. So, it should be taken into account construction completeness to stick with concrete construction as the main part.

Prior to sloof construction (block foundation) or other construction such as concrete blocks, slabs, columns and concrete steps, concrete shelter should be available and ready to be installed. Many builders are replacing concrete shelter with other materials such as wood, brick pieces, debris pieces, broken tiles or coral. This is actually the wrong way because in the long run will accelerate the destruction of the iron system in the concrete.

Concrete shelter is not only used for high buildings, small buildings were required to use them. This is the first requirement to be met and the price is not too expensive.

The process of making shelter or tofu concrete

1) Prepare a flat and even field. Plywood and other materials can be used
2) Make a wooden frame with 2.5 cm height fitted around a plywood board to form a mold.
3) Create a concrete mixture with a ratio of 1 cement : 4 sand.
4) Pour mixture into a mold, then level the surface.
5) After a bit dry use a putty knife or other objects to divide the dough and wood ruler. Cut concrete dough in 3 cm x 3 cm.
6) Prepare wire concrete V-shaped with a length of 10 cm.
7) Insert the wire into the tofu concrete that has been formed boxes.
8) Allow concrete to dry out and harden.
9) Once it has been hardened, collect in one place like a used sack of cement.
10) Tofu concrete installed on begel.

Make the soil excavation for foundation

1. Plan the size of the stone foundation the height 70 cm lower width 70 cm and upper width 30 cm.
2. Create a soil excavation with a width of 90 cm and 75 cm high.
3. Solidify below ground.

The next step is designing earthquake resistant buildings, starting from the foundation. Foundation to be used is the stone foundation. This type of foundation is most widely used by building owners. Here is a stage of making a foundation stone for Sloof.

Stone foundation making process for Sloof

1) Prepare an iron anchor with of 12 mm diameter 20-25 cm length.
2) Put the stone in the planned size, then install iron anchor from concrete in the middle with the distance of 100 cm. Iron anchor implanted partially into the stone foundation stone of 10-15 cm length. The top part of 10-12 cm length.
3) To cover an iron anchor, cut the PVC pipe at least 1 inch diameter and 12-14 cm length. Put pipe on a ceramic pair. Make sure that the anchor positions are in the midst of PVC pipe. To make anchor position right in the middle of the pipe, wedge anchor with styrofoam to stabilize the anchor position. Then close the ends of PVC pipe with thick plastic so as not hit the concrete. PVC pipe should not be conceding the concrete mixture. PVC pipe must be fused with Sloof if it is casted and should not change its position.
4) Then, mortar can also be installed on around the edge of the pipe or pipe tide to an iron pipe in order to remain motionless when casting is done.
5) If some of the foundation is finished, the top surface of the stone was given mortar sand. Then put the old tiles with a smooth surface. The Installation is same as like installing ceramic floor. Former ceramics may be used intact or cracked. Slippery part is attached to it at the top.
6) Surface of the stone foundation might enter into the soil as deep as 5 cm only.

Stone Foundation Making Process for the foot of the column

On the foundation with column, the surface is widened to the size 40 cm x 40 cm.

1. Make a hole for the column box at 13 cm x 13 cm size so that the width of the hole become 13 + 4 + 4 cm (4 cm thick is the sum of styrofoam 1.5 cm and thickness 2.5 cm concrete shelter = 4 cm). Thus, the size of the hole becomes 21 cm x 21 cm with a depth of 10 cm.
2. Surface of the box hole is also given broken tiles with a smooth surface on the top.
3. Sand mortar for stone in the pit box is made with a ratio of 1 cement: 2 sand.
4. Another alternative may be made of 6 mm diameter concrete rings fitted three pieces, then box is casted.

In calculating the size of the hole width of the column must consider the size of the column. If the column size 15 cm x 30 cm, the size of the hole should be added with a 1.5 cm thick Styrofoam and 2.5 cm thick concrete shelter a total of 4 cm. Therefore should be installed on each of two sides of the column, the column size must be increased 8 cm (4 + 4 = 8 cm). For column size 15 cm x 30 cm, required hole size is 23 cm x 38 cm with a fixed depth of 10 cm.

Local foundation

Actually, recommended foundation for this system is the foundation with stone material. However, it is possible to use other types of foundation that is the local concrete slab foundation. Generally, the type of foundation is widely used in multi-storey buildings that the soil conditions is not good enough for the use of stone material. Usually in addition to the use of stone is also combined with a local concrete slab foundation. In addition, in order to decrease vibration propagation due to the influence of the earthquake to the upper part of the building, support columns can be made. Making process is the same as the stone for the columns. In these details, the type of local concrete slab foundation will be made.

Hole size for media space depends on the size of the column by adding 1.5 cm space around the column with 15 cm depth. Iron columns are forwarded to the top including iron begel or cross bar. Three pieces cross bar is installed.

Next step is same in stone system that is like the installation broken floor tiles, plastic, and Berta Styrofoam. The existence of weight and mass of the building allows the column to come out of the media is very small. This weight of the building makes the column will remain on the movement space. Unless a very large earthquake, what happened would have been different.

Sloof

Casting Sloof

1. Install first plastic sheet on ceramic surface.

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2. Enter a series of metal sloof on plasti. Give wedge with tofu or shelter concrete.
3. Install basketting of board cast, then casted.
4. Terms depth of the stone foundation upper part maximum of only 5 cm from ground level.

Column

Foot column casting

1) Install plastic sheet on the box columns and install series of metal column. Column position must be completely located in the middle of the hole.
2) Layer around the edge of the holes put styrofoam 1.5 cm. After the column is inserted, wedge with concrete to the four sides of the iron columns and given a stud (retaining the iron frame column).
3) Iron frame column bottom part must not touch plastic and ceramic surfaces. It is advisable to make binding at the end of the column iron, may be upright or semi-circle. Take the easiest be made.
4) Hanging at 2.5 cm high or a wedge with a tofu concrete.
5) The foot of the column casted first. Once casted and dried, then iron sloof is installed. The purpose for the position is to make the column foot fixed, unchanging in its hole.
6) Install the series of metal Sloof on stone foundation.

Iron column system for resistant earthquake building

Determine the distance of cross bar installation or iron begel on the column needs to be more careful. If you buy a ready-made column, the distance between the cross bar is within 20 cm and up to 30 cm. This size is really not safe for structures power. Generally, traders do not know the function of cross bar on a column. What they know is only great advantage without regard to strength.

For the bottom and the top part is taken 1/4 of the height of the column. If the column height of 4 m then the distance the top and bottom of each of 1 m. On the bottom and top, the distance of cross bar installation is 10 cm. While at the center is 2 m length, the distance cross bar installation is 20 cm. This was caused by quake force that occurred on the bottom and top of the column is greater so it is required special treatment. The purpose is to reduce the magnitude of earthquake forces that arise at the top and bottom of the column. Next, hooks major iron on the cross bar.

Generally iron begel or cross bar is installed on a circular column like a ring. This is to facilitate installation. This way weakens the construction of the column itself. It is recommended that installation of the hook on cross bar follows the applicable construction provisions, the hook length of 5 cm and angle of 45 °.

Column Casting

1) Install the anchor for the binding partner-brick walls with iron of 8 mm diameter. Install with a distance every 50-60 cm. The length of iron anchor is 45 cm. Outwards along the 30 cm and the rest goes into the field with prior formed letter L for corner column.
2) Install Bekesting board.
3) To avoid a loss on the bottom part of the column, first make mortar cement before casting. Mixture of cement and sand in the ratio 1: 2. Toss with enough water. Then pour this dough into the bekesting column. Make the dough as much as two plastic bucket. After that, do the casting of concrete.

Iron Concrete Anchoring

At every meeting between the iron columns and iron ring bar should be consider the anchorage at each end of the iron columns and steel ring bar. The recommended anchorage length is 40 times the diameter of iron used. For example, the length of the iron used is 8 mm so the length of anchor is of 40 mm x 8 mm = 320 mm or 32 cm.

Anchoring in system structure has important role to withstand the quake vibration in a building. It is hoped the building owner will take into account the length of this anchorage. Anchorage length greatly contributes to building resilience at the time of the earthquake.

TABLE 3
OF CONCRETE IRON ANCHORING LENGTH

No	Iron diameter	Anchoring length
1	6 mm	240 mm or 24 cm (6 mm x 40)
2	8 mm	320 mm or 32 cm (8 mm x 40)
3	9 mm	360 mm or 36 cm (9 mm x 40)
4	10 mm	400 mm or 40 cm (10 mm x 40)
5	12 mm	480 mm of 48 cm (12 mm x 40)
6	13 mm	520 mm or 52 cm (13 mm x 40)
7	16 mm	640 rnm or 64 crn (16mm x 40)

So far, in building a house, many workers ignored the requirements of iron anchorage length. As a result the bond between the iron columns and iron bar or ring bar does not meet the construction requirements.

Supporting media to Earthquake Resistant Houses

For designing earthquake resistant buildings, it takes some media. Media is generally easy to find and is all around us.

Styrofoam media (movement room media)

Styrofoam is a kind of white colored plastic foam that is commonly used to secure electronic items in a box. This object is very light, soft, and chewy. Cutting can be done with a cutter knife. For earthquake resistant buildings, styrofoam serves to create a space or distance for casting concrete columns. Styrofoam should not be replaced with another object because it is possibility that the system is not running. Although its characteristics are soft, Styrofoam can hold concrete castings at the time of casting concrete columns so the column does not change the mold after the concrete dries.

If an earthquake happens, the column will automatically move in any direction. 1.5 cm thick Styrofoam will be destroyed by the movement stressed concrete columns. The destruction of styrofoam would make room for a column of 1.5 cm around the column. It can be concluded that the styrofoam is referred to as media room or as a means of freedom of column movement. If the earthquake will appear at

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the next time, the column is bound to move flexibly in all directions in the space surrounding the former styrofoom.

Ceramic and plastic media (media vibration absorber)

Movement of a large earthquake will propagate from the ground to the foundation stone, then to Sloof. Next Media is a separator in the form of broken flooring tiles and plastic sheet that lies between the stone and Sloof. This media may be called vibration absorber media. Earthquake vibration would be reduced by this media. Logically, the absorption of earthquake vibration will reduce the vibration that propagates to the building.

When a strong earthquake from the ground moves and moves the stone so the stone will sway. The strength of stone vibration will be inhibited by this medium. Weight or mass of the building will make Sloof stay on top of the foundation, but the vibrations received Sloof become small. Indirectly it will cut the media will cut the vibrations force on the foundation stone. A reduction of this vibration is expected to minimize the collapse of the building. It is expected that with this system there will be more and more houses are still standing on the ground without significant damage. If it is difficult to find old broken floor tiles, another way to do is put on the ceramic floor tiles KW 3 or low quality ceramic.

Surface Foundation Media

The foundation surface depth from the original land a maximum of only 5 cm, it would be better if it is flush with the ground surface. This depth requirements are to reduce that reduce the tremor that will move to the top of the building. As is known earthquake movement starts from the ground and move up the soil surface, and then spread to the building until the building collapsed. By these symptoms, to reduce the strength of the tremor, the surface of the foundation should be placed closer to the ground surface. On top of stone, there is a media made of ceramic and plastic that is flexible so as to make the movement of the earthquake will be reduced.

Media box 21 cm x 21 cm x 10 cm (buildings anchors media)

In general, the smallest columns for houses is 13 cm x 13 cm or as thick as the bats walls before it is plastered. Around the column there will be free space available of 1.5 cm. The box with width 16 cm, length 16 cm, depth 10 cm aimed to keep shifting the foundations and columns from the influence of the tremor. These jugs can be referred to as building anchor media.

Such a strong earthquake motion, if this media is absence, the overall building will be shifted from the foundation stone. If this happens, there will be major damage to buildings on it because it is no longer "sit" on top of the foundation. The building anchor media making is aimed to withstand column, sloof and upper part of the building remain in its position. The possibility of building rise up so far is very small. Box size of 21 cm x 21 cm x10 cm is for column 13 cm x 13 cm. If the column size 15 cm x 30 cm, media box made into a 23 cm x 38 cm x 10 cm. The condition is that the column size is added 4 cm around.

The next anchor medium is anchor iron with minimal diameter of 12 mm equipped with PVC pipe with at least 1 inch installed in every of 1 m. The use of iron concrete with at least 12 mm in diameter is very important. If using a smaller iron, it is feared anchor could not resist the influence of earthquake motion of building.

Iron anchor must be embedded in the foundation stone. PVC pipes must become a complete unit with Sloof and stand on the tiles freely. Anchor position located in the center of the pipe will limit the Sloof holder movement so that the building does not shift, then away from the foundation. Therefore, the anchor foundation should not be fused with Sloof bar or foundation bar.

Security Installation in Underground Pipes

Tremor could lead to changes of the stone foundation in the ground. If it happens that would have damaged is the water pipes in the ground in the middle of the foundation stone. Pipes are sewage pipes (septick tank), the waste water pipe (sewer lines in the ground), and water pipes. If there is damage or broken, the pipes will cause problems. In order to minimize the damage factor, each pipe should break through the foundation stone made a special sparring.

Supplementary Materials In Buildings (Anti-Earthquake) Wall

Wall installation can be by a brick, Celcon brick or Hebel bricks, lime, or brick. For a good and earthquake resistance building, it is advisable to use red brick. Walls made of red brick will be able to increase resistance to earthquakes. For perfection, the wall still has to be plastered. When the wall installation has finished, ring bar construction installed to cover the mounted walls.

1. Brick Wall Angkur
   For the installation of a brick wall, wall anchor is needed. The function of anchor is to hold the wall to remain standing during the tremor. In addition, the anchor brick also serves to transfer the earthquake forces. If the wall is damaged, the damage only occurs in the anchor. Installation of anchor is usually done after bekesting installed. Anchor can use iron of 8 mm diameter. The length of the edge of the column at least 30 cm. Anchor is installed to the column that will be installed a brick wall. The distance between the anchor installations is between 5-8 stacking masonry.
2. Limitation of Wall Area
   On the wall that has an area of 9 m2 or less than 9 m2 does not require the addition of stiffeners column (column practically). However, the extent of the walls which exceed 9 m2 must be fitted with a column amplifier. For example, the length of the wall in the living room of 4 m and a height of 3 m. Mean wall area is equal to 4 m x 3 m = 12 m2. Because of the extent of more than 9 m2 will require a practical field for wall bracing in the middle.

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In the other cases to the area of a wall that more than 9 m2, for example, the length of the wall 5 m and 5 m high wall, the total wall area is 5 m x 5 m = 25 m2. For such cases a column wall requires additional practical and a practical concrete blocks placed in the middle of the wall. Thus obtained wall area of 2.5 m x 2.5 m = 6.25 m2 (less than 9 m2). Not all walls should be added the bar in the middle of the wall. For walls having a height greater than 5 m, the addition of the bar has to do with the structure calculations.

On the frame, especially on the doors or windows that are wide (60-80 cm) is required rollag brick installation. While for frames that have a width of more than 1 m concrete blocks should be added on top of the frame. This concrete block has to enter the column if the width of 3-4 m. If the width is only 1.5 m, on both sides of the frame column clamp frames created and on the frame made of concrete blocks. Indeed the opening in the wall will weaken the wall of the damage when an earthquake. Because open space is needed for air circulation, residents exit-entry, and the inclusion of light, then window or door is made. The existence of an open space in the wall area must be offset with additional reinforcement in the form of concrete columns and reinforcement concrete bar.

Roof Construction

A roof construction has big contribution to earthquake resistant buildings. If the roof collapses, the building above it also will be damaged. This requires a construction system that safe from damage when an earthquake happens.

1) Frame Roof

There are several types of roof truss material:

- Bracket profit steel roof or WF (wide flange),
- Lightweight steel roof truss or zincalum,
- Concrete roof truss (gin-gin), and
- Wood roof truss.

Roof truss of a building also played a role in accelerating the collapse of a residential building. Most construction workers carrying out roof truss installation by their own sense. If it is considered to be safe, roof installation is finished. Yet structurally, careless roof installation is very dangerous for the occupants, especially if the owner is a person who does not know about building construction. Here is an example of roof installation on ring bar and a brick wall.

Installation of roof truss on concrete bar or ring bar must consider the joints between the roof truss and a ring bar. Iron anchor as a binding framework should really get into the wood bar. Most workers are lazy to make holes in the wood, even it just need to bend an iron anchor on the bar, then reinforced with a few nails.

In the construction, there are two special treatments to binder roof trusses on concrete bar (ring bar). Steel roof truss or wood roof truss has the same treatment. In two places, joints between concrete bar and roof truss had to use an iron anchor. The joints between the concrete bar and trusses called pedestal. One of the pedestal must be “dead” tied, which is called support joint. Another pedestal is tied up with a flexible or movable with certain restrictions, it is called roll pedestal. If an earthquake happens, the system can move the elastic joints following the earthquake shaking and do not damage the wall. However, if both ends are “dead” tied, most likely the walls will collapse due to shake the rafters. Iron anchor needed for joints are about 12 mm or 14 mm diameter.

Ideal distance from the wood roof frame to another frame made of concrete or soil roof is 3.5 m. If imposed by a distance of 4 m, its gording should be large, at least 8 cm x 15 cm. If the gording size is smaller, for example 8 cm x 12 cm, most likely the roof will be sagged to the bottom. This deflection can cause roofs to leak or tampias. It can even result in roof truss collapse.

2) gording

In gording installation, keep in mind is on the edge of wall at the lot boundary. This section is called sopi-sopi edge. Sopi-sopi is actually a replacement of wood roof truss. Using a sopi-sopi for roof truss is very practical, because the space under the roof can be used for the room. There is also sopi-sopi position at the center of the building, called the middle sopi-sopi.

Once the requirements are done, then every joints of the wooden frame also needs to be given a reinforcing steel plate. Installation of sheet iron on a wood frame should not be nailed, but by giving the nuts and bolts in accordance with the holes on the iron plate. The nuts and bolts are at least 8 mm in diameter. This section is also generally forgotten. In fact, its effect is also large enough to the strength of the wood trusses.

Gording installation with a system in the picture above can reduce the influence of the vibration magnitude on a brick wall roof. When the tightening nuts on the anchor gording, nuts in this section should not be tightened, add space 1-2 mm. If there is sway, gording can move freely without causing any effect on the wall. While for the battens installation there is no special requirement, it worked as general.

3) Roof

There are several materials types for roof coverings

1. zinc roofing material,
2. Asbestos cement roofing materials,
3. Burn soil roofing materials that natural and glazed,
4. Concrete tile roofing material, Berta
5. Metal roofing materials (there is a basic ingredient of metal and some basic materials PVC plastic).

The weight of roofing materials also contributed to the collapse of buildings. The more severe the material, the more risky the buildings during an earthquake. Most of house owners prefer to choose the roof material of the isthmus, glazed tiles and concrete tiles. Soil and concrete roof tiles are very attractive and can beautify a house. While the zinc roofing material only for houses with very limited finance. Asbestos roof option for the lower classes community still much in demand because it is cheap, strong, and safe. Metal roof is starting to be the style. In addition to its interesting style and a lot of variation in color, the roof is very lightweight and fire resistant. For earthquake resistant

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buildings, any roofing material may be used of course with certain requirements.

4) Soil and Concrete Roof Tile

Roofing material of iron or asbestos does not make many problems in case of earthquake. This is because the material is very light. If isthmus or concrete tiles are used, installation of the battens should be on the screws. If an earthquake happens, roofing materials still remain in the position respectively.

5) Metal Roofing

According to installation direction from the factory, metal roofing is installed using a nail as the media bordering on battens. The requirement is due to severity of roofing materials. If not nailed, roofing materials will be flying when the wind came. However, these factors are very favorable for earthquake resistant buildings. Overall weight of building mass or buildings will be reduced. If an earthquake happens roof truss will remain firmly in place and can reduce the risk of roof damage.

This roofing material is made up of two types (metal and PVC plastic), metal material is then advisable. The purpose is to be resistant to fire. These materials display well. However, the selection of roofing materials is up to each house owner.

6) Houses Fence

What is the relation between the fences with earthquakes? It is often seen in the electronic media and print media news that fence collapsed caused victims. According to the authors, the problem of fence also needs to be inserted in this book. This is due to fencing includes in many elements that complement to be built in the building.

The main issues that make the fence collapsed are error in construction implementation. Many workers or foremen who ignore fence construction issues. So far, the fence is considered as non-structural parts. Thus, it is not treated specially. The construction is simple and requires no analysis. This could be wrong and true. Fence construction does not require analysis, if the length of the fence is not more than 20 m and only about 1 m high fence. If the high is more than 2 m and length of more than 20 m, it do need further treatment to bring safety for surrounding residents.

Fence construction as above is not easy to collapse than the artificial fence builders. There is a growing field in the foundation stone so that the fence becomes resistant against the vibration or wind pressure. Moreover, the materials will weathered by the age.

Anchor that is installed on the stone is not much benefit if the fence has been prepared collapse at any time. Fence height of 2 m to 30 m length has weighing up to 2 x 30 x 250 kg = 15,000 kg or 15 tons. Anchor strength that is planted will be ripped from the foundation and the fence collapsed. It is recommended that when creating a long, high fence to take account on the column installation technique.

Foundations, Key Success to Earthquake Resistant Buildings

In general, Sloof house foundation stay on stone masonry. This sloof is as heavy retaining wall media. For residential construction, all elements of the building rested on the surface of the foundation. Unless if the foundation stone combined with local concrete foundation.

Earthquake resistant houses AOV system is not structurally change the construct, but just add a system for earthquake resistant buildings. Overall the building weight is still bearing on the surface of the foundation stone. For material options, it is recommended use the stone material. If there are building owners who will use materials other than stone, it is advisable to use the former or old concrete road slab pile because this material is a high quality concrete. This is a wasted chunk of unused material.

AOV system (absorption of vibration) serves only to reduce the tremor that arise in building construction. If an earthquake happens, only the foundation alone will get a strong vibration, while building on the foundation the vibration will be reduced. With this system, it is expected to minimize damage to the building and be able to prevent loss of life.

Storey building that use stone can also use this system with regard that the soil condition is good enough. At least the land has a carrying capacity of at least 0.7 kg / CML. If it is less than 0.7 kg / CML, the foundation will be different. Most people will use a local concrete foundation or slab stake. Structure planners typically will design foundations using a local concrete slab at the columns that bear the major burden. Local concrete slab foundation can be replaced with stone. Foundation thickness can reach 1 m, while the length and width comparable to the length and width of the local concrete slab foundation. Construction of the top such as columns, bars, and concrete slab construction should be put on a truly qualified for multi-storey buildings.

Having examined the overall system of earthquake resistant houses, so it can be drawn the form of the foundation as a whole.

Summary of Minimum Requirements Earthquake Resistant Residential Building

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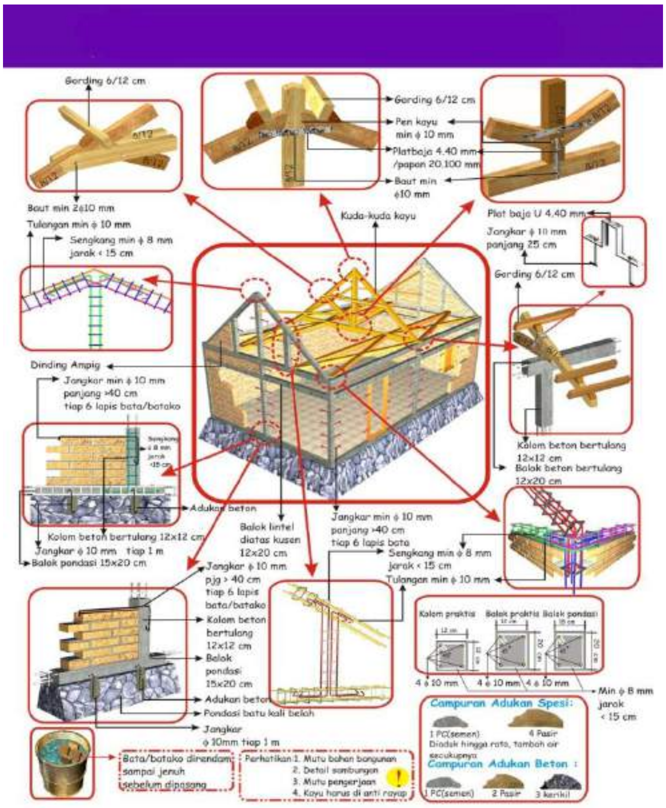

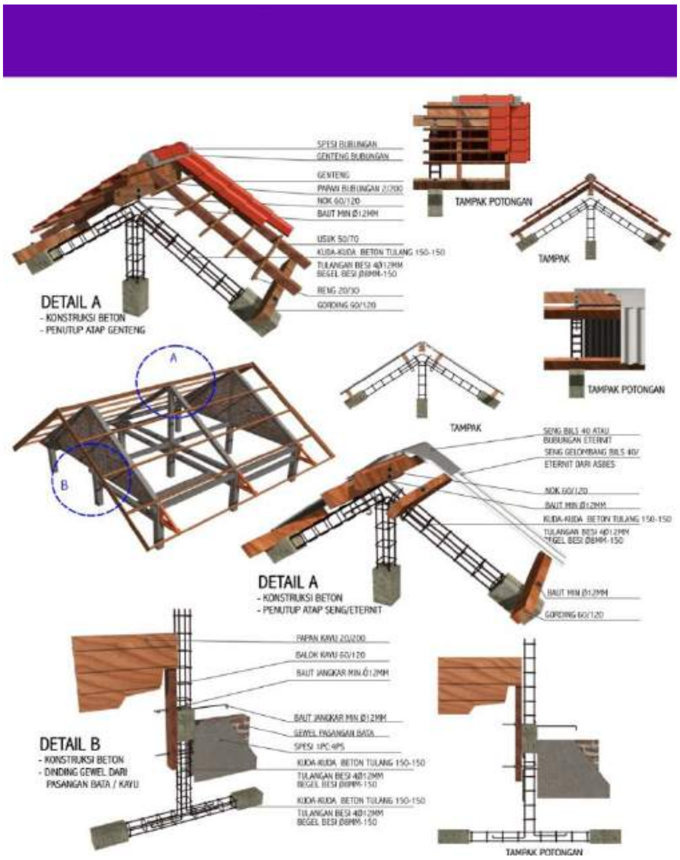

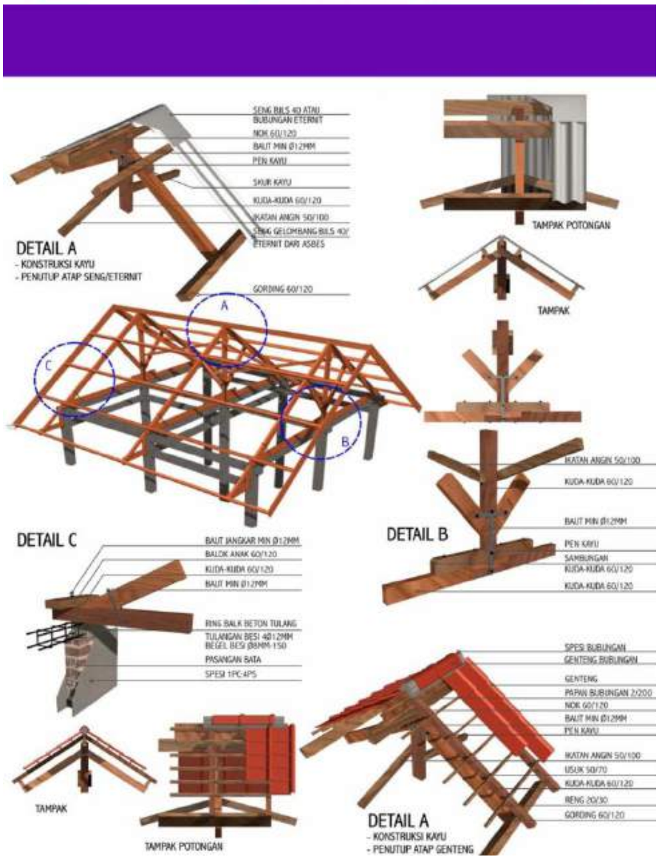

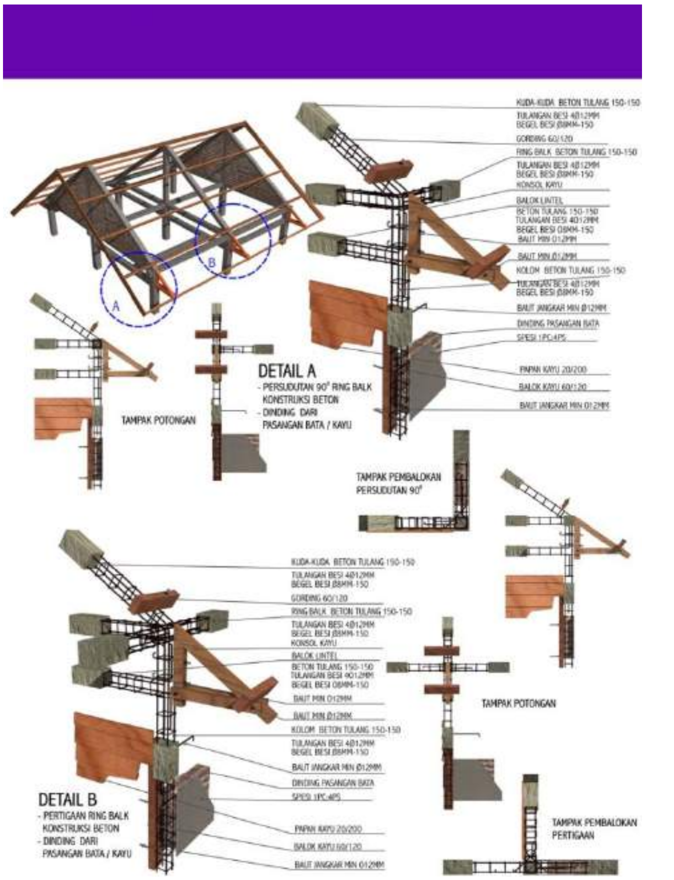

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Conclusion

To build a building, both a house and building to be resistant to earthquakes, actually it is not too difficult, nor expensive. When compared with the risks that occur when built without planning to withstand earthquake shocks, it must be because the fact that Indonesia is a country with earthquake-prone region.

For a simple house, it can be done by building houses with most of the material are from timber. Because wood is light. So the force is also small when the earthquake happened. Because, the greater the mass of the house, the greater the force received. What need to be considering in building a wooden house is a connection between the timbers must be strong.

From the data obtained in number of areas subject to earthquakes, both foreign and domestic, those which are not destroyed are houses that have a good foundation, and a good standing on the ground. In addition, the building must have reinforced concretes that are tightly tied between the concrete and other concrete.

Things to be considered in building an earthquake resistant building are as follow.

1. Building location should not stand on loose sandy soil. Tremor can cause changes in the position of the soil grains. That could make the buildings on it dented, cracked, and shattered.
2. Do not put up buildings on the slopes, because of the earthquake likely to lead to the collapse of the slope, if you must set up on the slopes, choose a stable slope.
3. Building structure in earthquake-prone land is simple or symmetrical as like square-shaped, rectangular, round or hexagon. If the building cannot to be symmetrical, the prominent construction can be separated from the main building.
4. For too long buildings, or the length of the building is three times its width, or length of the building over 40 meters, its construction should be separated. What to be considered is also the location of wall insulation, doors, and windows, should be symmetrical to the axis of the building plan.
5. Building materials should have good quality. Reinforced concrete with standard mortar mixture composition which appropriate to the nature of each ingredient mixing mortar.
6. For the materials column / bar / lintel bar / Sloof bar, can use wood or bamboo that has been dried. For the column, can also be used steel profile or aluminum. But, this material is quite expensive, and need attention to fire protection, light material as possible should be used. "asbestos, tiles, or zinc cab be used."
7. Good construction, all joints between the connections must be tied properly. Between bars and columns must be there Anker concrete / steel reinforcement constantly. Foundation should also be made continuous around the building.
8. Between the walls and columns should be given Anker with a minimum length of 50 cm, or by inserting a metal reinforcement from column to column through a wall to be reinforced. Foundation should be made consistently at the same depth.
9. Wall is recommended to wear a red brick wall, brick Celcon, and Hebel bricks. Celcon and Hebel bricks are two types of light but solid brick that had a big role to withstand tremors.
10. Avoid the walls made of brick because it is not guaranteed strength. Because quality is declining due to the use of a minimal mixture of cementations materials.
11. Foundation used should be from stone or used chunks of stone piles, old concrete road demolition, or demolition former kansteen (the curb).
12. Follow the designed construction system by experts of construction, especially anchoring system of iron rods at each joints.
13. In building process, use of experts who already have high experience.
14. Avoid buying a fix series of metal to be sold in the shop building. Ironing assembled in bulk is not eligible for a strong building.
15. Try to cast the column practically up to the ring bar.
16. Install anchor iron anchor for bricks on all fields.
17. Consider the comparison of the dough mixture when making concrete casting.
18. In each wood bar joints on the roof should be attached with a metal plate to strengthen the roof sequence.
19. Plug the iron anchor for wood roof truss. For this kind roof, consider the joints system rested on the concrete bar. Wood trusses must be drilled for holes. Do not accept if the iron anchor just bent over the wooden bar, then clamped with a few nails. Spikes do not have the strength to hold such strong shearing motion of the earthquake.
20. And there are still some details left to do. It all can be applied easily. The problem is, whether we directly supervise construction or not. Therefore, it is very important if the information delivered directly to the foreman or workers who were involved directly in the field.

Some clues to address if an earthquake happens:

1. If land or buildings began to be shaking and rattling, do not panic. Save yourself under a table or bed. The purpose is that if the roof truss collapse, frame ceiling or wall, the first powerful rubble will be accepted by the table or bed. If a table or bed is not strong it will also collapse. Weight has been reduced a lot of debris so that people who are below it can still survive despite having "lumpy".
2. Cover the head with a pillow. The purpose is to reduce the weight of material falling from above. "Hand can be broken but the brain must be safe".
3. In the event of an earthquake on high buildings, first feel whether the tremor is big or small. If it is big, immediately go to below the desk. No need to run outside the building because not enough time.

4. If a position close to the roof (concrete roof), run to the roof. The place is considered safe, but the shaking will felt big.
5. Stay away from the glass window. If the glass is not strong to hold tremor, one can avoid the injuries caused by broken glass.
6. If it had been in a state of ready to run, avoid the escape by using lifts. Use of existing stairs or fire escape. The use of the elevator to save yourself from an earthquake can be fatal. Lift can be collapsed or damaged. Using the stairs will be safer. Because the ladder is designed to move elastically at the time of earthquake.
7. If the building collapsed the numbers 1 through 5 will be much beneficial for a person to be saved.
8. Surely please pray that Almighty God in order to survive and stay alive

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