PRESENTATION

GRADUATION PROJECT

MINERAL WOOL FACADE INTEGRATION

date : 01-07-2010

name : Jasper Overkleeft
studentnumber : 1318616
INTRODUCTION

I  why this graduation project?
II what are insulating materials?
III what are monolithic walls?
IV focus of research
V functions of the facade researched
VI concepts
VII conclusion
WHY THIS GRADUATION PROJECT?
WHY THIS GRADUATION PROJECT?

products

soft mineral wool

hard mineral wool
WHY THIS GRADUATION PROJECT?

products

soft mineral wool

hard mineral wool

additions
WHY THIS GRADUATION PROJECT?

ROCKWOOL

other insulators

competition other systems

other insulators

competition other systems
WHY THIS GRADUATION PROJECT?

other insulators

competition other systems

mineral wool

product

brick any insulation brick
WHY THIS GRADUATION PROJECT?

- Other insulators
  - Competition with other systems
- Mineral wool
  - Product
  - System (brick, any insulation, brick)
WHY THIS GRADUATION PROJECT?
WHAT ARE INSULATING MATERIALS
STOPPING CONDUCTION

AIR
WHAT ARE INSULATING MATERIALS
AIR TRAPPED INSIDE MATERIAL
WHAT ARE INSULATING MATERIALS

DENSITY OF MATERIAL

more still air
low density material

high density material

better insulation value

INTRODUCTION | ADJACENT INFO | RESEARCH | CONCLUSION
WHAT ARE INSULATING MATERIALS
DENSITY OF MATERIAL

future aerogel 95% air

more still air
low density material

high density material
better insulation value

INTRODUCTION | ADJACENT INFO | RESEARCH | CONCLUSION
DIFFERENT INSULATING MATERIALS

biological

minerals

fossil fuels
DIFFERENT INSULATING MATERIALS

- **biological**
  - wood fibres
  - soft board
  - cocos mat
  - sheep wool
  - hennep
  - paper

- **minerals**

- **fossil fuels**
**DIFFERENT INSULATING MATERIALS**

**Biological**
- wood fibres
- soft board
- cocos mat
- sheep wool
- hennep
- paper

**Minerals**
- foam glass
- mineral wool
- glass wool

**Fossil Fuels**
DIFERENT INSULATING MATERIALS

biological

- wood fibres
- soft board
- cocos mat
- sheep wool
- hennep
- paper

minerals

- foam glass
- mineral wool
- glass wool

fossil fuels

- PIR
- PUR
- EPS
## DIFFERENT INSULATING MATERIALS

<table>
<thead>
<tr>
<th>Biological</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- less environmental pressure&lt;br&gt;- use of recycled products</td>
<td>- short lifetime&lt;br&gt;- not fire resistant&lt;br&gt;- soft products</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Minerals</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- good fire resistant&lt;br&gt;- high strength&lt;br&gt;- no deterioration&lt;br&gt;- good recycling</td>
<td>- need to be mined&lt;br&gt;- need a lot of energy to make&lt;br&gt;- brittle materials</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fossil Fuels</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- high strength&lt;br&gt;- no deterioration</td>
<td>- uses fossil fuels&lt;br&gt;- low melting point</td>
</tr>
</tbody>
</table>
MONOLITHIC WALL
WHAT IS A MONOLITHIC WALL

layered wall
monolithic wall
monolithic wall
MONOLITHIC WALL
HISTORY

- Mud/sand/straw wall
- Carved stone wall
- Broken stone wall

Time:
- Antiquity
- Roman civilization
- Industrial Revolution
- Now
- Future

Introduction
Adjacent Info
Research
Conclusion
MONOLITHIC WALL
HISTORY

- mud/sand/straw wall
- Roman concrete (Opes ceamenticium)
- sun dry mud/sand bricks
- fired mud/sand bricks
- carved stone wall
- broken stone wall

Time:
- Antiquity
- Roman Civilization
- Industrial Revolution
- Now
- Future

INTRODUCTION | ADJACENT INFO | RESEARCH | CONCLUSION
MONOLITHIC WALL
HISTORY

- mud/sand/straw wall
- fired mud/sand bricks
- double twisted facade
- carved stone wall
- Roman concrete (Opes ceamenticium) phantheon, rome
- double skin facade
- broken stone wall
- sun dry mud/sand bricks
- portland cement concrete

Time:
- antiquity
- roman civilization
- industrial revolution
- now
- future

INTRODUCTION | ADJACENT INFO | RESEARCH | CONCLUSION
REFERENCE BUILDING

number of new buildings by building type

- Woningen: 64%
- Hallen en Loodsen: 13%
- Kantoren: 7%
- Combinatie bedrijfshallen: 1%
- Kassen: 1%
- Schuren en stallen: 1%
- Winkels: 1%
- Scholen: 6%
- Overige gebouwen: 2%
- Adjacent info

INTRODUCTION

ADJACENT INFO

RESEARCH

CONCLUSION
number of new buildings by building type

- Woningen: 64%
- Hallen en Loodsen: 13%
- Kantoren: 7%
- Combinatie bedrijfshallen: 6%
- Kassen: 5%
- Schuren en stallen: 2%
- Winkels: 1%
- Scholen: 1%
- Overige gebouwen: 1%
number of new buildings by building type

- Woningen: 64%
- Hallen en Loodsen: 13%
- Kantoren: 7%
- Combinatie bedrijfshallen: 6%
- Kassen: 5%
- Schuren en stallen: 2%
- Winkels: 1%
- Scholen: 1%
- Overige gebouwen: 1%

REFERENCE BUILDING

INTRODUCTION | ADJACENT INFO | RESEARCH | CONCLUSION
FACADE FUNCTION TREE
STANDARD HOUSING

INTRODUCTION  ADJACENT INFO  RESEARCH  CONCLUSION
FACADE FUNCTION TREE

Architecture
- Visual contact
- Relation in/outside
- Aesthetics
- Radiation
- Filtering
- Directing
- Contact noise
- Collecting heat
- Thermal insulation
- Heat radiation
- Quality
- Ventilation
- Wind
- Noise
- Opening
- Rain
- Moisture
- Dead load
- Wind load
- Thermal expansion
- Construction
- Energy
- Solar
- Natural resources
- Recycle
- Demolish

Building Physics
- Light
- Accoustics
- Heat
- Air
- Water
- Noise
- Opening
- Rain

Structural
- Construction
- Wind load
- Thermal expansion

Sustainability
- Energy
- Thermal
- Natural resources
- Recycle
- Demolish

INTRODUCTION | ADJACENT INFO | RESEARCH | CONCLUSION
Architecture
- Visual contact
- Relation in/outside
- Aesthetics
- Radiation

Building Physics
- Light
  - Filtering
  - Directing
- Acoustics
  - Contact noise
  - Collecting heat
- Heat
  - Thermal insulation
    - Heat radiation
  - Quality
    - Ventilation
  - Wind
    - Noise
    - Opening
    - Rain
- Air
- Water
  - Moisture
- Construction
  - Dead load
  - Wind load
    - Thermal expansion
  - Wind
  - Solar
- Energy
- Thermal
- Natural resources
- Recycle
  - Recycle
- Sustainability
  - Demolish
MINERAL WOOL FACADE

- aesthetics
- wind
- rain
- moisture
- dead load
- wind load

mineral wool

needed functions
MINERAL WOOL FACADE

mineral wool

necessary functions

function possible with mineral wool

aesthetics
wind
rain
moisture
dead load
wind load

INTRODUCTION | ADJACENT INFO | RESEARCH | CONCLUSION
MINERAL WOOL FACADE

- aesthetics
- wind
- rain
- moisture
- dead load
- wind load

mineral wool

needed functions

function possible
with mineral wool

not possible

adjacent info

research

conclusion
MINERAL WOOL FACADE

MINERAL WOOL

needed functions

function possible with mineral wool

changing material mineral wool

not possible

aesthetics

wind

rain

moisture

dead load

wind load

INTRODUCTION

ADJACENT INFO

RESEARCH

CONCLUSION
MINERAL WOOL FACADE

mineral wool

needed functions

aesthetics
- wind
- rain
- moisture
- dead load
- wind load

function possible with mineral wool

not possible

adding layer

changing material

INTRODUCTION  |  ADJACENT INFO  |  RESEARCH  |  CONCLUSION
AESTHETICS

traditional

masonry

concrete

wood
AESTHETICS

traditional

masonry

concrete

wood

today new solutions

stone strips

stucco work

plastic

INTRODUCTION | ADJACENT INFO | RESEARCH | CONCLUSION
MINERAL WOOL FACADE

Mineral wool

Needed functions:
- Aesthetics
- Wind
- Rain
- Moisture
- Dead load
- Wind load

Function possible with mineral wool

Not possible

Adding layer

Changing material
BUILDING PHYSICS

WIND

wind pressure through facade

inside

outside

simplified structure
mineral wool
BUILDING PHYSICS

WIND

wind pressure through facade

compressed layer
mineral wool

inside
outside
BUILDING PHYSICS
WIND

added closing layer outside
mineral wool
BUILDING PHYSICS

WIND

added closing layer inside mineral wool

inside

outside
BUILDING PHYSICS
RAIN

monolithic material
saturated with water
BUILDING PHYSICS
RAIN

monolithic material saturated with water

water drained with cavity
Building Fysics

Rain

- Monolithic material saturated with water
- Water drained with cavity
- Closing layer on outside
MINERAL WOOL FACADE

- aesthetics
- wind
- rain
- moisture
- dead load
- wind load

Function possible with mineral wool

Not possible

Changing material

Adding layer

Mineral wool

Needed functions
Dew point in single slab brick wall
Dew point in single slab brick wall

- \( \theta_e = -15 \, ^\circ\text{C} \)
- \( \theta_i = 18 \, ^\circ\text{C} \)
- \( \theta_i = 21 \, ^\circ\text{C} \)
MINERAL WOOL FACADE

- **mineral wool**
- **needed functions**
  - aesthetics
  - wind
  - rain
  - moisture
  - dead load
  - wind load
- **function possible with mineral wool**
- **not possible**
- **adding layer**
- **changing material**

- **INTRODUCTION**
- **ADJACENT INFO**
- **RESEARCH**
- **CONCLUSION**
horizontal dead load
permanent load = 1,50 N/mm²
STRUCTURAL FACADE LOADS

pressure testing vertical direction
pressure testing horizontal direction
pressure testing the different direction

horizontal dead load
permanent load = 1,50 N/mm²
Horizontal dead load
permanent load = 1,50 N/mm²
horizontal dead load
permanent load = 1,50 N/mm²

non load bearing wall 21 mm
MINERAL WOOL FACADE

mineral wool

needed functions

function possible with mineral wool

not possible

adding layer

changing material

aesthetics

wind

rain

moisture

dead load

wind load
vertical wind load
variable load $= 1,06 \text{ kn/m}^2$
vertical wind load
variable load = 1.06 kn/m²

STRUCTURAL
WIND LOAD

test bench inside material
braking of mineral wool
vertical wind load
variable load = 1,06 kn/m2

test bench inside material
braking of mineral wool

Distributed weight
Hard layer on bottom
Hard layer on top
Hard layer on side
vertical wind load
variable load = 1,06 kn/m2

wall 540 mm
**Structural Wind Load**

- Test bench reinforced netting
- Test bench reinforced netting and gypsum
- Delaminated reinforced netting and gypsum

Graphs showing:
- 430 mm thick wall
- 540 mm thick wall
- Maximum deflection 10 mm

**Diagram Notes**
- Only gypsum or reinforced netting
- Gypsum or concrete and reinforced netting
- Reinforced netting fibers in different direction

**Fig. 39a**: Reinforced material test bench reinforced netting and gypsum delaminated reinforced netting and gypsum

---

**Sections**
- Introduction
- Adjacent Info
- Research
- Conclusion
CONCEPT WALL
ONLY MINERAL WOOL

advantages
- perfab possible
- easy recycling
- no glue needed
- only waterproofing layer necessary

disadvantages
- 550 mm thick wall
- low bending pressure

- 550 mm thick wall
- low bending pressure
CONCEPT WALL
LAYERED MINERAL WOOL

- Cut in shape for roof fitting
- Adjustable clamp
- Stucco with water proofing, reinforced netting
- Glue connection
- Weight distribution
- Stucco with water proofing, reinforced netting
- Water seal
- Stability connection
- Foam glass insulation
- Concrete riser

- Mineral wool
- Glue
- Gap protection with reinforced netting
- Reinforced netting for bending stresses
- Stucco for rain protection
- Mineral wool
- Reinforced netting for bending stresses
- Stucco for rain protection
- Profile for draining water
- Foil for draining moist
- Profile for draining moist
- Foil for draining moist
- Reinforced netting for bending stresses
- Stucco for rain protection
- Profile for draining water

INTRODUCTION ADJACENT INFO RESEARCH CONCLUSION
CONCEPT WALL
LAYERED MINERAL WOOL

advantages
- existing products can be used
- size can be defined on site
- higher bending force possible

disadvantages
- a lot of glue needed
- thicker protective layer
- reinforced netting needed
- less recyclable
CONCEPT WALL
STABILITY

advantages
- existing products can be used
- small wall possible
- high bending force
- detachable facade

disadvantages
- other material for bending strength
# COMPARATIVE FACADE CHART

<table>
<thead>
<tr>
<th>Standard Facade</th>
<th>Density (kg/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>414</td>
</tr>
<tr>
<td>II</td>
<td>265,7</td>
</tr>
<tr>
<td>III</td>
<td>54,6</td>
</tr>
<tr>
<td>IV</td>
<td>364</td>
</tr>
<tr>
<td>V</td>
<td>214,6</td>
</tr>
<tr>
<td>VI</td>
<td>344</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Least</th>
<th>Average</th>
<th>Best</th>
</tr>
</thead>
<tbody>
<tr>
<td>Only mineral</td>
<td>414</td>
<td>276</td>
</tr>
<tr>
<td>Wool concept</td>
<td>126</td>
<td>132</td>
</tr>
<tr>
<td>Layer concept</td>
<td>92,5</td>
<td></td>
</tr>
<tr>
<td>Stability concept</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Facade</td>
<td>Density (kg/m²)</td>
<td>Compression Strength (N/mm²)</td>
</tr>
<tr>
<td>--------------</td>
<td>----------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>I</td>
<td>414</td>
<td>42.7</td>
</tr>
<tr>
<td>II</td>
<td>265.7</td>
<td>45.2</td>
</tr>
<tr>
<td>III</td>
<td>54.6</td>
<td>20.2</td>
</tr>
<tr>
<td>IV</td>
<td>364</td>
<td>35</td>
</tr>
<tr>
<td>V</td>
<td>214.6</td>
<td>38</td>
</tr>
<tr>
<td>VI</td>
<td>344</td>
<td>29.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Facade</th>
<th>Least</th>
<th>Average</th>
<th>Best</th>
</tr>
</thead>
<tbody>
<tr>
<td>Only mineral wool concept</td>
<td>126</td>
<td>132</td>
<td>92.5</td>
</tr>
<tr>
<td>Layer concept</td>
<td>214.6</td>
<td>38</td>
<td>5.30</td>
</tr>
<tr>
<td>Stability concept</td>
<td>344</td>
<td>126</td>
<td>17.30</td>
</tr>
</tbody>
</table>

**COMPARATIVE FACADE CHART**
<table>
<thead>
<tr>
<th></th>
<th>standard facade I</th>
<th>standard facade II</th>
<th>standard facade III</th>
<th>standard facade IV</th>
<th>standard facade V</th>
<th>standard facade VI</th>
<th>least</th>
<th>average</th>
<th>best</th>
<th>only mineral wool concept</th>
<th>layer concept</th>
<th>stability concept</th>
</tr>
</thead>
<tbody>
<tr>
<td>density (kg/m²)</td>
<td>414</td>
<td>265,7</td>
<td>54,6</td>
<td>364</td>
<td>214,6</td>
<td>344</td>
<td>414</td>
<td>276</td>
<td>54,6</td>
<td>126</td>
<td>132</td>
<td>92,5</td>
</tr>
<tr>
<td>compression strength (N/mm²)</td>
<td>42,7</td>
<td>45,2</td>
<td>20,2</td>
<td>35</td>
<td>38</td>
<td>29,5</td>
<td>20,2</td>
<td>35</td>
<td>45,2</td>
<td>0,30</td>
<td>5,30</td>
<td>17,30</td>
</tr>
<tr>
<td>conduction coefficient (m² W/mK)</td>
<td>3,78</td>
<td>4,28</td>
<td>2,71</td>
<td>3,82</td>
<td>2,83</td>
<td>3,9</td>
<td>2,71</td>
<td>3,55</td>
<td>3,9</td>
<td>13,5</td>
<td>10,75</td>
<td>6,25</td>
</tr>
</tbody>
</table>
## Comparative Facade Chart

<table>
<thead>
<tr>
<th>Density (kg/m²)</th>
<th>Standard Facade I</th>
<th>Standard Facade II</th>
<th>Standard Facade III</th>
<th>Standard Facade IV</th>
<th>Standard Facade V</th>
<th>Standard Facade VI</th>
<th>Least</th>
<th>Average</th>
<th>Best</th>
<th>Only Mineral Wool Concept</th>
<th>Layer Concept</th>
<th>Stability Concept</th>
</tr>
</thead>
<tbody>
<tr>
<td>414</td>
<td>265.7</td>
<td>54.6</td>
<td>364</td>
<td>214.6</td>
<td>344</td>
<td>414</td>
<td>276</td>
<td>54.6</td>
<td>126</td>
<td>132</td>
<td>92.5</td>
<td></td>
</tr>
<tr>
<td>Compression Strength (N/mm²)</td>
<td>42.7</td>
<td>45.2</td>
<td>20.2</td>
<td>35</td>
<td>38</td>
<td>29.5</td>
<td>20.2</td>
<td>35</td>
<td>45.2</td>
<td>0.30</td>
<td>5.30</td>
<td>17.30</td>
</tr>
<tr>
<td>Conduction Coefficient (m² W/mK)</td>
<td>3.78</td>
<td>4.28</td>
<td>2.71</td>
<td>3.82</td>
<td>2.83</td>
<td>3.9</td>
<td>2.71</td>
<td>3.55</td>
<td>3.9</td>
<td>13.5</td>
<td>10.75</td>
<td>6.25</td>
</tr>
<tr>
<td>Water Vapour Diffusion Resistance μ (dry) *</td>
<td>141</td>
<td>131</td>
<td>221</td>
<td>21</td>
<td>221</td>
<td>41</td>
<td>41</td>
<td>129</td>
<td>221</td>
<td>34</td>
<td>34</td>
<td>34</td>
</tr>
</tbody>
</table>

* based on independent material properties and no complete facades
## COMPARATIVE FACADE CHART

<table>
<thead>
<tr>
<th></th>
<th>standard facade I</th>
<th>standard facade II</th>
<th>standard facade III</th>
<th>standard facade IV</th>
<th>standard facade V</th>
<th>standard facade VI</th>
<th>least</th>
<th>average</th>
<th>best</th>
</tr>
</thead>
<tbody>
<tr>
<td>density (kg/m²)</td>
<td>414</td>
<td>265,7</td>
<td>54,6</td>
<td>364</td>
<td>214,6</td>
<td>344</td>
<td>414</td>
<td>276</td>
<td>54,6</td>
</tr>
<tr>
<td>compression strength (N/mm²)</td>
<td>42,7</td>
<td>45,2</td>
<td>20,2</td>
<td>35</td>
<td>38</td>
<td>29,5</td>
<td>20,2</td>
<td>35</td>
<td>45,2</td>
</tr>
<tr>
<td>conduction coefficient (m² W/mK)</td>
<td>3,78</td>
<td>4,28</td>
<td>2,71</td>
<td>3,82</td>
<td>2,83</td>
<td>3,9</td>
<td>2,71</td>
<td>3,55</td>
<td>3,9</td>
</tr>
<tr>
<td>watervapour diffusion resistance μ (dry) *</td>
<td>141</td>
<td>131</td>
<td>221</td>
<td>21</td>
<td>221</td>
<td>41</td>
<td>41</td>
<td>129</td>
<td>221</td>
</tr>
<tr>
<td>element costs (€/m²) **</td>
<td>196</td>
<td>309</td>
<td>70</td>
<td>161</td>
<td>113</td>
<td>141</td>
<td>309</td>
<td>165</td>
<td>70</td>
</tr>
</tbody>
</table>

* based on independent material properties and no complete facades

** materials cost only, no labour included

---

**Introduction**

**Adjacent Info**

**Research**

**Conclusion**
## Comparative Facade Chart

<table>
<thead>
<tr>
<th>Element</th>
<th>least</th>
<th>average</th>
<th>best</th>
</tr>
</thead>
<tbody>
<tr>
<td>cost (€/m²)</td>
<td>126</td>
<td>132</td>
<td>92.5</td>
</tr>
<tr>
<td>thickness mm</td>
<td>265</td>
<td>276</td>
<td>54.6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Element</th>
<th>least</th>
<th>average</th>
<th>best</th>
</tr>
</thead>
<tbody>
<tr>
<td>density (kg/m²)</td>
<td>414</td>
<td>265.7</td>
<td>54.6</td>
</tr>
<tr>
<td>compression strength (N/mm²)</td>
<td>42.7</td>
<td>20.2</td>
<td>20.2</td>
</tr>
<tr>
<td>conduction coefficient (m² W/mK)</td>
<td>3.78</td>
<td>2.71</td>
<td>3.9</td>
</tr>
<tr>
<td>water vapour diffusion resistance µ (dry)</td>
<td>141</td>
<td>221</td>
<td>221</td>
</tr>
</tbody>
</table>

* Based on independent material properties and no complete facades.
** Materials cost only, no labour included.
CONCLUSIONS

- mineral wool facade technical possible

- better bending stiffness mineral wool required

- thickness wall should be decreased

- combination of functions in one layer crucial

- aesthetics survey has to be done