ITB
21 Juli 2017

Bamboo Construction:
Research and Exploration

Dr.-Ing. Andry Widyowijatnoko

School of Architecture, Planning and Policy Development
Institut Teknologi Bandung
Indonesia

1999…fall in love at the first sight…

Ex-sugar factory in Jatiroto, Lumajang, East Java, built in early 1900

Pictures were taken in 1999

- bamboo workshop and erection process

plastered bamboo construction
pasir impun - bandung

plastered bamboo construction

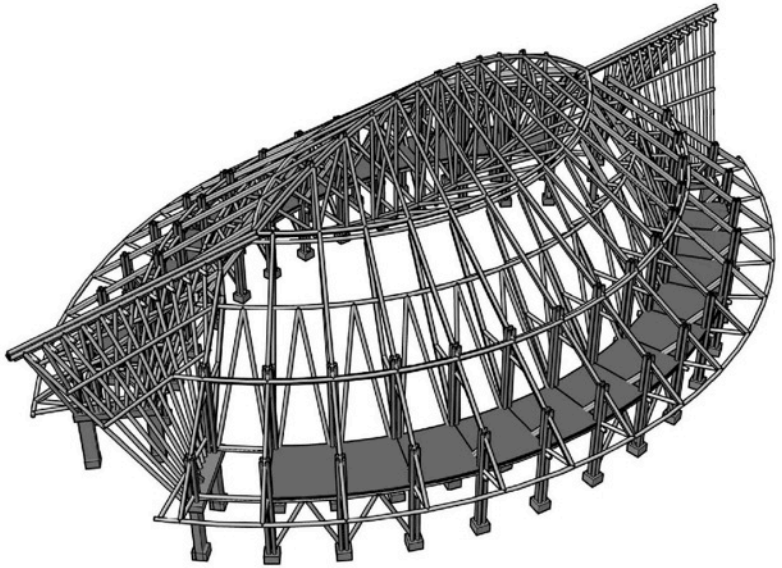
2006 > turning point

journey to Colombia


Outward
Bound
Indonesia

great hall OBI

- 20x31 m free column
- 8000 bamboos

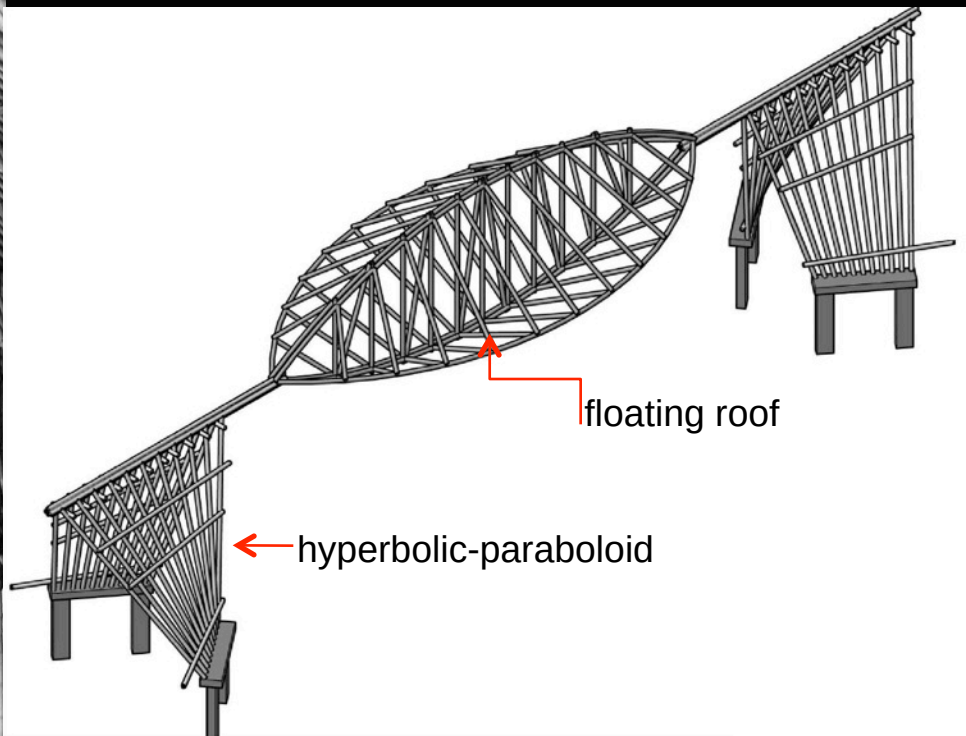


a product of green design

- local bamboo as main building material, coco-palm fiber and thatch as roof cover
- combination between local wisdom, technique with modern structural design
- *skylight* for natural lighting

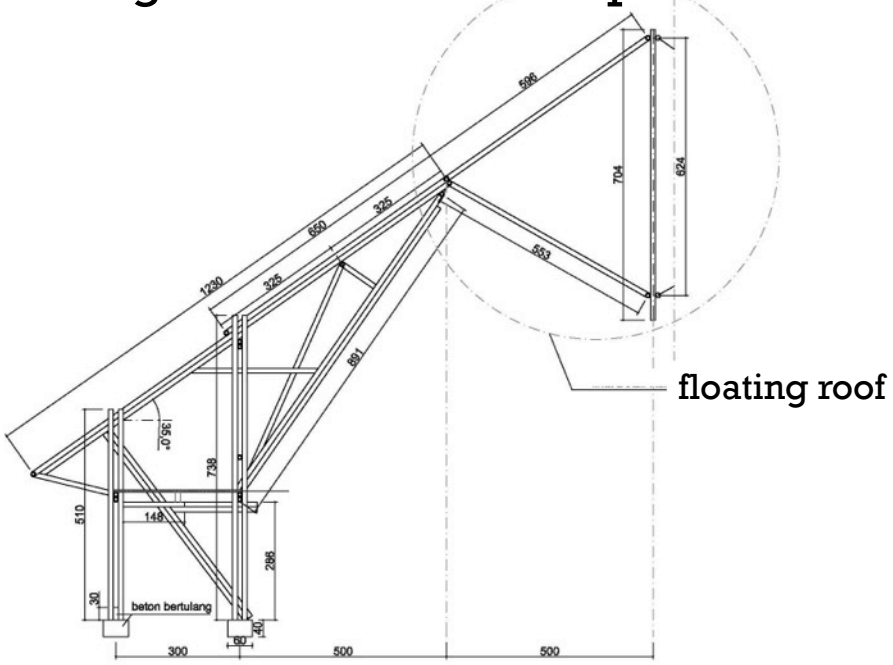
a breakthrough on Structural Design

- *floating roof* for wide span
- *bamboo hyperbolic-paraboloid as main entrance*



a creative Construction Method

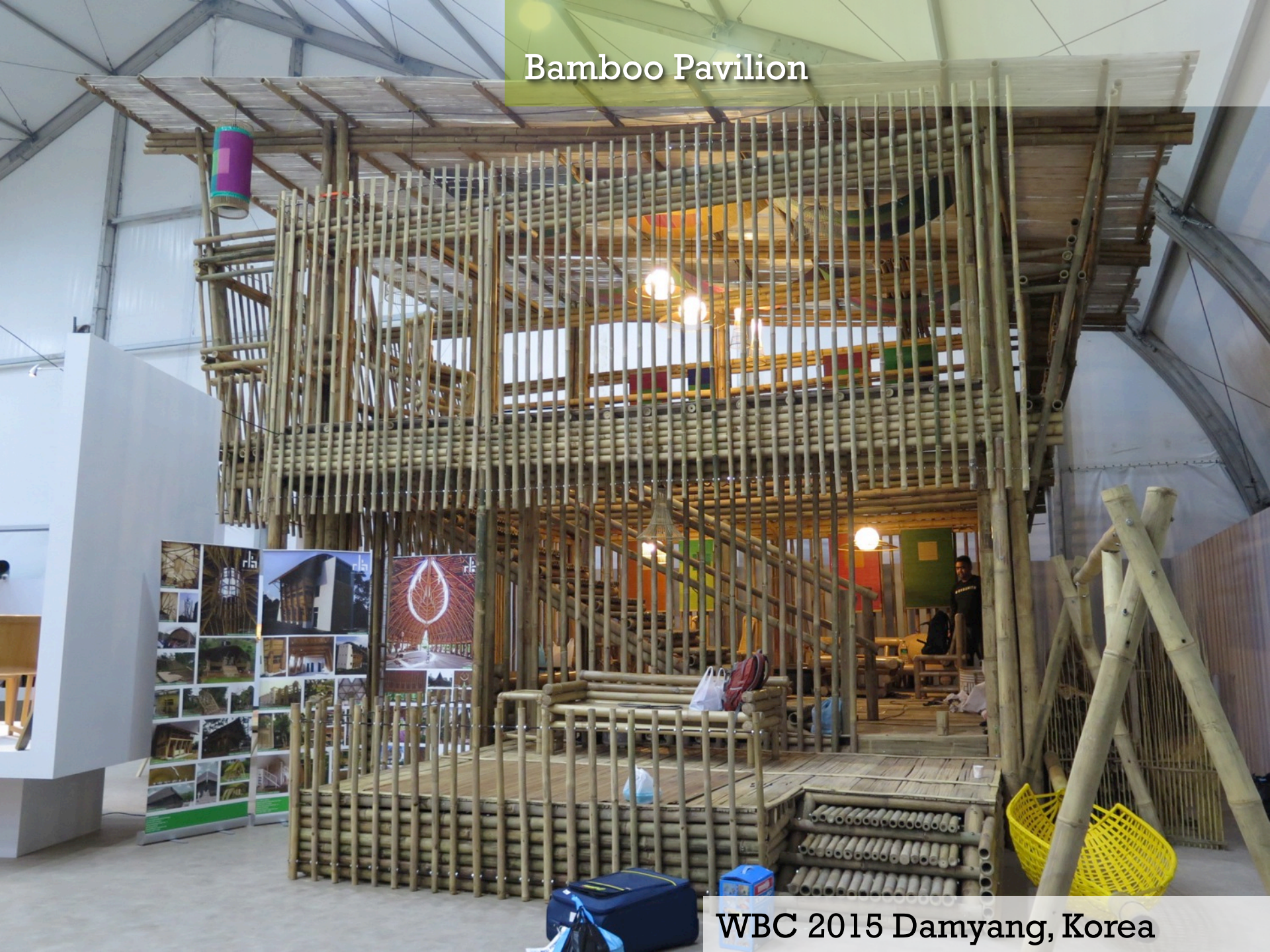
- 30 pieces of 2D frame, formed in horizontal position on the ground for ease of workability
- using modern bolted joint, combined with traditional lashing
- 2D frames should be erected radial forming a kind of boat shape




Eko Purwono

Great Hall OBI, Jatiluhur


THERE IS MORE IN YOU THAN YOU THINK
TO SERVE TO STRIVE AND NOT TO YIELD


Bamboo Pavilion
WBC 2015 Damyang, Korea


Bamboo Pavillion
WBC 2015 Damyang, Korea

Mother and Child Healthcare

Jatiluhur, West Java

Mother and Child Healthcare

Jatiluhur, West Java

Mother and Child Healthcare

Jatiluhur, West Java

Pulau Bawah Hotel and Resort

Pulau Bawah Hotel and Resort

Pulau Bawah Hotel and Resort

2009-2012 > going deeper

research on traditional and innovative joints in bamboo construction
in rwth aachen germany

+ 2016

joint research with fh erfurt germany

Bamboo Joints*

existing bamboo joints

*Andry Widyowijatnoko, Traditional and Innovative Joints in Bamboo Construction

Bamboo Joints: New Classification

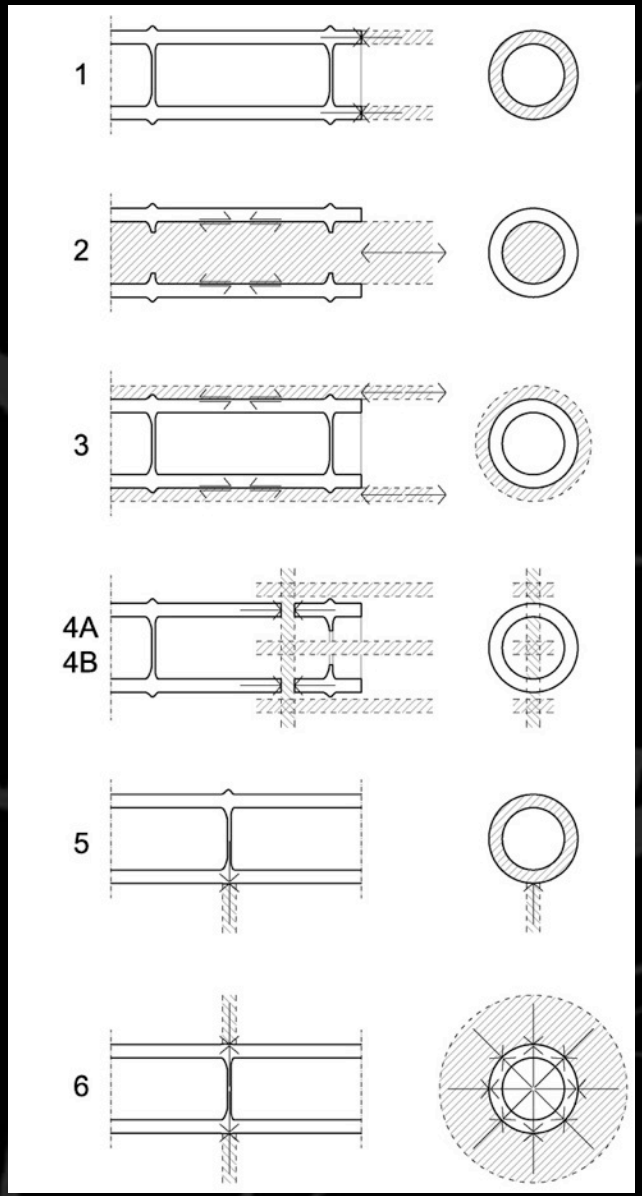
Classified by Janssen as one joint in Group 1, classified in new classification as two joints in Group 1 and Group 5

Based on following criteria:

- The ways of force transfer
- The position of the connector: attached in the inside or on the outside of the poles, and attached parallel or perpendicular to the fibers
- A type of joint is considered as a connection between one bamboo and its connector or supporting base.

  It is different with the classification by Janssen, which mostly define a joint as a connection between two bamboos

Classification of Bamboo Joints: Basic Principles



1. Transferring compression through contact to the whole section

2. Transferring force through friction on the inner surface or compression to the diaphragm

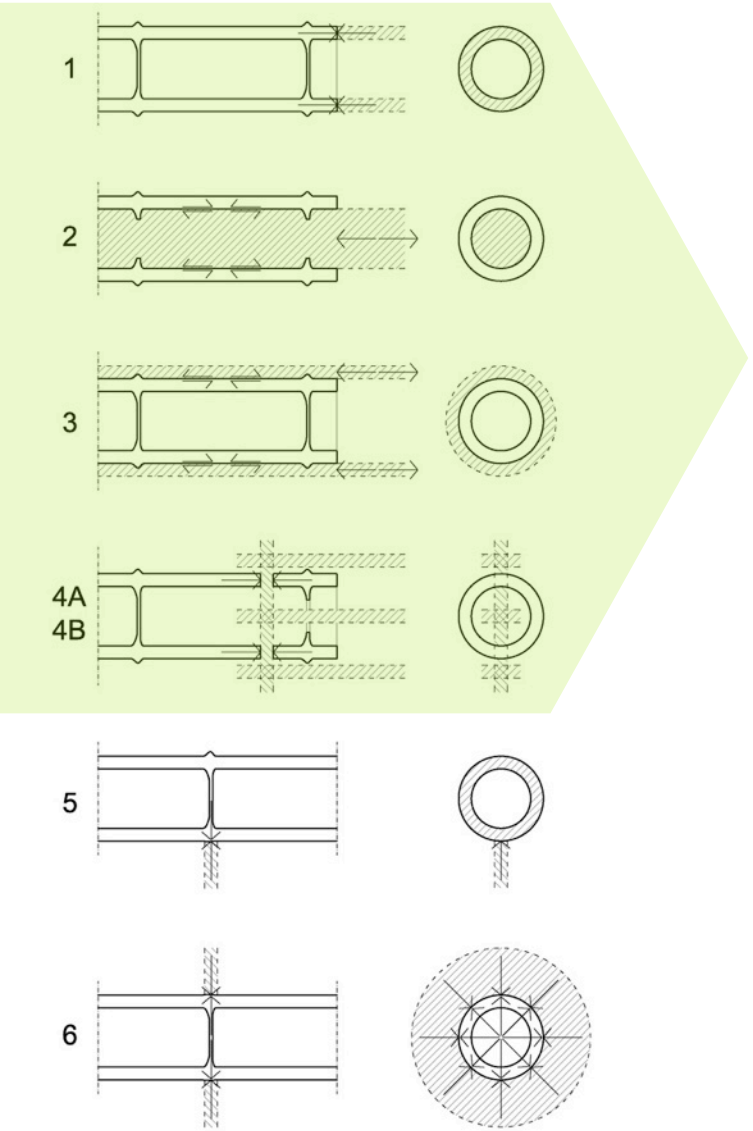
3. Transferring force through friction on the outer surface

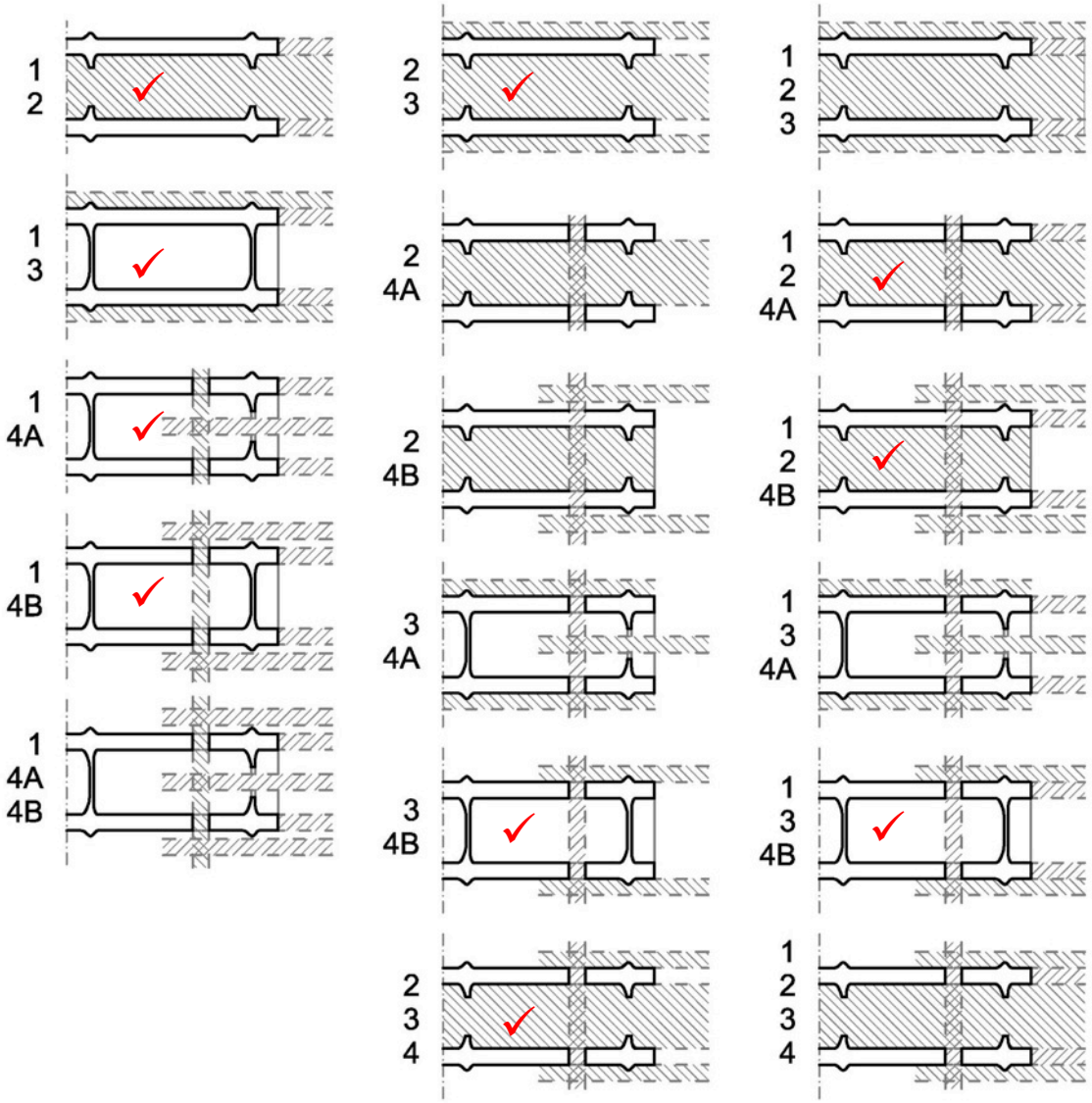
4. Transferring force through bearing stress and shear to the bamboo wall from perpendicular element connected from inside (4A) or outside (4B)

5. Transferring force perpendicular to the fibers

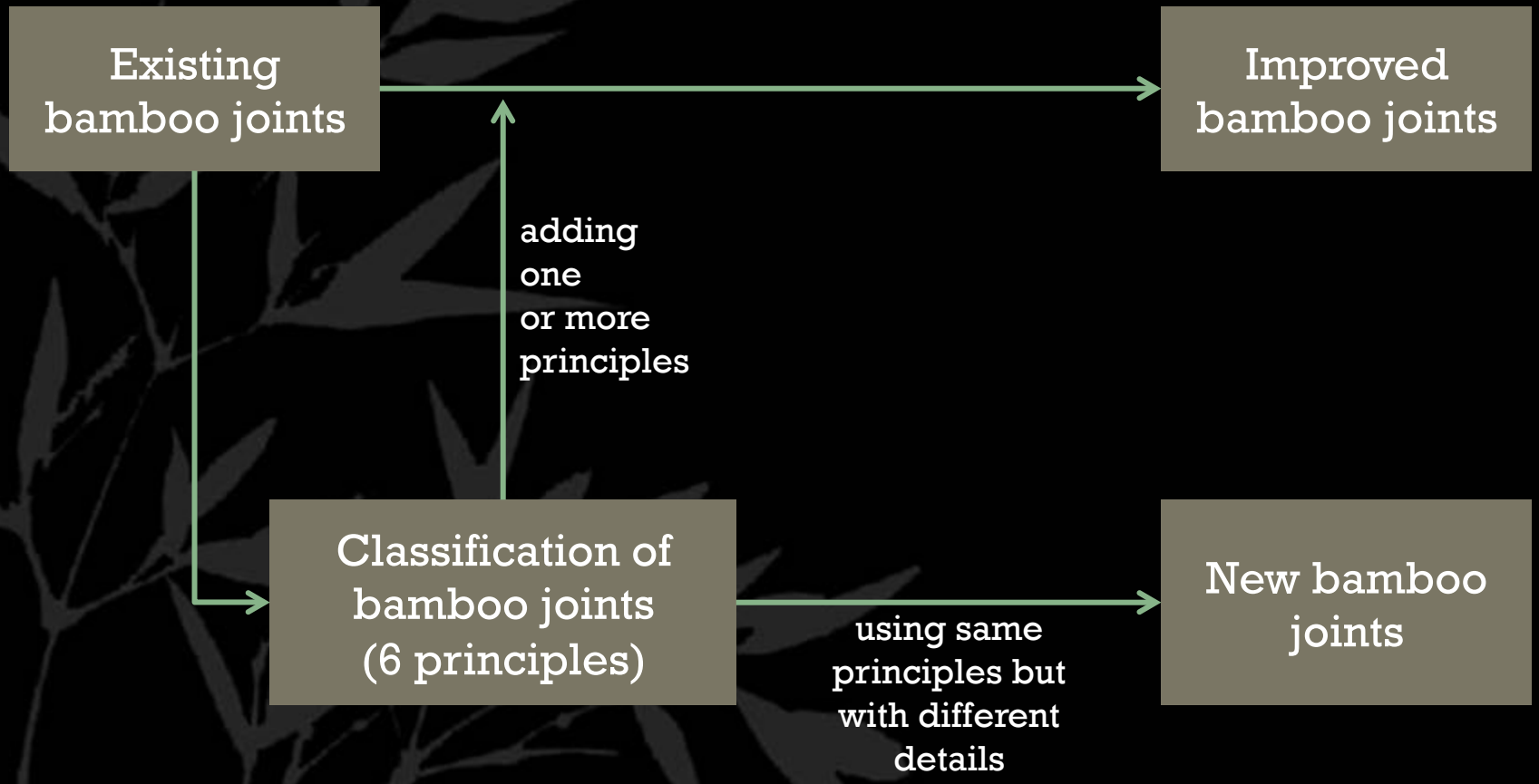
6. Transferring force perpendicular to the fibers to the center of the pole

Combination of Basic Principles



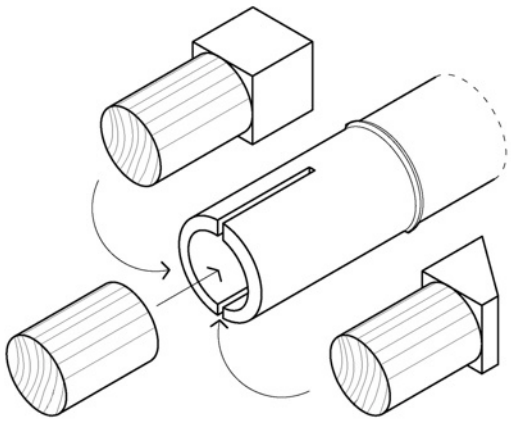


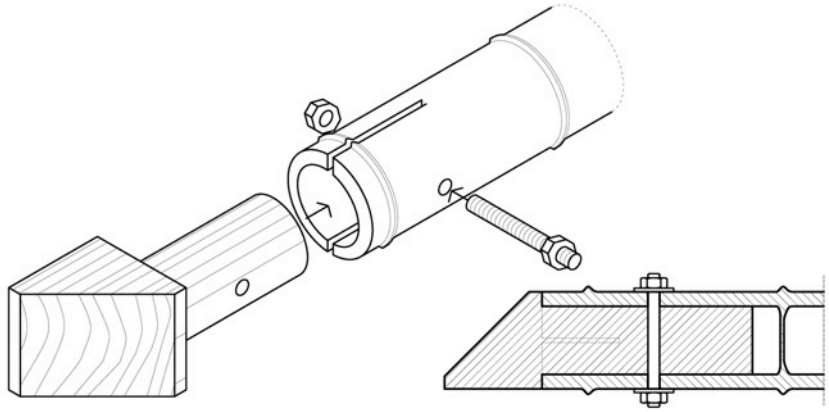
The Use of Bamboo Joint Classification

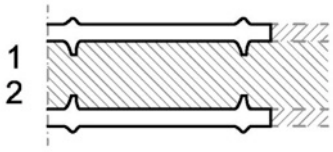


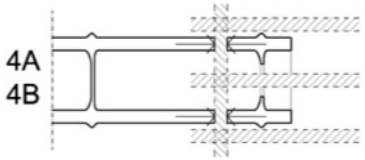
The Use of Bamboo Joint Classification

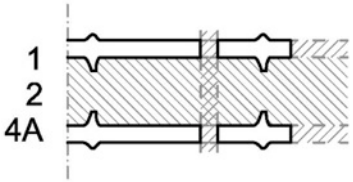
Bamboo joint by Arce + Adding another principle = Improved Arce's joint









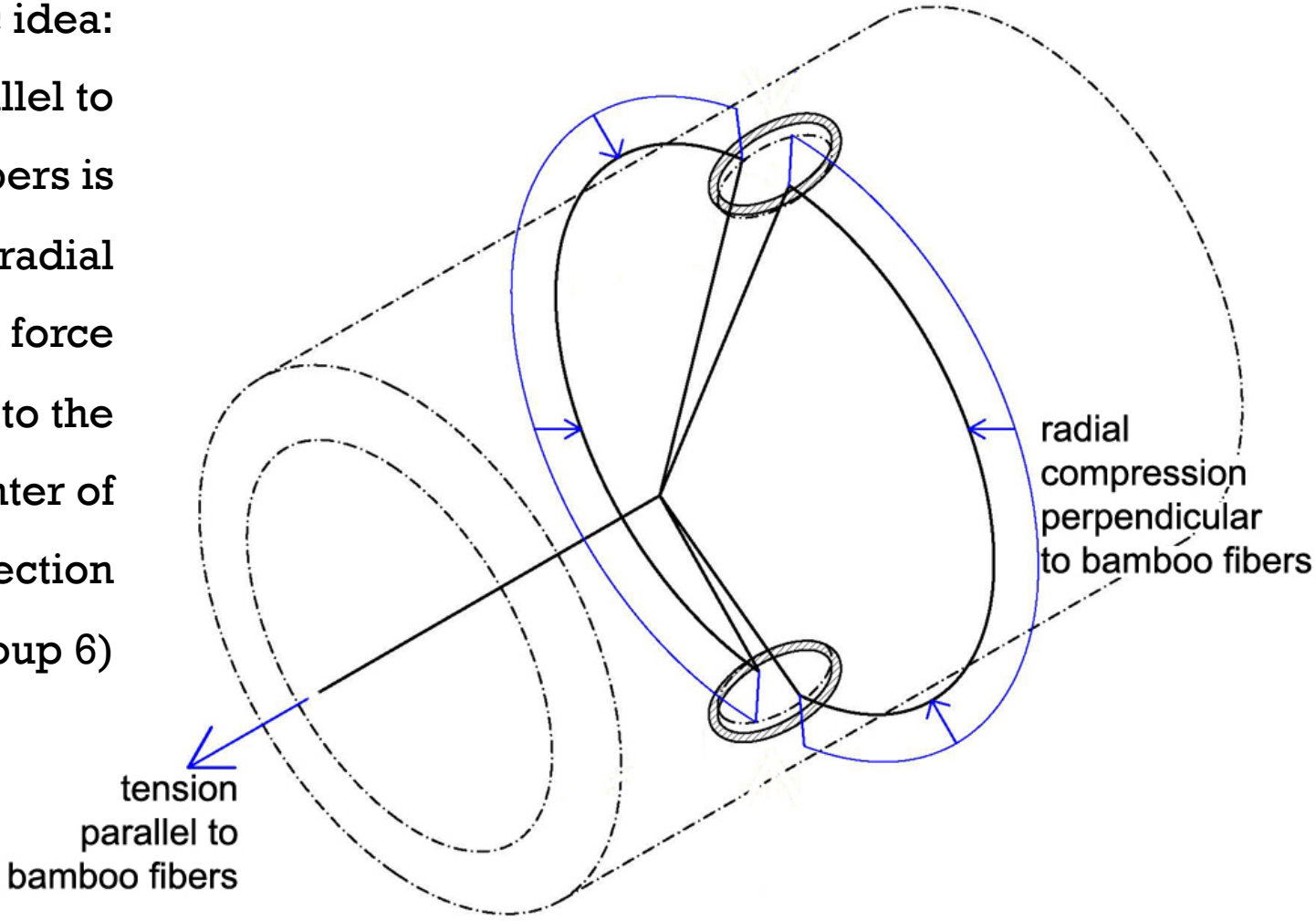


Development of Bamboo Joints: Basic Idea

Basic idea:

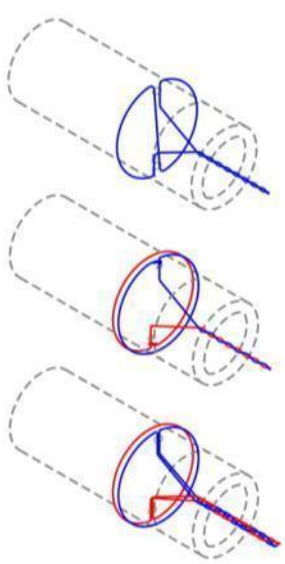
tension force parallel to bamboo fibers is converted into a radial compression force perpendicular to the fibers to the center of bamboo cross section

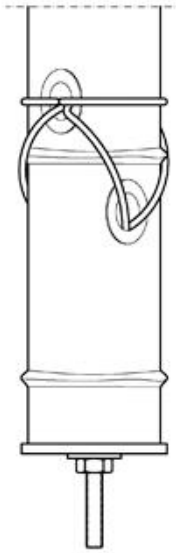
(Group 6)

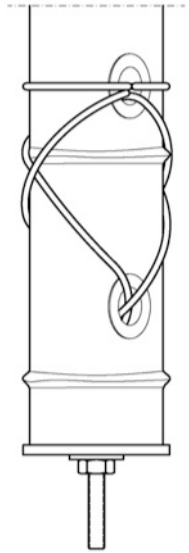


Development of Bamboo Joints

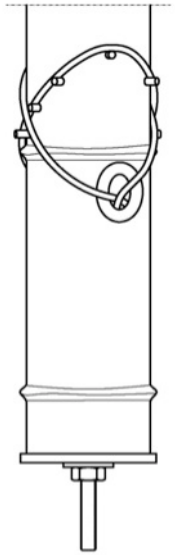
Lashing Configuration

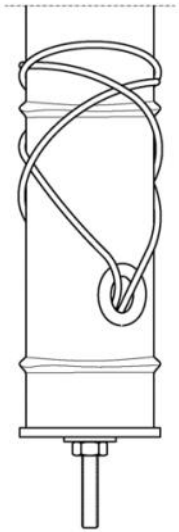


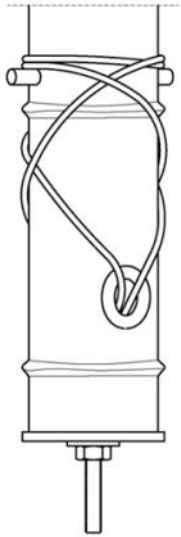




Lashing configuration to spread the force into wider surface area on the bamboo and/or more holes

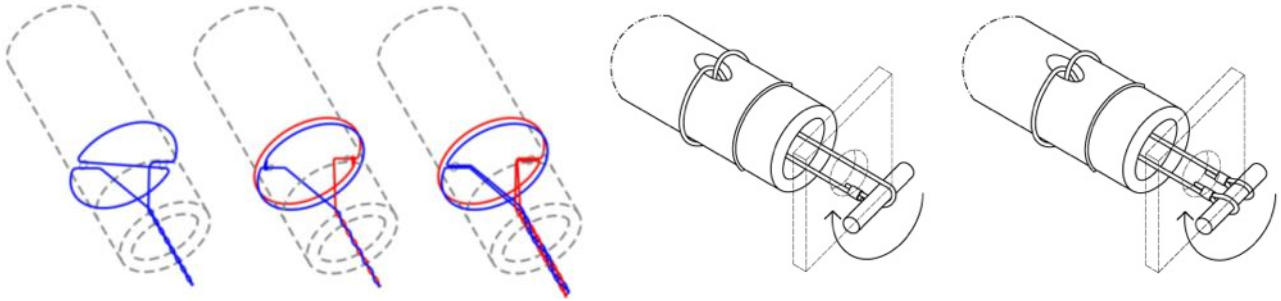




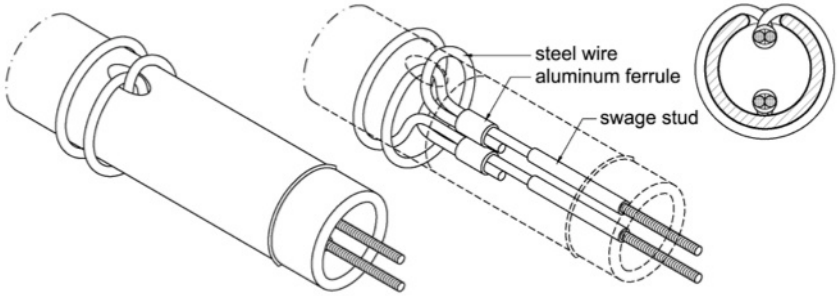


Development of Bamboo Joints: End Connector

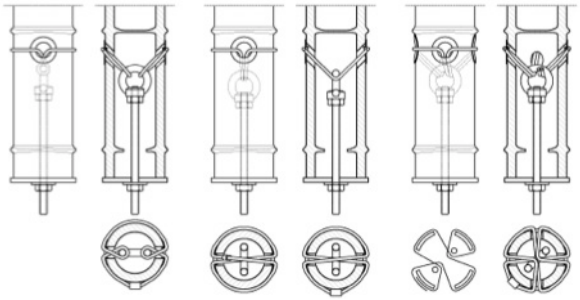
Twisting as post tensioning



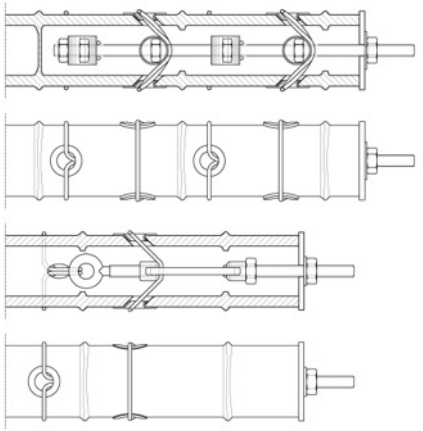
Using swage stud terminal



Using eye-bolt

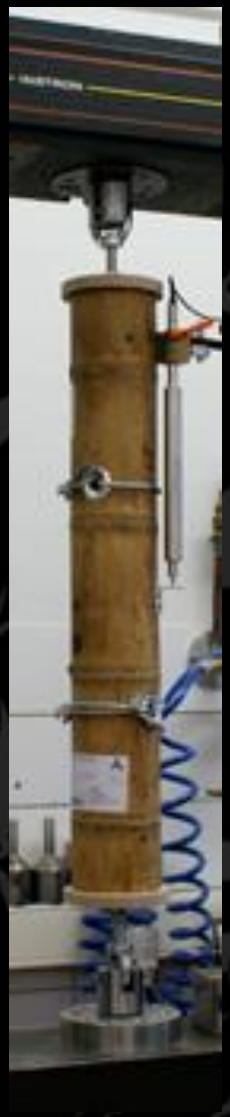


Using multi knots



Development of Bamboo Joints: Tests

1



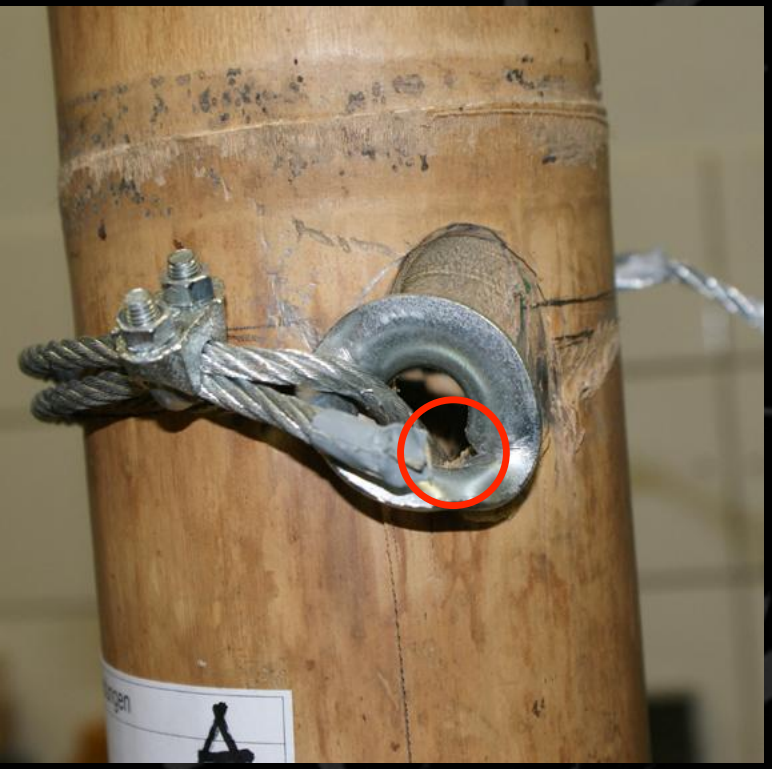
2

3

Three types of test:

1. Radial compression tests on bamboo tubes
2. Tension tests on bamboo joint with eye-bolt
3. Tension tests on the improved joints

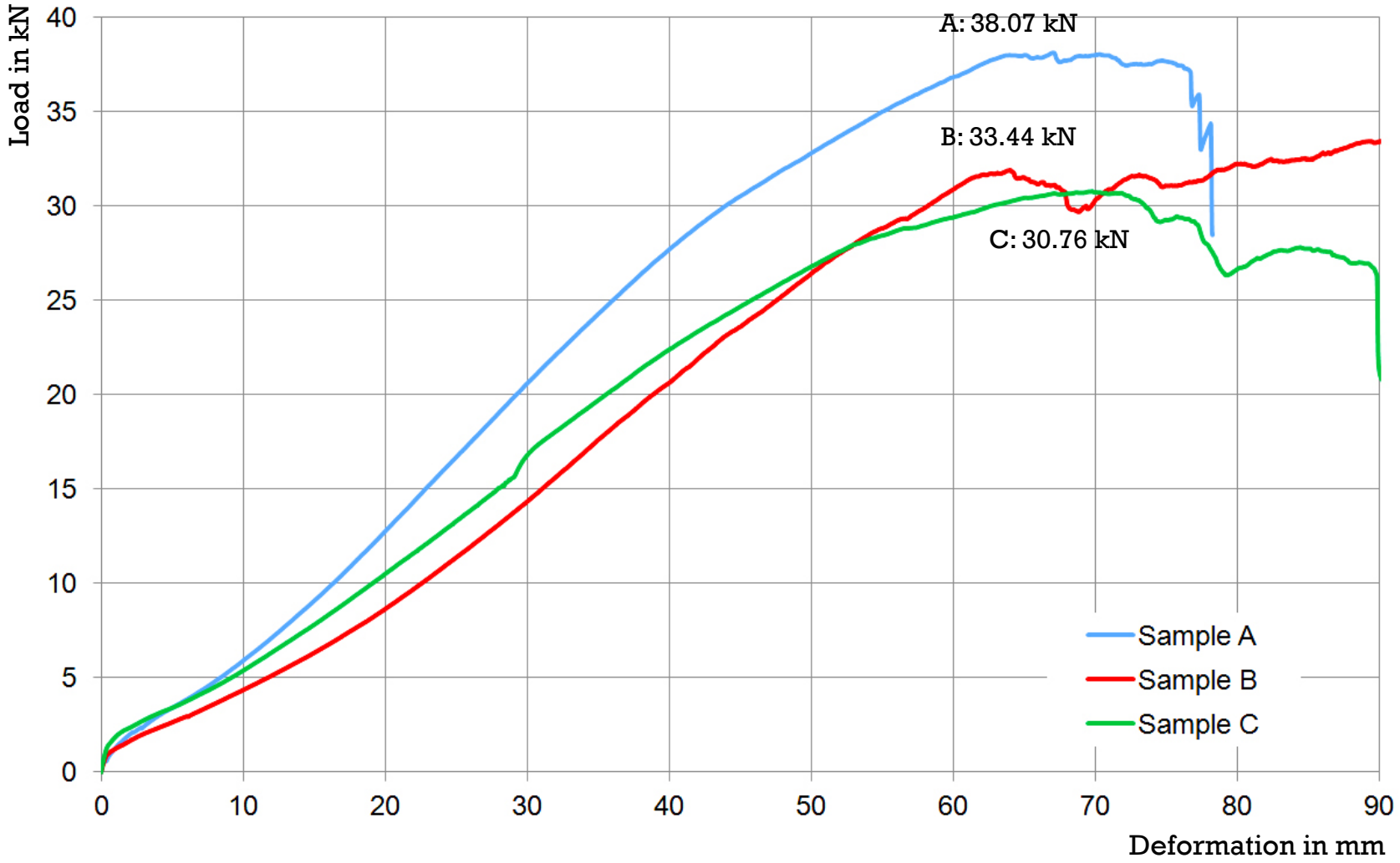
Tension Test on Barcom Joint: Failures



The wire tore the ring and caused a V-slice with sharp edges that later cut the wire

The rings slipped into the holes and the wire sliced the bamboo, started from the edge of the holes

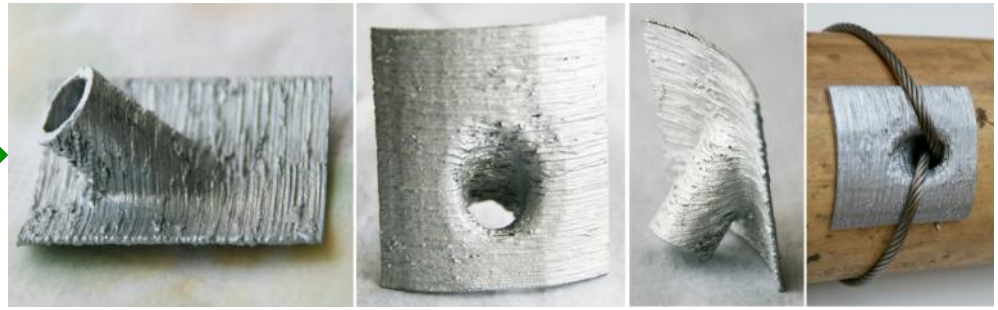
Tension Test on Barcom Joint: Result



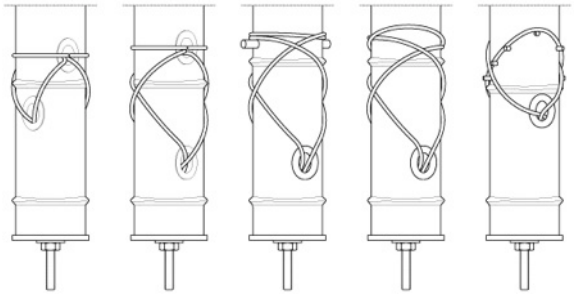
Average ultimate-load capacity 34.09 kN

Development of Barcom Joints: Improvement

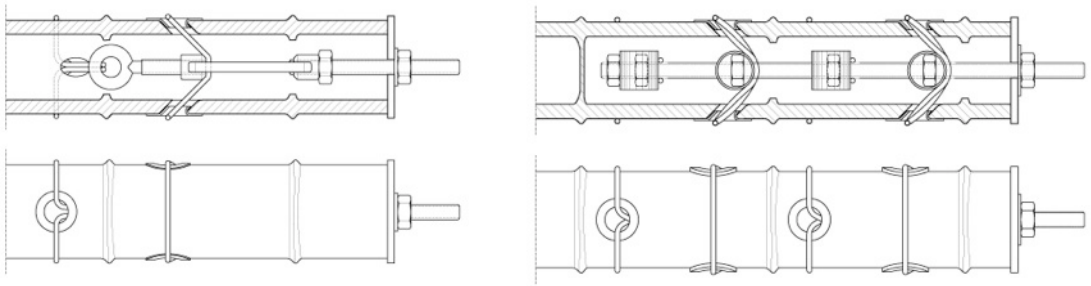
Using improved rings



Using better lashing configuration

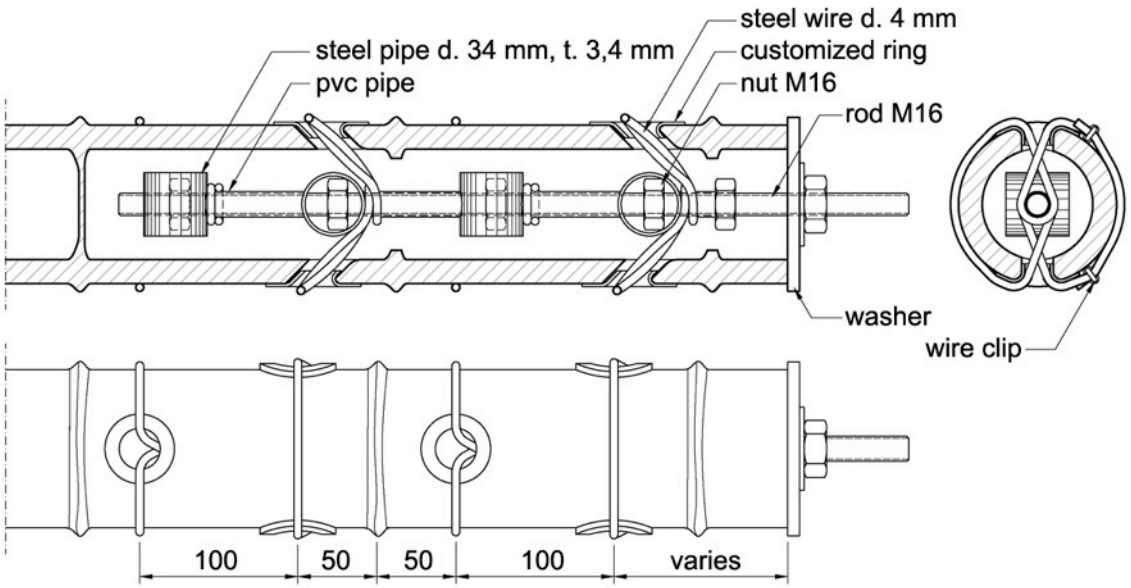


Using multi knots



Barcom Joints with Multi-knots

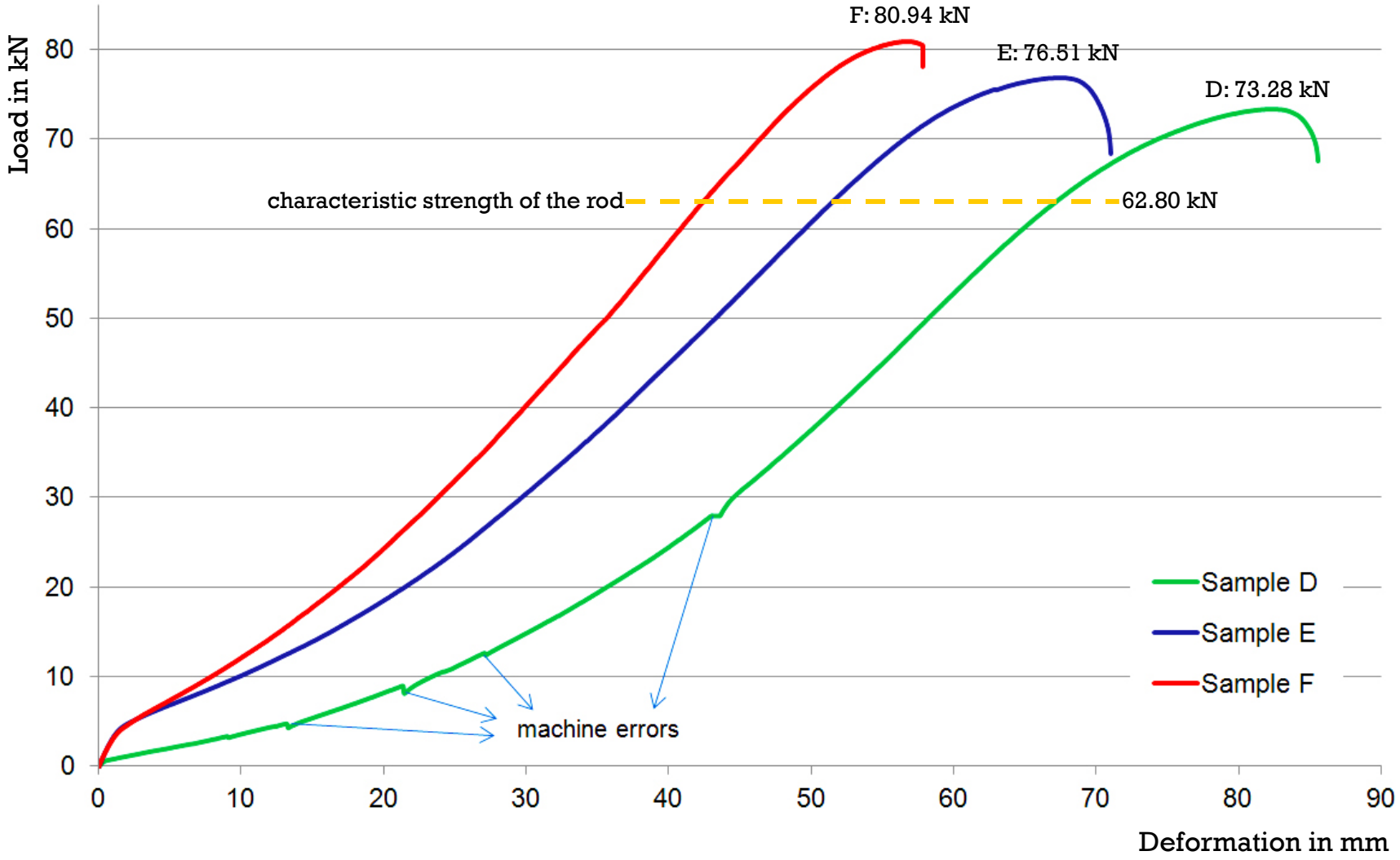
- Three samples D, E and F
  - Six typical joint 1 to 6
- *Guadua angustifolia* with 5 nodes or 4 complete internodes in each sample
  - 4 knots each joint
  - 2 knots each internode
- M16 Rod class 4.6, characteristic strength 62.80 kN
  - Steel pipe as cross dowel



Barcom Joints with Multi-knots: Failures

All tests showed similar failure in the breaking off the rod with only light scratches on the bamboo skin and the rings

Barcom Joints with Multi-knots: Results



Average load capacity: 76.91 kN

Development of Lashing Configuration FH Erfurt, Germany 2016

Joint Research

Cross lashing joint on:

- Gigantochloa apus
- Guadua angustifolia

Traditional and innovative Joints in Bamboo construction

Autor: Andry Widyowijatnoko

Auflage: 1

Seiten: 190

Einband: Paperback

ISBN 13: 978-3-86130438-4

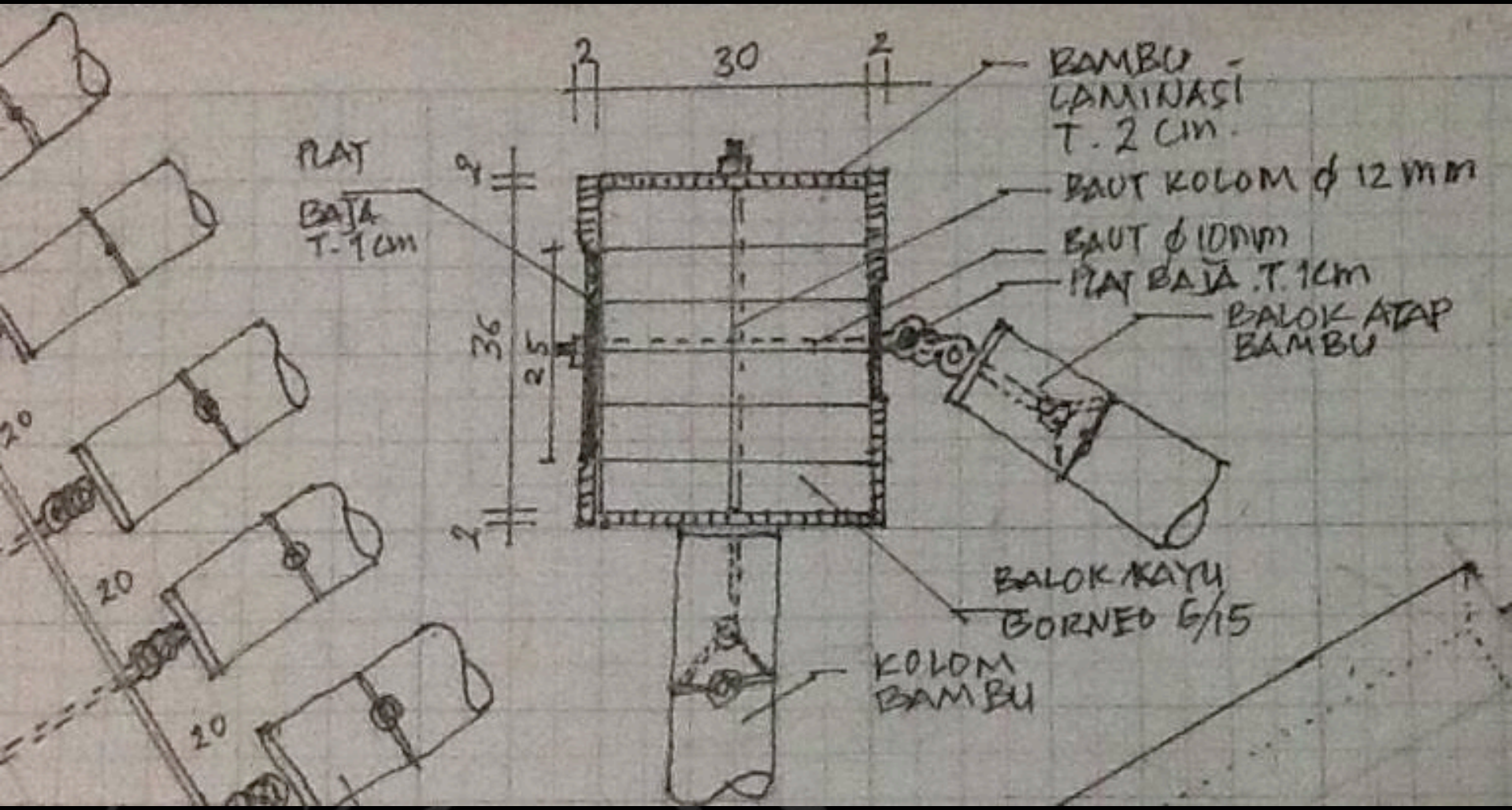
Preis: 49,00 EUR

inkl. 7% MwSt

zzgl. Versandkosten

Application: Three Mountain Building

Application: Three Mountain Building



Application: Three Mountain Building

Application: Tensegrity Structure

pagoda
rwth aachen germany 2011

2012 > going further

new approaches to design bamboo construction

tensegrity -

reciprocal frame -

parametric design approach -

Bamboo Reciprocal Frame

Bamboo Tunnel Toraja

Bamboo Reciprocal Frame

Bamboo Tunnel Toraja

Bamboo Reciprocal Frame

Bamboo Tunnel, Parongpong

Bamboo Reciprocal Frame

Reciprocal Frame,
Summer Camp ITB-UII

Parametric Approach on Split BC

Parametric Approach on Split BC

Parametric Approach on Split BC

Bamboo Geodesic Dome

WBC 2015 Damyang, Korea


Bamboo
Geodesic
Dome


국립공원 자원봉사

Tensegrity

9 bamboos
hasso-plattner institute germany 2012

tensegrity bamboo wheel
creative market
south tangerang 2015
with nusantara bamboo academy

Tensegrity

tensegrity bamboo wheel
creative market
south tangerang 2015

Tensegrity

bamboo tensegrity dome as
meeting hall
jcc 2014

Tensegrity

bamboo tensegrity dome as
meeting hall
jcc 2014

Tensegrity

bamboo tensegrity dome
as meeting hall
jcc 2014

Tensegrity

Tensegrity Lamp

Tensegrity

tensegrity bamboo hypar
summer camp itb-uii 2015
bamboo n parametric design

bamboo tensegrity needle tower and dome
itb 2015

Tensegrity

tensegrity bamboo dome
institut teknologi bandung

Tensegrity - Rection

reciprocal tension – indonesialand 2016
institut teknologi bandung

reciprocal tension – indonesialand 2016
institut teknologi bandung

terima kasih
thank you
salamat po
muchas gracias

griya AWi
under construction...

andry@ar.itb.ac.id
a.widyow@gmail.com