Multi Generation house
A modular facade system

Souad Bokzini
CONTENT

Theory
Methodology
Generation house
Thermal comfort
Visual comfort

Practice
Questionnaire
Measurement

Design
Discussion and conclusion
Recommendation for a follow up study
METHODOLOGY

Problem statement

- Sharp rise of the ageing population -
- Netherlands count 200 different nationalities -
- Changes in the behaviour and physiology of the human body -
- 65 year old born in 1934, year 2000 (CBS)
  Man vs woman

- 65 year old born in 1951, year 2017 (CBS)
  Man vs woman

- 65 year old born in 1964, year 2030 (CBS)
  Man vs woman
METHODOLOGY

Research aim
- Design the facade of an independent house for the elderly in the Netherlands -

Research objective
- The design should be customizable to accommodate differences in standards of thermal and visual comfort, that exist within the elderly population of the Netherlands -

Research questions
- “How can facade be designed for a house for elderly people, where their children can take care for them in close proximity, while being flexible enough to customize for the thermal and visual comfort of a multicultural population ?”-

sub-questions,
-What types of houses already exist for multi-generational families that want to live together?-  
  - Which ethnic groups live in the Netherlands?-  
  - What is thermal comfort? -  
  - To what extent can thermal comfort be regulated for the elderly?-  
  - What is visual comfort? -  
  - To what extent can visual comfort be regulated for the elderly?-  
- What are the different standards of thermal and visual comfort within the different ethnic groups in the Netherlands?-  
  - To what extent do the elderly feel visually comfortable in their existing homes?-  
  - To what extent do the elderly feel thermally comfortable in their existing homes? -  
  - What are the possibilities for designing a façade? -
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**Literature study**

- Defining brief
  - Defining reference building
  - Defining requirements for thermal and visual comfort of elderly
  - Defining building permit laws
  - Exploring lease options
  - Defining ethnic groups in the Netherlands

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**Phase 1**

- Research
  - Research by questionnaires
    - Measure thermal and visual comfort of elderly people in their homes
  - Finding a strategy to customize a facade for the elderly house

- Design

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**Analysis and prototype**

- Analyse results research
- Develop prototype

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**Testing**

- Analysis design phase 1
- Evaluation design phase 1

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**Validation**
THERMAL COMFORT

- mean radiant temperature -
- relative air velocity -
- humidity -
- activity level -
- clothing thermal resistance -

Psychological comfort

- personalization -
- freedom -
- space -
- warmth -

Internal heat gain = External heat loss
<table>
<thead>
<tr>
<th>Study</th>
<th>Mean age (yr)</th>
<th>Preferred ambient temp. (°C)</th>
<th>Mean skin temp. at comfort (°C)</th>
<th>Evaporative weight loss during comfort (g/m²/hr)</th>
<th>Number of subject</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nevins et al. [23]</td>
<td>21</td>
<td>25.6</td>
<td></td>
<td></td>
<td>720</td>
</tr>
<tr>
<td>Fanger [2]</td>
<td>23</td>
<td>25.6</td>
<td></td>
<td></td>
<td>128</td>
</tr>
<tr>
<td>Fanger [2]</td>
<td>68</td>
<td>25.7</td>
<td></td>
<td></td>
<td>128</td>
</tr>
<tr>
<td>Rohles and Johnson [30]</td>
<td>74</td>
<td>24.5</td>
<td></td>
<td></td>
<td>228</td>
</tr>
<tr>
<td>Fanger Langekilde [30]</td>
<td>23</td>
<td>25.0</td>
<td>33.5</td>
<td>18.0</td>
<td>64</td>
</tr>
<tr>
<td>Langekilde [30]</td>
<td>84</td>
<td>25.4</td>
<td>33.2</td>
<td>12.4</td>
<td>16</td>
</tr>
<tr>
<td>Comfort equation, Fanger [2]</td>
<td></td>
<td>25.6</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
VISUAL COMFORT

Term that is related to lighting performance and human psychology

Daylight
Quality of the eye decrease with age

- Contrast sensitivity -
- Poor color discrimination -
- Elderly need more effort to see object sharper -
<table>
<thead>
<tr>
<th></th>
<th>% persons with min. 1 limitation (period 2013)</th>
<th>% limitation in view (period 2013)</th>
<th>% limitation in view (period 2016)</th>
</tr>
</thead>
<tbody>
<tr>
<td>65 – 75 years</td>
<td>18.4</td>
<td>8.4</td>
<td>3.4</td>
</tr>
<tr>
<td>75 years +</td>
<td>38.3</td>
<td>11.4</td>
<td>11.4</td>
</tr>
<tr>
<td>Native</td>
<td>12.3</td>
<td>5.6</td>
<td>-</td>
</tr>
<tr>
<td>Western- foreign 1e generation</td>
<td>17.7</td>
<td>8.4</td>
<td>-</td>
</tr>
<tr>
<td>Western- foreign 2e generation</td>
<td>13.4</td>
<td>6.6</td>
<td>-</td>
</tr>
<tr>
<td>Nonwestern- foreign 1e generation</td>
<td>18.9</td>
<td>9.9</td>
<td>-</td>
</tr>
<tr>
<td>Nonwestern- foreign 2e generation</td>
<td>7.0</td>
<td>3.8</td>
<td>-</td>
</tr>
</tbody>
</table>
Practice

- Questionnaire -
- Measurement -
Respondents

Practice

Moroccan
- Female: 11
- Man: 9

Turkish
- Female: 6
- Man: 2

Native
- Female: 3
- Man: 5

Suriname
- Female: 2
- Man: 1

Total: 39
### Questionnaire and results

<table>
<thead>
<tr>
<th></th>
<th>Most Comfortable</th>
<th>Average temp. inside</th>
<th>Average temp. prefer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Native</td>
<td>75%</td>
<td>19°C</td>
<td>18°C (↓)</td>
</tr>
<tr>
<td>Moroccan</td>
<td>57%</td>
<td>21°C</td>
<td>22°C (↑)</td>
</tr>
<tr>
<td>Turkish</td>
<td>50%</td>
<td>21°C</td>
<td>22°C (↑)</td>
</tr>
<tr>
<td>Surinamese</td>
<td>0.33%</td>
<td>19°C</td>
<td>22°C (↑)</td>
</tr>
</tbody>
</table>
Questionnaire and results

Man more comfortable then woman.

Moroccan and Turkish woman more inside then outside.

Native sport twice as often participants.
Questionnaire and results

Able to control the temperature.

Spend most of the time in the livingroom.
Practice

Moroccan

Turkish

Native

Suriname

Female: 11, Male: 9
Female: 6, Male: 2
Female: 3, Male: 5
Female: 2, Male: 1

Total: 39
Questionnaire and results
Questionnaire and results

Television

Window opening
### Visual comfort

<table>
<thead>
<tr>
<th>Room</th>
<th>Date</th>
<th>Time</th>
<th>Weather</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nr.1</td>
<td>15/11/2017</td>
<td>12:30h</td>
<td>☐ Clear sky</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>☐ No rain</td>
</tr>
<tr>
<td>Nr.2</td>
<td>15/11/2017</td>
<td>13:05h</td>
<td>☐ Clear sky</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>☐ No rain</td>
</tr>
<tr>
<td>Nr.3</td>
<td>16/11/2017</td>
<td>11:10h</td>
<td>☐ Clear sky</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>☐ No rain</td>
</tr>
<tr>
<td>Nr.4</td>
<td>17/11/2017</td>
<td>12:05h</td>
<td>☐ Clear sky</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>☐ No rain</td>
</tr>
<tr>
<td>Nr.5</td>
<td>23/11/2017</td>
<td>12:03h</td>
<td>☐ Clear sky</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>☐ Strong wind</td>
</tr>
<tr>
<td>Nr.6</td>
<td>25/11/2017</td>
<td>12:30h</td>
<td>☐ Cloudy</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>☐ Drizzling rain</td>
</tr>
</tbody>
</table>

Konica Minolta T-10
Measurement and results

Room 1

Plan room 1

Section room 1

Room 2

Plan room 2

Section room 2

Room 3

Plan room 3

Section room 3
Measurement and results

Room 4

Plan room 4

Section room 4

Room 5

Plan room 5

Section room 5

Room 6

Plan room 6

Section room 6
# Measurement and results

<table>
<thead>
<tr>
<th>Room 1</th>
<th>Room 2</th>
<th>Room 3</th>
<th>Room 4</th>
<th>Room 5</th>
<th>Room 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Points</td>
<td>Lamp off</td>
<td>Lamp on</td>
<td>Points</td>
<td>Lamp off</td>
<td>Lamp on</td>
</tr>
<tr>
<td>1a</td>
<td>0.9</td>
<td>0.9</td>
<td>1a</td>
<td>1.1</td>
<td>2.3</td>
</tr>
<tr>
<td>1b</td>
<td>1</td>
<td>1.7</td>
<td>1b</td>
<td>2</td>
<td>1.2</td>
</tr>
<tr>
<td>2a</td>
<td>0.5</td>
<td>0.7</td>
<td>2a</td>
<td>0.5</td>
<td>1.3</td>
</tr>
<tr>
<td>2b</td>
<td>0.5</td>
<td>0.7</td>
<td>2b</td>
<td>1</td>
<td>1.3</td>
</tr>
<tr>
<td>3a</td>
<td>0.2</td>
<td>0.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3b</td>
<td>0.2</td>
<td>0.4</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Daylight level** = \[
\frac{\text{Illuminance inside}}{\text{Illuminance in free field}} \times 100\%\]

<table>
<thead>
<tr>
<th>Daylight level (DL)</th>
<th>Quality of the daylight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Abundant daylight</td>
</tr>
<tr>
<td>2</td>
<td>Good daylight</td>
</tr>
<tr>
<td>3</td>
<td>Rational daylight</td>
</tr>
<tr>
<td>4</td>
<td>On the gloomy side</td>
</tr>
<tr>
<td>5</td>
<td>Too little for a living space.</td>
</tr>
</tbody>
</table>
Design

Possibility of the size of the house

Construction and climate strategy

Shape
Design
Design
Steel vs Aluminium

Positive effect
- Light in weight
- Strong
- Weatherproof
- Sustainable
- Decorative
- Easy to work
- Good conductive material

Negative effect
- Cost
- Buckling
- Temperature
- Fatigue
- Thermal expansion
- Corrosion
- Deflection
"How can facade be designed for a house for elderly people, where their children can take care for them in close proximity, while being flexible enough to customize for the thermal and visual comfort of a multicultural population?"
Recommendations for a follow-up study

• A model of the entire proposed building should be made and tested for thermal and visual comfort in the programme ‘Design Builder’.

• A site could be chosen in order to fully develop the design, from its exterior relationship to the context, to its interior manifestation. This report began this process by looking at the strategies for construction that would allow the building to be flexible.

• The questionnaires should be conducted with a larger sample size, with equal participants in the various ethnic groups. The measurements can also be taken at different times of the year, so that various weather conditions are captured. This will allow for firmer conclusions to be drawn.