Design adaptability of the 2ndSkin project in the Northern European market of residential buildings

Sofia Tsogia 4414594
STATUS QUO

- Increased CO$_2$ emissions
- Essential key: REFURBISHMENT
- Improves building’s performance

2ndSKIN PROJECT

- Post-war buildings
- Integrated facade system for nZEB
- Porch apartment blocks in Rotterdam-Zuid
- Upscaling into the European market
EUROPE

- MFH 40%: flat, complex of flats, apartment block
- Majority Dwellings: Post-war period
- High Energy Consumption
- Owner Occupied
- Construction type: Brick, Masonry
- Dominant Consumer: Space Heating
WHY GERMANY?

- Continental climate region
- Mainstream: Sustainability (1990s)
- Motivation and action/Energy Saving Legislation
- The largest Residential stock, 39.43 million
- The biggest space heating consumer, 527kWh/m²
- MFHs with 3-4 floors & Single leaf masonry
Breslauer Complex in Krefeld, Germany

**Popular German building type:**
- Multi Family House with 4 flats
- Post-war period
- Construction type: Brick, Masonry
- Dominant Consumer: Space Heating

**Similar and different characteristics with 2ndSkin reference building:**
- n. Storeys
- Low performance
- Roof
- Balcony
- Window layout
PROBLEM STATEMENT

- Old Residential Stock **high energy consumption** \(\Rightarrow\) **CO\(_2\) INCREASE**

- **2ndSkin** Refurbishment concept \(\Rightarrow\) nZEB \(\Rightarrow\) **EXPORT** in Germany

- Explore flexibility \(\Rightarrow\) Improve **Design & Offer options**

AIM OF THE RESEARCH

- Export the **2ndSkin** refurbishment concept in Germany

- Focus on Facade Design

- Discuss adaptability & flexibility of **2ndSkin** Design

- Assess the limitations of the design

- Propose design variation
MAIN RESEARCH QUESTION

“How can the 2ndSkin design be flexible and adaptable to be applied on a German residential building regarding the building type, the building construction and building services, while exploring design variation of the façade composition?”
1. Introduction of research and graduation plan

2. State of the art of Refurbishment in Europe
   - Refurbishment
   - Residential Stock in Europe

3. The German housing stock
   - Building Sector
   - Construction type
   - Building services
   - Characteristics

4. Comparative Study of Reference Buildings in NL & DE
   - 2ndSkin/NL
   - Construction type
   - Building services
   - Details
   - Case study Germany

5. Application of 2ndSkin on case study in DE
   - Design adjustments
   - Design adaptability
   - 2ndSkin limitations

6. Designing additional elements
   - Samples façade constructions
   - Evaluation:
     - Architectural character
     - Design flexibility
   - Design catalogue
   - Design suggestion

7. Conclusions
   - Recommendations
   - Evaluation
Comparative study of reference buildings
1. Introduction of research and graduation plan

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   - Refurbishment
   - Residential Stock in Europe

3. The German housing stock
   - Building Sector
   - Construction type
   - Building services
   - Characteristics
   - Building typology
   - Energy performance

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KEY ELEMENTS FOR COMPARISON

- Floor plan
- Balcony type
- Wall construction
- Window layout
- Roof construction
- Floor slab projection
- Entrance, staircases
Breslauer Complex in Krefeld, Germany
FACADE ANALYSIS: WEST ELEVATION

ZONE 1: Window floor to ceiling
- Transparent
- Opaque: frame

ZONE 2: Square window
- Transparent
- Opaque: concrete block

ZONE 3: Rectangular window
- Opaque: wall
- Transparent
- Opaque: wall

ZONE 4: Entrance
- Pavers
- Concrete frame around

ZONE 5: Ground floor window
- Transparent
- Opaque: wall

Current structure
FACADE ANALYSIS: EAST ELEVATION

ZONE 1: Balcony Window
- Transparent
- Opaque: Concrete rail
- 2600mm

ZONE 2: Square window
- Transparent
- Opaque: Concrete block
- 1570mm

ZONE 3: Ground floor window
- Transparent
- Opaque: Wall
- 400mm

Current structure
Reference building in Rotterdam-Zuid, NL
REFERENCE BUILDING IN NETHERLANDS

Elevations

Cross Sections

Plans

(Source: 2ndSkin Team)
<table>
<thead>
<tr>
<th>Building Information</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Country</strong></td>
<td>Netherlands</td>
<td>Germany</td>
</tr>
<tr>
<td><strong>Location</strong></td>
<td>Zuid-Rotterdam</td>
<td>Gartenstadt, Krefeld</td>
</tr>
<tr>
<td><strong>Date of construction</strong></td>
<td>1956</td>
<td>1967</td>
</tr>
<tr>
<td><strong>No of storeys</strong></td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td><strong>No of apartments</strong></td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td><strong>Orientation</strong></td>
<td>North-South (long façades)</td>
<td>North-South (short façades)</td>
</tr>
<tr>
<td><strong>Floor plan</strong></td>
<td>Kitchen and staircase adjacent to façade</td>
<td>Kitchen, bathroom and staircase adjacent to façade</td>
</tr>
<tr>
<td><strong>Structure</strong></td>
<td>Reinforced concrete slabs 140mm</td>
<td>Concrete in-situ slabs 130mm</td>
</tr>
<tr>
<td><strong>Load bearing walls</strong></td>
<td>Massive wall 150mm</td>
<td>Masonry brick walls 175mm</td>
</tr>
<tr>
<td><strong>Façade</strong></td>
<td>Cavity wall, brick cladding (short façade, narrow windows)</td>
<td>24mm lightweight concrete blocks, brick cladding (short façade, blind wall)</td>
</tr>
<tr>
<td><strong>Windows</strong></td>
<td>u-PVC Frame, Double-glazing, 25-30 years</td>
<td>u-PVC Frame, Double-glazing, 25-30 years</td>
</tr>
<tr>
<td><strong>Glass</strong></td>
<td>U-value=4.3 W/m2K</td>
<td>U-value=1.20 W/m2K</td>
</tr>
<tr>
<td><strong>Balcony</strong></td>
<td>Half loggia/half overhang. Made on site, in combination with the floor</td>
<td>Incised loggias</td>
</tr>
<tr>
<td><strong>Roof</strong></td>
<td>Flat roof, Concrete 105mm, insulation 120, finishing 50mm</td>
<td>Pitched, 12° slope. Timber joists, wooden casing bitumen roofing membranes/attic floor in-situ concrete 130mm</td>
</tr>
<tr>
<td><strong>Ground floor</strong></td>
<td>Concrete 100mm</td>
<td>Concrete in-situ slabs 130mm</td>
</tr>
<tr>
<td><strong>Slab projection</strong></td>
<td>Slab extensions needed to divide the load of the brickwork over the story floors</td>
<td>No extension</td>
</tr>
<tr>
<td><strong>Parapet</strong></td>
<td>Part of the façade panel</td>
<td>Part of the façade panel</td>
</tr>
<tr>
<td><strong>Window wall ratio</strong></td>
<td>60%</td>
<td>50%</td>
</tr>
<tr>
<td><strong>Entrance</strong></td>
<td>Cover above door</td>
<td>Cover frame around door</td>
</tr>
<tr>
<td><strong>Energy source</strong></td>
<td>Gas</td>
<td>Gas</td>
</tr>
<tr>
<td><strong>Heating system</strong></td>
<td>Individual panel radiators</td>
<td>Individual panel radiators</td>
</tr>
<tr>
<td><strong>Ventilation</strong></td>
<td>Natural</td>
<td>Natural</td>
</tr>
<tr>
<td><strong>Current energy label</strong></td>
<td>D, E</td>
<td>E, F</td>
</tr>
</tbody>
</table>
2ND SKIN CONCEPT DESCRIPTION
BUILDING IN ROTTERDAM

An integrated facade system for ZERO ENERGY

THREE AXES:

- Skin of the Building
- Building Services
- User Interaction

TOOLBOX

- Window replacement
- Insulation
- PV panels
- Ventilation

(SOURCE: 2ndSkin team)
2NDSKIN APPLICATION, NL

- Old and new structure
- Insulation board
- Ventilation pipes
- Interior view

SOURCE: 2ndSKin team
Application of 2ndSkin design to DE
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INTRO

LITERATURE STUDY

COMPARATIVE STUDY

DESIGN

CONCLUSION
1 Technical dimension
Basic point, 2ndSkin: Improve thermal performance, Improve air quality, Update installations
Renovation suggestions:
Exterior: Integrate elements like closed balconies, elevator or sunshades
Interior: Update kitchen, bathroom, wall treatment

2 Architectural dimension
- Aesthetics, Improve living conditions, User-friendly apartments for all ages, Increase comfort

3 Economical dimension
- Energy saving, Low energy costs, Higher rent, Fast payback

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PROCESS REQUIREMENTS
- Explore flexibility and adaptability of 2ndSkin design, Germany - Assess limitations of design

BUILDING REFURBISHMENT

RESULTS
ENERGY UPGRADE/SAVING
DESIGN VARIATION
COMFORT
HEALTHY WORKING ENVIRONMENT
2NDSKIN

WRAP THE ENVELOPE

APPLY 2NDSKIN DESIGN, DE
DESIGN INSPIRATION

Facade Design:
- Create symmetry
- Preserve vertical zoning
- Smart cladding grid
- Interior uses WINDOW types
- Floor to ceiling windows
- More light transmission

Materials:
- ThermoWood cladding
- Improved durability, stability, low maintenance
FACILITIES DESIGN

Building services:

- Introduce the pipe system
- Heat recovery units under roof
- Air inlet from facade
- Mechanism: Top part of windows
- Preserve the radiators for heating
- Reuse interior shaft for air outlet
ALTERATIONS MADE ON STRUCTURE

West facade:
- Remove non-loadbearing parts
- Longer windows
- Remove glass blocks

East facade:
- Floor to ceiling windows
- Remove old railings
- Cover some groundfloor windows
WINDOW DESIGN

A_ Living room

Translucent glass railing

B_ Kitchen

C_ Bathroom

Translucent glass

D_Staircase

West facade
WINDOW DESIGN

E_ Living room Balcony

F_ Sleepingroom

West facade

Translucent glass railings

Translucent glass part
**PANEL APPLICATION**

**STEP 1**
West facade

- **Existing walls (concrete, brick cladding)**
- **Slab, concrete**
- **Wooden posts**

- **Wooden posts**
  - 70x250 mm

- **Steel U-beams**
PANEL APPLICATION

**STEP 1**
East facade

Existing walls (concrete, brick cladding)

Slab, concrete

Wooden posts

Wooden beams 100x260 mm

Wooden posts 70x250 mm

Steel U-beams
PANEL APPLICATION

Central panels (including ventilation)

Wooden sticks 50x50mm

STEP 2
West facade

Existing walls (concrete, brick cladding)
Slab, concrete
Wooden posts
Insulated panels
PANEL APPLICATION

Central panels (including ventilation)

Side rockwool insulation

Wooden sticks 50x50mm

Existing walls (concrete, brick cladding)

Slab, concrete

Wooden posts

Insulated panels

STEP 2
East facade

APPLY 2ND SKIN DESIGN, DE
PANEL APPLICATION

Right/left prefabricated panels

Window frames (including sunshades)

STEP 3
West facade
PANEL APPLICATION

Right/left prefabricated panels

Window frames (including sunshades)

Wooden posts

Insulated panels

STEP 3
East facade

APPLY 2NSKIN DESIGN, DE
ELEVATIONS

- Grid based on wooden posts' location
- Window frames
- Glass railings
MORE FACADE COMPOSITIONS

- Variety of facade compositions
- Long window design
- The maximum light transmittance
1. **SUBSTRUCTURE:**
   Wooden posts 70x250mm, U-beams

2. **CENTRAL PANEL:**
   EPS Insulation 200mm, ventilation pipes, wooden sticks 50x50mm

3. **RIGHT & LEFT PANEL**
   Window frames, sunshades

4. **LININGS:**
   Interior and exterior wooden coated boards

5. **CLADDING:**
   Thermowood profile 21x118mm
EXISTING STRUCTURE:
Concrete wall
Brick cladding

PREFAB INSULATION PANELS

VENTILATION PIPES

WOODEN POSTS

LININGS

WOODEN CLADDING

THERMOWOOD CLADDING
INTERIOR VIEW

- Existing structure
- Sticks for lining support
- Insulation panels
- Ventilation inlet mechanism

- Interior linings
- Existing structure
- Window frame type_B

APPLY 2ND SKIN DESIGN, DE
WINDOW DETAIL

New structure
Vertical section

Existing structure:
- Precast concrete block 300mm
- Prefabricated panel 140x220mm
- Fiber cement sheet 10mm
- EPS Insulation Board 200mm
- Insulated profile
- Thermowood Cladding:
  - Channel profile 25x118mm
  - Ventilated cavity
  - Wooden batten 40x40mm
- Plant system integrated in the panel:
  - Ventilation pipe Ø 50mm
  - Air inlet mechanism

Apply 2ndSkin Design, DE
WINDOW DETAIL

Horizontal Detail 1

- Interior finishing board
- Aluminum window with integrated shading system
- Steel element water drainage

- Interior lining board
- Concrete load bearing
- 860x1060mm Plant system panel board
- Ventilation pipe Ø 250mm
- Fiber cement sheet 10 mm
- EPS Insulation Board 200mm
- Ventilated cavity 40mm
- Wooden batter 42x42mm
- Thermowood pine cladding: profile 02x118mm

- Wooden beam 40x290mm
- U-steel profile
- Wooden post 70x250mm
- Blumen vapour barrier

EXTERIOR

Aluminum window with integrated shading system
Steel element for water drainage 2mm
Perforated ventilation profile
Blumen vapour barrier
Stainless steel wood rail

VIRTUAL DETAIL

- U-beam profile
- Framing structure
- Brick cladding 10mm
- Concrete slab 130mm

- Plant system
- Integrated in the panel
- Ventilation pipe Ø 250mm
- Air inlet mechanism
- Interior lining

Vertical Detail 1
West facade
DESIGNING ADDITIONAL ELEMENTS
OPEN/CLOSED BALCONY

INFO:
- Extra space of 6.4 m²
- New balcony structure

INSPIRATION:
- Extrude the balcony
- Frame the balcony

*(source: Archdaily)
OPEN/CLOSED BALCONY

**Step 1:**
- Extent interior floor
- Apply window frames at the edge

**Step 2:**
- Steel structure:
  - I columns 140mm
  - C beams 45x120mm

**Step 3:**
- Wooden cladding
- Glass railings
OPEN/CLOSED BALCONY

- Wooden Balcony Floor
- Sheet Glass 8mm / 12mm

Vertical section

- Steel angle
- Prefabricated panel 200mm
- Fiber cement sheet 10mm
- EPS Insulation Board 30mm
- 6mm clear glass balustrade
- Steel balustrade 140mm

East Elevation

DESIGNING ADDITIONAL ELEMENTS
**ELEVATOR DESIGN CONCEPT**

**INFO:**
- 1 Corner elevators, New staircases
- Steel structure: I beams 140mm
- Exterior passage

**INSPIRATION:**
- Access for everyone
- Improved floor plan
- 2 extra sleeping rooms

DESIGNING ADDITIONAL ELEMENTS
ELEVATOR DESIGN CONCEPT

Floor plan

West Elevation

DESIGNING ADDITIONAL ELEMENTS
SUNSHADES DESIGN CONCEPT

INSPIRATION:
- Glare protection
- Light transmission
- Individually adjustable sliding system

INFO:
- Sliding sun shading system:
  3 Stripped lattices
- Lightweight material

* Use of sunshades at East facade
SUNSHADES DESIGN CONCEPT

Horizontal section

- Balcony floor
- Glass railing
- Operable wooden sunshades
- Thermowood cladding, profile 21mm

3D view

East Elevation
C2C CERAMIC CLADDING CONCEPT

INSPIRATION:
- Sustainable cladding
- More options for the user

INFO:
- Cradle to cradle ceramic tile
- Various sizes
- Grey beige color

* Source www.mosa.com
**Open/Closed Balcony**
- Extra space of 6.4 m²
- Self supported structure as balcony addition
- Wooden cladding

**Sunshades**
- Modified wood or bamboo composite
- Sun transmission
- No glare

**Cladding**
- C2C ceramic tile
- Lightweight
- Sustainable

**Elevator**
- New floor plan, two rooms extra
- Exterior staircases and corner elevator

*Source: www.mosa.com*
DESIGN SUGGESTION

2ndSkin Design

Open | Closed balcony concept

Sunshades concept

- Thermowood cladding: profile 21x118mm
- Operable sunshades
- Balcony floor
- Glass railing

Ceramic cladding

DESIGNING ADDITIONAL ELEMENTS
CONCLUSIONS
HOW THE SYSTEM AFFECTED THE BUILDING?

- Energy upgrade
- Facade compositions variety
- Updated installations
- Additional elements Catalogue
<table>
<thead>
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<tbody>
<tr>
<td>• 6.4 m² extra</td>
</tr>
<tr>
<td>• Buffer zone</td>
</tr>
<tr>
<td>• New balcony area</td>
</tr>
<tr>
<td>• Improved climate</td>
</tr>
</tbody>
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OPEN/CLOSED BALCONY
- 6,4 m² extra
- Buffer zone
- New balcony area
- Improved climate

SUNSHADES
- Glare protection
- Light transmission
- Individual system
- Improved climate
### OPEN/CLOSED BALCONY
- 6.4 m² extra
- Buffer zone
- New balcony area
- Improved climate

### SUNSHADES
- Glare protection
- Light transmission
- Individual system
- Improved climate

### CERAMIC CLADDING
- Durable
- Sustainable
<table>
<thead>
<tr>
<th>OPEN/CLOSED BALCONY</th>
<th>SUNSHADES</th>
<th>CERAMIC CLADDING</th>
<th>ELEVATOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>• 6.4 m² extra</td>
<td>• Glare protection</td>
<td>• Durable</td>
<td>• Accessible for everyone</td>
</tr>
<tr>
<td>• Buffer zone</td>
<td>• Light transmission</td>
<td>• Sustainable</td>
<td>• Improved floor plan</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Extra rooms (12m²)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
IS THE 2NDSKIN SYSTEM FLEXIBLE?

2ndSkin Application

Wooden posts: YES

SO & SO: YES

Ventilation

Insulation panels: YES

Windows: YES
VENTILATION

Floor plan

Window
Size, location

Pipe system
Air inlet location

Top inlet mechanism
min, h=180 mm

Bottom inlet mechanism
min, h=350 mm
**Wooden Posts**

- Yes

**WWR**

- Min spam: 1.20m
- Max spam: 5.20m

**Windows**

- Yes

**Existing window layout**

- Height: 0.63-3.8m
- Width: 1.65-2.4m

**Architect’s intention**
Insulation panels

**WWR**
- Min section: 68x220 mm
- Max size: 3.5x8 m

**Roof**
- 140mm min gap

**Slab projection**
- Half loggia/Half overhang
- Short panels

**Balcony**
- Incised
- Extra substructure

CONCLUSIONS
ESSENTIAL FACTORS FOR FUTURE APPLICATIONS

2ndSkin Application

- WWR
- Wooden posts

Floor plan
- Window size, location

Ventilation
- Pipe system
- Air inlet location

Insulation panels
- WWR
- Various shapes & sizes

Slab projection
- 140mm min gap

Windows
- Existing window layout
- Architect’s intention

Balcony
- Half loggia / Half overhang
- Incised
- Extra substructure
- Short panels

Conclusions
PROS AND CONS

- Improved energy performance
- Updated installations
- Fast and easy installation
- Sustainable, Scalable
- Flexibility
- Design variety: Facade compositions, Catalogue

CONCLUSIONS

- Just 2 buildings studied
- Only Northern climates
- Not so flexible ventilation: central rooms
- Thick facade width (no slab projection)
- Cost not accounted
RECOMMENDATIONS

- Ventilation: Interior pipe routes

- Incorporate water pipes:
  Challenging maintenance

- Problematic facade width:
  Remove parapet

- More building types:
  Single Family Houses (34% Germany)

- Southern climates: cooling

- Business plan
THANK YOU!