Bio-based Prefab Construction in Bandung

Designing an affordable prefabricated housing system for the rapid and low-cost construction with Bio-based and Recycled material

aE Intecture Graduation Studio  |  P5 Presentation  |  July 10 2018
Liang Guo 郭亮
Content

/1 Site Intro.
/2 Research
/3 Analysis
/4 Design Framework
/5 Design
Site Intro.
PT Kahatex
- Manufacture Textile and Garment
- Employ more than 16,000 Workers

RW2 & RW12, Cigondewah
- Around 50% Migrant Workers
- 742 Families, > 3000 Residents
- 66% of Families earn < Rp. 6,750,000 per Month (450 Euro)
Kampung Housing (Self-built)
- High density and poor quality
- Meet the basic need for living

Commercial Residence (Formal)
- Huge gap between demand and supply
- The majority of people cannot afford
In-Between Housing

- Reduce Cost?
- Improve Quality?
- Prefab? (Faster Construction)
Research
Different Construction Methods

Material  
Element  
Panel  
Module

degree of prefabrication

Non-Load Bearing  
Load Bearing

less  
more
Different Construction Methods

On site construction
- First choice to build a house
- Available concrete and brick material
- Affordable and mature
  ▲ Noise and environmental effect
  ▲ Obvious time and labor input

Modular construction
- Time and labor saving
- Little on site work
- High degree of completion
- Excellent for repeating units
  ▲ Almost impossible to be delivered inside Cigondewah
Different Construction Methods

Non-Bearing Panel construction
- Easy to upgrade / replace panels
- Time and labor saving
- Fit various buildings
- Low environmental effect
 ▲ Durability
 ▲ Question during the assembly process

Bearing panel construction
- Less components / panels
- Easy to assembly
- Little on site work
- Low environmental effect
 ▲ Durability
 ▲ Lifter Requirement
Table 1. Comparison among Different Construction Methods

<table>
<thead>
<tr>
<th></th>
<th>On-site construction</th>
<th>Non-load-bearing Panel + Structure</th>
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<th>Modules</th>
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<tbody>
<tr>
<td>Labor Efficiency</td>
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(The more dots represent the higher performance)
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(The more dots represent the higher performance)
Prefab Manufacturer

- Simple machines required
- Low capacity
- Flexible
- Low initial investment
- Lower Skilled workers

- High level of automation
- High capacity
- Labor saving
- High investment
- Higher skilled workers
Prefab Manufacturer

- Simple machines required
- Low capacity
- Flexible
- Low initial investment
- Lower Skilled workers

- High level of automation
- High capacity
- Labor saving
- High investment
- Higher skilled workers
/3 Analysis
Photo of migrant worker’s home
November, 2017
Residence Study

(Own Illustration)

(Drawings by students from the Built Environment Analysis Class, Institut Teknologi Bandung)
Residence Condition

Rental Rooms (Kos-Kosan)
- Around 3m x 4m bedroom
- Repeating room unit
- Shared bathroom and kitchen
- Lack of public space
- Rp.35,000 per M² monthly

Private House (Rumah)
- Around 40 M² per storey
- Diverse room type
- 1 to 2 storeys normally
- Family owned
- Rp.2 to 2.5 Million per M²
Target Group

- Usually share room with others
- Conscious about cost
- Around 5–7 m² per person (private and shared)

Single Worker

- Need privacy for bedroom
- Don’t mind shared facilities
- Around 15 m² per couple (private and shared)

Young Couple

- Need a family room
- Prefer private facilities
- Around 40 m² per family (private and shared)

Migrant Family
Analysis

- **Shared**
  - Kitchen
  - Bathroom
  - Living Room
  - Bedroom

- **Private**
  - Single Worker
  - Young Couple
  - Migrant Family

/3 Analysis
Room for couple

Room for single worker

Shared washing unit

Room for couple with child

Room for family

3000
Kahatex PT
- Provide rooms for workers

Workers
- Reduce the cost of living

Government
- Solve housing Shortage urgently

Other Parties
- Investors, Banks, other Works...
Kahatex Textile Factory
- Provide dormitories for part of the workers

Workers
- Share a rental room with others
- Pay Rp. 35,000 per M² Month

House Owners
- Rent the rooms out for profits
Waste from Kahatex

- Natural Fiber: Cotton, Wool, Linen...
- Chemical Fiber: PET, Nylon, PP, PAN...

Current House Construction

- Labor & Machine come from outside
- Non-degradable construction material
Cooperative Company
- Provide lower cost housing
- Make use of textile waste from Kahatex

Other Workers
- Rent a room with a lower cost

House Owners
- Increase profits
- Reduce maintenance work
New Construction Method

- Make full use of Waste fiber & fabric
- Local Craftsman + Tools
- Natural Bamboo as Main Structure
Existing Worker
from Cigondewah
- Carpenter / Craftsman
- Textile Sorter
- Other Labor

Required Machine
to proceed with Bamboo & Wood
- Drill
- Drum Sander
- Saw

Required Machine
to proceed with Chemical Fiber
- Shaping Machine
- Grinder
- Melting Pot
- Squeezing Machine
Existing Worker
from Cigondewah

- Carpenter / Craftsman
Lack of Quantity

- Other Labor
Insufficient Skill

- Textile Sorter

Training

Required Machine
to proceed with Bamboo & Wood

- Drill
- Drum Sander
- Saw

Required Machine
to proceed with Chemical Fiber

- Shaping Machine
- Grinder
- Melting Pot
- Squeezing Machine

Quality Control
Bamboo Plantation
- 12-20km away from Cigondewah
- Raw, Rp.30,000 for Ø10cm x 9m
- Treated, Rp.90,000 for Ø10cmx9m

Treating Process
- CAA / CQA Treatment, Non-Toxic
- 2% Soaked for 48 Hours
- 30 Years Durability

Hand Saw + Truck Transport
Bamboo Treatment

1. Diameter Control
   - Chemical Treated Cutting

2. Length Control
   - Sandering

3. Structural Joint
   - Drilling

4. Cement Reinforce
   - Further Extension
2% of Kahatex Workers
- A pilot project
- Training workers
- Evaluating on-site performance

Construction
- Cheaper than the Brick-Concrete House
  (Rp.2 - 2.5 Million per M²)

Local Employment
- Let local workers benefit from the project

Reuse Texile Waste
- Reduce the cost of the production
- Create win-win situation for Kahatex
# Business Model of Cooperative Company

<table>
<thead>
<tr>
<th>Key Partners</th>
<th>Key Activities</th>
<th>Value Propositions</th>
<th>Customer Relationship</th>
<th>Customer Segments</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Kahatex</td>
<td>1 Design Houses</td>
<td>1 Provide lower cost houses for workers from Kahatex.</td>
<td>1 Rental Agency</td>
<td>- Workers from Kahatex</td>
</tr>
<tr>
<td>- Landlord</td>
<td>2 Produce &amp; Assembly</td>
<td>2 Reduce the construction cost and time so that Kahatex can afford.</td>
<td>2 Telephone Service</td>
<td>- Potential Self-builders</td>
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<tr>
<td>- Other Investor</td>
<td>3 Maintaince</td>
<td>3 Reduce the non-degradable waste which would be a threat to people.</td>
<td>3 Online Service</td>
<td></td>
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<tr>
<td></td>
<td>4 Rental Agency</td>
<td>4 Raise the value of the future houses based on the modular system.</td>
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<tr>
<td>Key Resources</td>
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<tr>
<td>- Modular Design</td>
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<td>- Prefab System</td>
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<td>- Labor Training &amp; Input</td>
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<tr>
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</table>
Bamboo Structure
Rp. 90,000 for Ø10cm x 9m
20% waste during processing

Flooring & Ceiling
Bamboo splint + insulation layer
Rp.120,000 per M²

Staircase
Bamboo Frame
Rp.900,000 for 3M

Wall Panel
Wood Frame, insulated, Glass window
Rp.1,200,000 Each

Textile Insulation
0.041-0.053W/mK; 200-400 kg/M³
Rp.15,000 for 1 kg

Roof Tile
PVC 1300mm (20% Overlapping)
Rp.50,000 for 1 M² / 4kg

Brick Infill
PE or PP
Rp.15,000 for 1 kg

Ø12mm Rope
Nylon or PE
Rp.75,000 for 10 M / 1kg
PVC Roof Tiles

Anti-Earthquake Beams

Infill between Columns

Wood/Bamboo Frame

Plastic Surface & Natural Fiber Insulation

500x500x800mm Footing
Brick+Concrete

Material 50-70%
Labor 20-40%
Rp. 2-2.5 Million per M²

VS

Bamboo+Textile

Material 30-50%
Labor 40-60%
Rp. 1.8-2 Million per M² (Standard)
Rp. 1.6-1.8 Million per M² (Lower Standard)
Cooperative Company

0.42 Million Rents per M²
Shared Space not Included

Rp. 150.2 Million per Year

Bamboo+Textile

321.6M² Rental Rooms
36M² Workshop / Shop
774M² in Total

Rp. 1400 Million Total Cost

<10 Years Payback Period
/4 Design Framework
Module 3M x 3M

Modular Structure

Modular Panel
Column-Beam Joint

Sandering

Rubber

Tie Up
Strengthened Joint

Drilling

Insert Cement

Tie Up
Column Detail

- 10mm Elastic Rubber
- 300x300mm Plastic Brick Infill
- φ80mm PVC Pipe
- 5mm Sealant
- φ120mm Bamboo Column
- 15mm Split Bamboo
- 500x800mm Concrete Footing
- Compacted Fill
- 200mm Gravel Base
Floor Detail

- Modular Floor Units
- Same Module with Wall Panel

5mm Joint Sealant

15mm Flattened Bamboo
5mm Waterproof Layer
40mm Sound Insulation
30mm Wood Panel

70mm Sound Insulation
15mm Plastic Panel
Extendable Tubes

- Bamboo Wedge
- Wood Stick
- Rubber

Tie Up
Basic Panel

2.7 x 2.7 Meter

Easily Assembled & Reusable

15mm Plastic Tiles

80x150mm Wood Stud

80mm Natural Fiber Insulation Layer

15mm Plastic Tiles

50x100mm, 9mm Double Glass Window
- Panel Pattern
- Color Pallet
- Interior Sample
Assembly

Round-Plane Joint Connection
Nylon / PE
Assembly
/5 Design
Construction Sequence
Construction Sequence
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Construction Sequence
Function Division

- **Bathroom**
  - 4 bathrooms (1.35x1m) on each floor
  - 2 basins (3m) for laundry on each floor

- **Common Space**
  - Kitchen and dining table on first floor
  - Desk and couch on each floor

- **Staircase**
  - 1.2m wide

- **Workshop**
  - 9x4m space for workshop on ground floor
- For single workers
- Shared facilities

- For couples
- Shared facilities
- Family unit
- Private bathroom
- Living room

- For couple with/without kids
- Private bathroom
- Collective Space
- Kitchen
- Reading Space
Future Application
Thank You

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