STUDY THE TRADITIONAL JOINT OF BAMBOO HOUSES IN THE EARTHQUAKE AREAS BY TILTING TABLE

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Most of the earthquake that occurred in Indonesia destroying **non engineer buildings** which had been built without calculated the strength and safety.

**Caused by:** *error construction* was not appropriate with the rule of structure endure earthquake and *Variety of the materials used.*
of the house with **bamboo construction** slightly damaged and it was not collapsed although the connection system that used simply rope string and dowel/pin connections) bamboo or wood that is legacy of our great-grandparents.
Bamboo can tolerate high values of deformations in the elastic range i.e. possesses high elasticity. Therefore bamboo houses when properly constructed are ductile i.e. being able to sway back and forth during an earthquake, without any damage to the bamboo poles. The construction materials for building a bamboo house should be readily available and accessible. The bamboo based house has a very low weight therefore foundation can be minimized.

In 1980 Jakarta and Surabaya that 41.5% of dwellings of the low income groups were still being constructed from bamboo.
We tried to perform experiments on the strength of traditional connections in a bamboo house.
BAMBOO

Bamboo is one of the countries with the largest bamboo resources in the world. Nowhere, however, is bamboo of greater importance than in building construction.
TYPE OF BAMBOO

Awi duri atau bambu duri
Awi tutul
Awi krisik atau bambusa multiplex
Awi bitung atau bambu betung
Awi ampel (warna kuning) .. haur koneng
Awi Awi cangkoreh Awi tali atau bambu tali
Awi hideung atau Bambu hitam
Awi temen atau bambu ater
Awi Tela atau awi Lengka atau Bambu Lengka
Awi Gombong atau bambu Gombong
Awi mayan atau bambu mayan
Awi eul – eul
Awi Tali Koneng atau Bambu Lemang.
Awi Tamiyang atau Bambu Suling
Awi Jepang atau Bambu Bangkok

AWI = BAMBOO
BAMBOO BETUNG

BAMBOO ROPE/STRING
Strength of Bamboo

- Gombong bamboo
- Tali bamboo
- Mousou bamboo

Field taftness of steel

Time (minute)

Field taftness (MPa)
THE APPLICATION and TESTING OF DOWEL/PIN

Penggunaan pantek dalam sambungan sederhana

Pengujuan keteguhan tarik sambungan pantek pada bumbu
Test result

Bolt 12 mm diameter

Bamboo dowel 12 mm diameter
Identification of Seismic Sources

The dot represent the epicenters of earthquake with magnitude, $M_s \geq 5$
PETA WILAYAH GEMPA INDONESIA SNI 2002
EARTHQUAKE ZONE OF INDONESIA 2010
TEST EQUIPMENT FOR BUILDING STRUCTURE

REACTION WALL

TILTING TABLE
TILTING TABLE

Length ........................................... = 700 cm
Width ............................................. = 800 cm
Thickness of the table plate = 8.8 mm
MODEL OF SPECIMENTS

- **Size** = (6 x 6) m
- **Height of ceiling** = 2.6 m
- **Column and trusses included purlins use:** Bamboo betung ø 12 cm.
- **Bracing beams:** String Bamboo (bambu tali) ø 10 cm
- **Joint connectors:** coco rope and dowel/jig from bamboo.
- **Roofing covers:** corrugated zink
CONNECTION SYSTEM

- A
- B
- C
- D
- E
- F
- G
- H

- Trusses
- Rafter
- Top beam
- Column
- Foot foundation
- Connection system
- Pengaku
- Slope
FOUNDATION FOR TESTING SAMPLE

Steel plate
Screw bolt
The lateral forces will activate if the table is moved by tilting to the left and right. Power is driven with two hydraulic jacks with a capacity of 60 tons. The lateral force of gravity equals the weight of the mass of the building when it is moved. All of the data from all of the processed transducers mounted on all of the joints between components.
METHODE OF TEST

The loading step:

Step 1 = 0° - 6°
Step 2 = 0° - 12°
Step 3 = 0° - 18°
Step 4 = 0° - 24°
Step 5 = 0° - 30°
Step 6 = 0° - 42°
Transducers Tr-10, Tr-9, Tr-8, Tr-5, Tr-4, Tr-3 which located in the foundation parts and in slope direction of the building can be represented for the results.

Displacement of the frame construction determined 1.5% from the ceiling height = 1.5% x 2.60 m = 3.90 m.

Transducers Tr-10, Tr-9, Tr-8, Tr-5, Tr-4, Tr-3 indicates the displacement be read < 3.9 cm after the end of testing (slope reach 42°).

This mean the building is earthquake resistant category. With a plain of view, there are not severe damages in all of joint between column and trusses components. The quality of bamboo still in a good condition although because we selects qualities of all bamboo before used like age of bamboo must be 3 years and water contents less the 15%.
Not all behavior of the transducers clear to be read because some reasons as explain from the diagram of the relation between displacement and lateral forces below.
Loading test was carried out in the cross section same as structure analysis calculation and in this direction the shear strength of building supported by four (4) portal trusses. 

- Same as some previously test for masonry houses the building safety determined = 3 to anticipate the difference quality works and building materials used (in laboratory and fields).

- The result of testing based on data logger and computer calculation maximum response spectra = 0.67 G.

- Using the Building Planning Resistant Code SNI 03-1726-2002 explains that this house model can be built on all of earthquake zone (hard and soft soil).
CONCLUSION

The connection use coco rope and bamboo dowel is a good system for materials with tubular shapes in particular bamboo,

The structures design is available used in earthquake areas because the test result shows the displacement < from 3.9 cm (1.5 % from the height of ceiling = 2.60 m) and in plain view the frame construction still in a good condition (not crack and collapse) up till the testing finish.

Bamboo can tolerate high values of deformations in the elastic range i.e. possesses high elasticity. Therefore bamboo houses when properly constructed are ductile i.e. being able to sway back and forth during an earthquake, without any damage to the bamboo poles.

The quality of bamboo must be more then 3 years old and the water contents < 10 % because very influence the construction strength.
ACKNOWLEDGMENTS

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THANK YOU
BAMBOO SPECIFICATION

Tensile strength varying results from 1000 – 4000 kg/cm²
Compression strength varying result from 250 – 1000 kg/cm²
Bending strength varying result from 700 – 3000 kg/cm²
Dulus elasticity varying result from 100.000 – 300.000 kg/cm².
The response spectra earthquake

<table>
<thead>
<tr>
<th>Condition</th>
<th>Earthquake Zone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil</td>
<td>1</td>
</tr>
<tr>
<td>Hard</td>
<td>C = 0.33</td>
</tr>
<tr>
<td></td>
<td>Ok</td>
</tr>
<tr>
<td>Soft</td>
<td>C = 0.38</td>
</tr>
<tr>
<td></td>
<td>Ok</td>
</tr>
</tbody>
</table>

Note:
- C = Coefficient of earthquake, calculate by gravitation
- Ok = Building in the elastic condition
- Δ = Building in the inelastic condition
- X = Building is collapse

(SNI 03-1726-2002)