Paraseismic Housing Guideline

Translation and comments from
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The “Building Code” is being called in Indonesian “Petunjuk Pembuatan Rumah Sederhana Tahan Gempa”, which I have translated with “Paratiseismic Housing Guideline”, as it is not really a building code, but mostly a selection of recommendations for building.

I have noticed many mistakes, and the content of the text let me believe that it mostly sums up few of the recommendations a constructor could give for the people building a permanent dwelling, but not exactly what a paraseismic dwelling could be, so I am not sure about the real paraseismic reality of the guideline. Few recommendations are those I would not give in the contexte of Sumatra, but I will write more about that with drawings and examples.

Some of the recommendations guiven in the Guideline are exactly the kind of mistakes that we notice when visiting the building collapsed in Bansa Aceh, due to a too hight rigidity of the structure which lastly does not distributes the horizontal loads equaly.

I have translated the text, which still be a draft that needs some real study by architects and ingeeners. For examples, some of the drawings show dimensions and sizing but do not proportionate the structure with the building. Drawing 4-9-a. should show the proper width of the wooden truss for the dimensions to be accurate. The dimensions must be perceived as a ratio, so that the people know that they have to adapt the guideline to their own needs and projects.

Chapter 3-6 had no sense, so I have translated the text, but which needs to be transformed with the indonesian author to become understandable in both languages. I have adapted also the chapter 4-8 to the translation for it to be clearly understandable.

I have also noticed sizing mistakes, so I recommend every ingeeners reading this draft to send us their own corrections. In chapter 4-2, the density of the beton cannot
be 150 kg/cm². The density must be verified considering local materials. In the chapter 4-5 there is a mistake with the framing description. The angle cannot be 135° but 45° and the diameter of the curve from the angle has a minimum of 10 mm. This point must be verified by the engineers, and eventually, a clearer drawing must be produced to be understandable by non architects.

I have used some of the construction words which sometimes might not be clear to anyone who is not an architect. When possible, I have turned out the sentence to bring more light about the meaning for examples when talking about the loads of the structure. For the vocabulary that cannot be described, I will add a glossary and a terminology of the translation. Paraseismic for example means anti earthquake seismicity. If paraseismic is a common sense in architecture, some non architects do not understand what it is about.

I have also changed the “drinking water” used in the Indonesian text by “rain water”, because it would be a mistake to believe that drinking water fits for building, while clean rain water is all right.

I suggest that this translation draft be posted in the mailing list, so that the engineers and architects can send their own comments. I particularly want to develop the chapter about the connection between the walls and the roof, because the local Sumatran architecture brings many examples that are paraseismic while I tend to believe that the recommendations in the Paraseismic Housing Guideline are not appropriate for paraseismic architecture.

The discussion about the paraseismic properties of the structure will open the discussion about the acculturation brought by the reconstruction of Banda Aceh and the way how we can prevent any mass mistake about architecture, the concept of modernity, and that of security.

The paratsunami (or big tide) properties have not been discussed in the draft so I suggest also to add some guidelines about how to build more secure with the risks of a tsunami (openings, walls, distributions). A chapter should also show how to think the urban planning to help secure the population in case of evacuations, or a quick
security intervention after earthquake. Urban planning factors must also talk about electricity, water piping, fire and sanitation.

Sanitation and fire are two big points that must be clearly explained also, because some of the reconstruction housing that have started to flourish everywhere do not consider local culture (rooms, space, bathroom adapted for women), sanitation, maintenance, and fire. The fire is as important as earthquake so we must be careful to not minimize the domestic risks while they can become devastitive too. Handicaps and children should have entered the draft, at least to bring some elements of knowledge to adapt the social life with the after tsunami.

This translation is a draft that is open to your critics, recommendations, comments and corrections. I hope it to be helpfull for the design of the last Building Code. A complete pdf file with the text in Indonesian, English, French, terminology, and glossary will be produced and I will illustrate the paraseismic properties of the Sumatran architecture to discuss the way we can adapt the technology to local reconstruction relief. As a foreword of my comments, I recommend you to read the FAO discussions about the Progresses in the Dwelling Technology of Indonesia.

With my bests regards,
Sincerely,

Sandrine
Singapore June 27, 2005
1. PREFACE

1. 1 Background

The earthquake and the tsunami that have hit the Province of Nanggroe Aceh Darussalam and North Sumatra on December, 26, 2004 already evokes the intensity of the loss being material or non-material. The loss that results from the earthquake is the loss due to the broken buildings and worthy the destruction of the living house. The many kinds of damages that we met on the buildings and the living houses due to the earthquake resulted generally into:

1. Roof damages
2. Roof truss and gable damages
3. Fissures on the bricks walls, particularly at the junction between the timbers and the beams.
4. Damages of the columns and beams, including thin fissures, large fissures but also the collapse of the structure.
5. Dislocation of the nobs between the timbers and the beams, or the building with its own foundations.
6. Downfall of the foundations.

The damages that occurred until now bring to conclude that:

1. Some dwellings do not have any resistance to earthquakes.
2. The quality of some dwellings is very relative.
3. Some materials do not follow any standard.
4. Some building procedures were not respectful to the building precepts.

Taking advantage of this experience accordingly to the needs, we have drawn the advices or guidelines in the process of building a fairly made and anti earthquake construction or house. The Service of the Urban and Residential Planing of the Province of Nanggroe Aceh Darussalam, as a representative of the government and adviser in the quality of building, assumed its responsibility in the need to settle the instruction for building earthquake proof dwellings. Our wish with writing those guidelines is to motivate the public in getting interest for the quality and the security of the constructions and dwellings.
1. 2 Objective
The Service of the Urban and Residential Planning of the Province of Nanggroe Aceh Darussalam established the criterias that are mapping the construction of a paraseismic house with the aim to:

1. Minimize the number of criterias that define a paraseismic house.
2. Deduct the material and non-material factors that result into the earthquake destructions.
3. Enhance references about scheduling and building paraseismic house.
4. Endow the concept so that the public can follow a procedure and a method for realistic paraseismic building.

1. 3 Standard housing
The standard housing for the Antiseismic Housing Guideline is as following:

1. The housing is distributed among three kinds of houses, each of 36m², 42 m², and 52m² which only have one floor.
2. The permanent houses must use reinforced concrete for the structure and bricks for the replenishment of the walls.

2. CONCEPT

2. 1 Single structure
One of the most fundamental paraseismic principle stands with having a single entire structure so that the loads can properly be distributed and directed to keep the balance. The building must be also properly chained so that the structure keep strongly maintained even if the structure has been altered by an earthquake.
2. 2 Shape of the building
The good way for building is using symmetry (four sides, cubic) and have a good proportional distribution of one side with the other, so that to minimize the burden forces and constrains that are amplified by the earthquake. Large constructions must have expansion joints to prevent from the earthquake effects. It must be also took at heart that the windows and doors cannot be too large. If the openings are too large, they will become the weakness of the structure where windows and doors are distributed.

Drawing 2. Example showing a good kind of house
2.3 Materials
The use of the good materials which quality can fit with the earthquake conditions must absolutely be plein materials which form can resist with the paraseismic properties of the house.

2.4 Application scope
To built a construction of quality, the building of the house must follow the procedures that are good and right.

2.5 The culture of Aceh
The planning for the paraseismic construction must contribute in the selection of the materials previous any Acenese cultural habits and customs so that to get both quality and performance. The realisation of the paraseismic dwelling do not have to change the shape of the building, or even the materials that have been in use, but the most important is to bring reinforcements so that the building can outlast an earthquake.
3. MATERIALS

3.1 Grindstones
The grindstones are used for making the linear foundations. The good grindstones have the following features:

1. They must be of a good quality, hard and regular.
2. They must be clean from dirt.
3. They must have proportional sizes (10 – 15 cm)

3.2 Sand
The sand that fits for building is the river sand that diameter is 0.25 to 5 mm. The sand generally has to have the following properties:

1. A sand with good building properties must not have more than 5% of mud otherwise the dirt will affect the quality of the construction.
2. The sand that is being brought from the ocean must be clean and it must be tightly verified that there is no more salt which may cause any construction failure to the steel reinforcements (the sea sand may be use where there is not any river).
3. The sand must have sharp and hard grains so that it can resist to the aggressivity of the weather.
4. The sand must not be wetty, have clots and be sticky.
5. The sand must have a diameter appropriate to its use.

3.3 Gravels
The minimum diameter for the gravels is 5 mm while the maximum diameter is 20 mm. There are two main kinds of gravels, which are the natural gravels, originally from a river and the broken stones which are produced mecanically with a buzz stone crusher. Broken stones are more appropriate for building than natural gravels, because their shape can tie closer and stronger into the mortar. Usually, the gravels that show good properties are as follow:

1. Gravels of good quality, hard, irregular and sharp.
2. Gravels that are clean from mud (under 1%) or any other dirt that may affect the quality of the building.
3. Gravels that are proportionate between its different diameters (gradation).
3. 4 Cement
The cement that can be used for building is the Portland, or even the cement that is known as Type I. The selection of the cement must follow the listed criteria, such:

1. The cement must be stored in well clean non ripped sacks.
2. The cement must be stored protected from weather and humidity.
3. The cement must not have been wet, have clots, and started the hydraulic solidification process.

3. 5 Reinforcement steel
There are two kinds of reinforcement steel, which are the twisted and the straight steel. The twisted steel has the best properties for building because it fits tighter with the mortar. The steel that is used for making the beton structure has the best physical properties. The beton in traction can only sustain 15% of the beton in compression, which means that the steel reinforcement does correct the traction failure. For the steel to grant the force, it requires that the thickness of the steel gets properly defined. A good quality of steel is U.24 with a density of 2400 kg/cm². The properties of the reinforcement steel must have the following properties:

1. The steel cannot be rusty, flawn, nor bent.
2. The steel cannot be re-used steel.
3. The steel must have been protected from the weather and the humidity.
4. The steel must have a diameter with enough large mortar contact that can fit with the physical properties wanted for the beton.

3. 6 Bricks
The ideal brick is sized 6 x 12 x 24 cm, but the brick which are produced nowadays are usually smaller. To know if the bricks have the solidity required in the construction manuals, such foot made bricks by the village people that are in use for building walls about 1 meter high. To get bricks that resist saturated with water, before to dispose them, they must be immerge into water. While this, there are few needs you have to check:

1. The bricks must be shaped with uniform sizes, straight, and regular.
2. The bricks must have an old red color.
3. The bricks must be without any fissure nor any default (no cracks).
4. The brick must have been cooked at the proper temperature.
5. The bricks must resist to the immersion into water.

![Drawing 4. The ideal sizes for bricks](image)

### 3. 7 Water
The requirements for the water used into making the beton are as follow:

1. The water used for making beton must be as clear as rain water (have similar properties than that of rain water)
2. The water must not be colored, must not have any taste and must not smell bad.
3. The water must not have any additive that may affect the chemical process of the beton (such chemical or organic nitrates, oil, salt)

### 3. 8 Wood
The wood that fits for building must at least be Class I (Simantuk) and Class II (Meranti, Damar). The properties of the wood are as follow:

1. The wood must be dry.
2. The wood must be old enough for building.
3. The wood must not be too flawed.
4. The nodes must not be too big.
3. 9 Roof

The material which can be used for the roof is the zinc. The zinc is chosen because its load is not heavy for the structure of the building. The zinc that suits is as follow:

1. The thickness of the zinc must be significant (minimum 3 mm)
2. The zinc must not be rusty and bleed.
3. The curvature of the zinc must fit with the design.

4. CONSTRUCTION

4. 1 Fondations

The foundations are the part of the structure which is closest to the ground and its fonction is to distribute the loads equably on the ground. The foundations must be displace on a ground which is hard. The minimum laying inside the ground is 60 cm. The disposal of the grindstones must be massoned with a mixture of cement and sand (grout) in a proportion of 1 cement to 4 sand. The grindstones once layed on the sand and aanslanding layers must be fully buried with compacted earth. The foundations must also strongly fit with the girder, and the jonction between the girder with the ground is layed with at least one metter high for the foundations. To get a more efficient description, see the drawing that follows:

![Drawing 5. Foundations footing](image)
4. 2 Beton

The beton that is used for making reinforced beton is proportionated with 1 cement, 2 sands and 3 gravels. The water which is used is ½ the volume of cement (FAS 0.5). The proportions are that of the volume containers. The equipment for measuring must be easy to find such a bucket or a bailer. The quality of the beton that is made with the mixture must reach 150 kg/cm² density.
4. 3 Moulded Beton (Moulds)
The properites for moulded beton are as follow:

1. The disposal of the mould must be steady and strong so that it can outlast the vibrations for compacting the beton.
2. Each realisation must minutely be repeated to reach the quality of the production needed.
3. The production of the moulded beton must be done with clean moulds and good materials so that the production does not suffer any damage while taking off the mould.
4. The moulded beton can be open after 28 days. While the beton has not yet reached full hardness, it must regularly be hosed with water (hydrolification).

Drawing 8. Mould
4. 4 Reinforced Beton

Reinforced beton is the most important feature of an paraseismic dwelling. The quality of the realisation must be very carefull. The use of the equipment, such moulds and vibrators for making reinforced beton must be advised and trained. To make the reinforced structure (curtain walls, sloof, beams) becomes one single structure which is tighted and regular, means that the frame must be very carrefully realised. The steel frame that is used for reinforced beton must have a minimum diameter of 12 mm, with a range of variable dimensions. A frame sample is developped with the following drawings.

The main use of reinforced beton is divided in two, which is columns/pilars and beams. A sample of dimensions for a reinforced structure is as follow:

1. Girder 15 x 20 cm
2. Main colomn 15 x 15 cm
3. Secondary column 13 x 13 cm
4. Belting structure 13 x 15 cm
5. Truss timbers 13 x 15 cm

Drawing 9. Distribution of the reinforcement between the foundations and the girder
4.5 Steel framing hooks

The steel framing hooks have a function to ascertain that the bones always keep straight (do not pierce) when there is an earthquake. The framing also acertains that the concrete won’t crumble (won’t crack) while occurring an earthquake. The minimum diameter that can be used for framing hooks is 8 mm. The angle bending the hook has a minimum of 45°, with a diameter at least of 10 mm as shown drawing 12.
below. The disposal of the hooks with the bones must also be alterned quincunx such not having a node in only one side of the framing (see drawing 13).

![Drawing 12. Hooks that are correct (a) compared with hooks that are not correct (b)](image1)

Drawing 12. Hooks that are correct (a) compared with hooks that are not correct (b)

![Drawing 13. The good quincunx disposal for the hooks](image2)

Drawing 13. The good quincunx disposal for the hooks

4. 6 Brick walls
The mortar that can be used to fix the bricks is made of grout with 1 proportion of cement for 4 of sand. For the areas where water may affect the solidity of the grout, the mixture is lowered to 1 proportion of cement for 2 of sand. To tight the bricks with the reinforced pilars and beams of the structure, there must have steel anchors each 50 cm with the length of 30 cm and a minimum diameter of 8 mm. Before the
disposal of the bricks, they must have been immerge into deep rain water such the bricks get saturated with the water. Between each layer of bricks, there must be at least 1 cm of layer grout.

Drawing 14. The fixation of the bricks with the pilars

4. 7 Sealer and plastering
Before plastering the walls, columns, beams and pilars, they must be springkeled with water until full retention. All the surfaces must also be correctly cleaned up before starting plastering.

4. 8 Openings
To fix the woodframing for windows and doors, there must be used anchors to tight the frame with the structure. Because the woodframing does not have any stress resistance, there must be a header beam upper all openings, such the openings can really resist to the loads distribution.
4. 9 Roof truss
a. Wooden truss
To make an eave that resists the loads, the wooden truss must be tight with steel anchor that already had been fixed into the masonry of the pilars/columns. The connection between the roof truss and the footing must carefully follow a methodology that is perfectly adapted to the seismic factors. To avoid any weakness during a quake, the structure must be triangulated. For more explanation, see the following drawing:
b. Masonry truss (Gable)

The Masonry truss is being framed with reinforced beton. Big walls cannot be too large, otherwise intermediate columns must be added to the structure.

Drawing 17. Gable with dimensions

5. CONCLUSION

We hope that the Paratiseismic Housing Guideline will be usefull nonetheless to the population of Aceh, but also the population of Indonesia as a whole. Your critics are immensely welcome to help us progress together.