FASHION FACTORY OF TOMORROW

creating a healthy and comfortable work environment
for factory workers of the fashion industry
INTRODUCTION
the fashion industry
problem statement
context
research
objective

DESIGN
site
guidelines
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construction
conclusion
INTRODUCTION

THE FASHION INDUSTRY

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THE FASHION INDUSTRY
THE FASHION INDUSTRY

some numbers:

about 60.000.000 to 75.000.000 people work worldwide in the textile, clothing and footwear manufacturing

80% WOMEN throughout the supply chain

2nd highest polluter: responsible for 10% of the global carbon emissions

1 in 6 people in the world work in fashion & related industries

$3.000.000.000 / year industry

2nd highest user of water

[source: fashionunited.com/global-fashion-industry-statistics]
THE FASHION INDUSTRY

- **textile factory**
  - raw fibre → fabric

- **garment factory**
  - fabric → clothes

- **vertically integrated factory**
  - raw fibre → fabric → clothes
INTRODUCTION

- the fashion industry

PROBLEM STATEMENT

- context
- research
- objective

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- layout
- construction
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**Problem Statement**

- Environmental pollution
- Poor working conditions
- Very low wages
- Lots of waste / little recycling
- Lots of pesticides
- Unsafe factory buildings
Problem Statement

- Environmental pollution
- Poor working conditions
- Very low wages
- Lots of waste / no recycling
- Lots of pesticides
- Unsafe factory buildings
Problem Statement

**AlterNet** | December 31, 2010 | Lauren Kelley

“Deadly Accidents, Inhumane Conditions

-- Why We Must Fight to Stop Abuse of the World’s Sweatshop Workers”

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**GlobalPost** | March 22, 2015 | Patrick Winn

“The slave labor behind your favorite clothing brands: Gap, H&M and more exposed”

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**In These Times** | June 15, 2015 | Erik Loomis

“In the Global Apparel Industry, Abusive and Deadly Working Conditions Are Still the Norm”

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**The Guardian** | April 22, 2015 | Jason Burke

“Bangladesh garment workers suffer poor conditions two years after reform vows”
PROBLEM STATEMENT

[source: 4]
Problem Statement
Existing textile and garment factories are often unsafe, unhealthy and uncomfortable workplaces.
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Java Island

Context

Jakarta

Bandung
(picture source: “Home at Work”, COCOCAN 2016)
CONTEXT

RW 02 & 12
Context

(picture source: “Home at Work”, COCOCAN 2016)
Context
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**Research**

**Indoor Environment**
- lighting
- indoor air quality
- thermal comfort
- acoustics
RESEARCH
**Research**

**Lighting Problems**

- absence of daylight
- uncomfortable artificial lighting
- no view to the outside
INDOOR AIR QUALITY

PROBLEMS

lack of (natural / mechanical) ventilation

dusty air

chemical air pollutants
THERMAL COMFORT

PROBLEMS

- high indoor air temperatures
- high relative humidity levels
- lack of indoor air movement
Research

Acoustics

Problem

Loud and continuous noise throughout the whole factory
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To design a sustainable **vertically integrated clothing factory** in Bandung, by making optimal use of passive building design strategies to create a **healthy and comfortable indoor environment** for the workers.
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SITE

(picture source: “Home at Work”, COCOCAN 2016)
existing factory and rice plantation
new factory and banana plantation
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DESIGN LAYOUT

plantation
acces
picture model - van voor, schuin van boven (weg zichtbaar)
Design Layout

routing products
routing workers
Design Layout

patio's
picture model - roofshape 3 parts and split by patio's
Design Layout

water basins
orientation indoor space - sun path
picture model - roof from side (roof windows)
Daylight

roofwindows
orientation indoor space - prevailing wind directions
building part 1 - production of the fabric
building part 1 - ground floor
building part 2 - production of the clothes
building part 3 - first floor
existing materials

concrete

steel

metal sheets

new materials

bamboo

Bangkirai wood

natural coconut fiber

banana fabric
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CONSTRUCTION
...
conclusion
existing steel frame
bracing
Construction

Lower roof parts
roof windows
bamboo construction
upper roof parts
Construction

Service zone

Gutter

Electricity cables & artificial lighting

Waterpipes & sewage system
Construction

Service zone | Artificial lighting
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conclusion
picture model - facade from side (mesh and windows)
two different window-types (openable and closed)
façade - operational windows
Elements

façade - operational windows
prevailing wind directions in Bandung: SSE and ENE

te openen ramen versus dichte ramen!!
THERMAL COMFORT

hot air escape via roof openings
hot air escape via roof openings
insulation - natural coconut fiber

banana fabric, dyed with turmeric
Harvesting Rainwater

collecting rainwater
Harvesting Rainwater

service zone | gutter
drainage via patio to water basin
pv-panels give 316455 kWh/year (= 47 Dutch households)
Lighting

sunshading system
Acoustics

acoustic ceiling panels
DAYLIGHT

10.00 a.m.

13.00 p.m.

16.00 a.m.

10.00 a.m.

sunpath
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CONCLUSION
Where would you like to work?
Thank You!
service zone | artificial lighting
Overall Design Question

How can a sustainable vertically integrated clothing factory in Bandung provide a healthy and comfortable indoor environment for the workers by using passive building design strategies?
What passive building design strategies are suitable to create a healthy and comfortable indoor environment in a garment factory located in the tropical climate of Bandung?

What (1) **passive building design strategies** are suitable to create a healthy and comfortable (2) **indoor environment** in a garment factory located in the tropical (3) **climate of Bandung**?
The diagram illustrates a production process involving various stages and departments, including:

- **Office**: Receives an order from a client.
- **Patterns & Sampling**: 2p.
- **Textile Production**: 400m², including 150m² garment production and 150m² finishing.
- **Garment Production**: 150m², including sewing (20p.), trimming (1p.), supervisor (1p.), quality check (1p.), workers that move the products (5p.), and sewing (20p.).
- **Finishing**: Drying/storage (2p.), fabric dyeing (2p.), weaving (2p.), yarn (2p.), fabric check (2p.), storage raw materials (2p.), quality check (2p.), measurement check (2p.), ironing (2p.), and storage (2p.).
- **Assembling**: 1p., including cutting (3p.), assembling (1p.), trimming (1p.), quality check (1p.), and assembling (1p.).
- **Supervision**: Helper (1p.), supervisor (1p.), trimming (1p.), quality check (1p.), and cutting (3p.).
- **Spot Washing**: 1p., including quality check (1p.), re-work (1p.), and spot washing (1p.).
- **Needle Check**: 1p., including quality check (1p.), cutting (3p.), and assembling (1p.).
- **Program**: Includes storage (2p.), packing (2p.), quality check (2p.), measurement check (2p.), ironing (2p.), assembly (1p.), and sewing (20p.).

The total production area is 12,000m² for the production garden, with additional areas for different departments:

- **±50m²**: Banana trunks region of Bandung
- **±50m²**: Office
- **±50m²**: Patterns & Sampling
- **±150m²**: Office
- **±150m²**: Patterns & Sampling
- **±12000m² = 1.2 ha** (±600 kg fibre / year)
- **850m²**: Factory

The diagram highlights the distribution of production areas and the flow of materials and processes within the factory.
large roof area in Tropical Climate

= challeses + opportunities

with regards to:

1. healthy & comfortable indoor environment

opportunity: lighting
- provide indoor space with daylight

challenge: thermal comfort
- keep direct sunlight out
- protect against high solar radiation
large roof area in Tropical Climate

= 

challenges + opportunities

with regards to:

1. healthy & comfortable indoor environment

2. suitable passive building design strategies

opportunities
- protect facade against direct sunlight
- stimulate natural ventilation
- hot air escape the building via roof openings
large roof area in Tropical Climate

= challenges + opportunities

with regards to:

1. healthy & comfortable indoor environment

2. suitable passive building design strategies

3. sustainability

opportunities
- energy production
- lower energy use on artificial lighting (daylight)
- harvesting rainwater
optimal orientation versus orientation of factory
Thermal Comfort

Global Horizontal Irradiation (GHI)

solar radiation and sunpath
roof design: finding the right **balance** between **open** and **closed**...
Roof studies | models
Roof studies | computer models
roof studies | daylight simulation (VELUX)
Roof

roof studies | daylight simulation (VELUX)
Bambusa bamboo Ø 100 mm

steel pin

frame
Bangkirai wood

cocoboard
natural coconut fibers

acoustic insulation
natural coconut fibers
Acoustics

Bangkirai wood

Concrete floor
prevailing wind directions in Bandung: SSE and ENE
Ventilation

half open facade (banana fabric mesh)
Indoor Environment

1. How is the lighting for you?

2. How is the noise for you?

3. How is the temperature for you?

4. How is the air quality for you?

<table>
<thead>
<tr>
<th>Good</th>
<th>Ok</th>
<th>Bad</th>
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</thead>
<tbody>
<tr>
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</tbody>
</table>
1. For how many years do you work in the factory?
2. How many hours a day do you work in the factory?
3. Do you feel chest tightness or breathing difficulty?
4. Do you have a blocked, stuffy or running nose in the factory?
5. Do you have a dry or irritated throat in the factory?
6. Do you have headaches / pain in your head in the factory?
7. Do you have any itch?
8. Do you have a rash or irritated skin in the factory?
9. Do you have dry skin in the factory?
10. Do you have pain in your ears?
11. Do you have pain in your eyes?
12. Do you have dry eyes when you are in the factory?
13. Do you have watering or itchy eyes in the factory?
14. Do you have flu-like symptoms in the factory?
15. Do you feel tired or sleepy in the factory?
16. Do you have other health-problems?
17. How do you sleep at night?
“Demand quality, not just in the products you buy, but in the life of the person who made it.”

_Orsola de Castro,
Co-founder of Fashion Revolution Day_
total:
- plantation
- factory
  3 production lines
  100 employees
  92 garment workers
  + 8 office workers

Program

- storage (2p.)
- needle check (1p.)
- packing (2p.)
- quality check (2p.)
- measurement check (2p.)
- ironing (2p.)
- re-work (1p.)
- spot washing (1p.)

- quality check (1p.)
- trimming (1p.)
- sewing (20p.)
- helper (1p.)
- supervisor (1p.)
- assembling (1p.)

- cutting (6p.)

- office (8p.) receives orders from clients
- patterns (2p.) & sampling (2p)

- fabric check (2p.)
- drying/storage (2p.)
- fabric dyeing (2p.)
- weaving (2p.)
- yarn (2p.)
- storage (2p.)

- banana trunks own plantation
  ±12000 m² = 1,2 ha
  ±600 kg fibre / year
  other plantations in region of Bandung
Program

- make the clothes
  - final check, packing & store
  - re-work (1p.)
  - spot washing (1p.)
  - ironing (2p.)
- make the fabric
  - cutting (6p.)
  - assembring (1p.)
  - sewing (20p.)
  - helper (1p.)
  - supervisor (1p.)
  - trimming (1p.)
  - quality check (1p.)
- office (8p.) receives orders from clients
- patterns (2p.) & sampling (2p.)

- fabric check (2p.)
- drying/storage (2p.)
- fabric dyeing (2p.)
- weaving (2p.)
- yarn (2p.)
- storage (2p.)

- banana trunks
- own plantation
  ±12000m² = 1,2 ha
  ±600 kg fibre / year
- other plantations in region of Bandung
facade - air flow through the building
PASSIVE BUILDING DESIGN STRATEGIES
<table>
<thead>
<tr>
<th>Orientation</th>
<th>Configuration</th>
<th>Materials</th>
<th>Roof, Facade &amp; Openings</th>
<th>Vegetation</th>
</tr>
</thead>
<tbody>
<tr>
<td>THERMAL COMFORT</td>
<td>1</td>
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<td>3</td>
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<td>LIGHTING QUALITY</td>
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<td>INDOOR AIR QUALITY</td>
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<td>16</td>
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<tr>
<td>ACOUSTIC QUALITY</td>
<td>19</td>
<td>20</td>
<td>21</td>
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</table>

**Vegetation**

- Oxygen (O₂)
- PM₁₀
- CO₂
- VOCs

**Materials**

- 1: Air pollutants
- 2: small
- 3: ENE
- 4: SSE
- 5: keep d small
- 6: E/W
- 7: N/S
- 8: N/S
- 9: N/S
- 10: N/S
- 11: N/S
- 12: N/S
- 13: ENE
- 14: SSE
- 15: D
- 16: β = 30-45°
- 17: β = 30-45°
- 18: β = 30-45°
- 19: β = 30-45°
- 20: β = 30-45°
- 21: β = 30-45°
Program
‘back on the envelope’ calculation:

suitable roof area = 2160 m\(^2\)

\[
2160 \, \text{m}^2 / 1.65 \, \text{m}^2 \text{ (pv-panel)} = 1309 \, \text{panels}
\]

\[
1309 \times 221 \, \text{W}_p = 289 \, \text{kW}_p
\]

\[
1095 \, \text{kWh/kW}_p/\text{year} \times 289 \, \text{kW}_p = 316455 \, \text{kWh/\text{year}}
\]

average Dutch household = 6712 kWh / year

\[
316455 / 6712 = 47 \, \text{households}
\]

*in Indonesia
Textile Production ➔ raw fibre ➔ yarn ➔ raw fabric ➔ fabric processing

raw fibre ➔ yarn ➔ raw fabric ➔ Garment Production

sewing ➔ value addition ➔ pattern & cutting ➔ processed fabric

sewing ➔ value addition ➔ Garment Production

finished product ➔ quality check ➔ rework ➔ ironing & packing ➔ storage & transport
daylight simulation (VELUX)
Lighting

ground floor - daylight via roofwindows
Lighting

first floor - daylight via roofwindows
indoor space:
finding the right balance
between open and closed...

A COUSTICS

open - airflow

closed - noise
well insulated roof!