Hybrid Hanok: OUN for Business Incubator Center
Transformation of the Traditional Hanok

The Hanok, a Korean traditional housing, is under the transformation to "hybrid Hanok" for zero-energy performance.

What is the Hanok style?

What is the Hanok's materials?

Wood, the main material of Hanok, commits to 40% reduction in carbon emissions by 2030.

What is the Hanok's structure?

Uniqueness of Korean timber structure in Hanok

- Purlin
- Girder
- Roof tile
- Pillar
- Stylobate
Design Constraints

Hanok Users’ Perceptions and Evaluations

Design Constraints toward Zero Energy Hanok

Roadmap of Zero-energy Hanok

2020
- Public Buildings (Over 1,000m²)
- Civil buildings (Over 1,000m²)
- Public buildings (Over 500m²)

2025
- Apartment Buildings (Over 30 households)

2030
- All Buildings, (Over 500m²)

Major Constraints

Architecture
- Durability and Resilience
- Engineering
- Integrated Performance
- Energy
- Embodied Environmental Impact
- Occupant Experience
- Comfort
- Market Analysis
- Conclusion
Site Contexts and Location

The entire mountain is made of granite and the bedrock is exposed. An altar built by King Taejo along with Jongmyo Shrine during the Joseon Dynasty.

Sajik-District (site), is located in the office center of Seoul, South Korea.

Architecture
- Culture heritage
- Residence
- Building
- Green
- Traffic

Engineering
- Integrated Performance
- Energy
- Embodied Environmental Impact

Occupant Experience
- Comfort
- Market Analysis

Conclusion
- Durability and Resilience
- Embodied Environmental Impact
- Comfort
- Market Analysis
The increasing rate of shared offices in Seoul

It is showing the distribution of shared offices and general offices in Seoul. There is no shared office in Sajik-dong, Jongno-gu, our site.
Design Vision

- Architecture
- Durability and Resilience
- Engineering
- Integrated Performance
- Energy
- Embodied Environmental Impact
- Occupant Experience
- Comfort
- Market Analysis
- Conclusion
**Design Strategies**

**Architecture**
- Durability and Resilience
- Engineering
- Integrated Performance
- Energy
- Embodied Environmental Impact
- Occupant Experience
- Comfort
- Market Analysis
- Conclusion

**PROJECT DATA**

<table>
<thead>
<tr>
<th>SUBJECT</th>
<th>DETAILS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>1-28, Sajik-dong, Jongno-gu, Seoul, South Korea</td>
</tr>
<tr>
<td>Climate</td>
<td>Hot &amp; Humid (Summer) and Cold &amp; Dry (Winter), Similar to the U.S climate Zone 4A</td>
</tr>
<tr>
<td>Total Floor Area and Unit Area</td>
<td>4,136 m² (44,527 ft²)</td>
</tr>
<tr>
<td>The Total Floor Area Ratio of Office to Non-office Space</td>
<td>53.6% (office) : 46.4%(non – office)</td>
</tr>
<tr>
<td>Space Use and Occupancy</td>
<td>Office, Atrium Office, Commercial, Community Center</td>
</tr>
<tr>
<td>Target Site EUI</td>
<td>Shared offices, Business incubator center, retail shops, community center, Historic site</td>
</tr>
<tr>
<td>Target Source EUI</td>
<td>Site EUI 129kWh/m²/yr (40.9 kBTU/ft²/yr), Source EUI 187kWh/m²/yr (59.3 kBTU/ft²/yr)</td>
</tr>
<tr>
<td>Construction Cost</td>
<td>USD 18,811,201 ($4,500/m², 420/ft²)</td>
</tr>
</tbody>
</table>
Eco-friendly Flame Retardant
Fire retardant treated wood provides benefits like slower ignition time, less smoke production, and no flaming droplets.

Minimize Toxic gas
The internal finishing materials are made of wood to minimize toxic gas emissions.

Heavy-Timber
Glulam beams and columns have given three off-the-shelf structural connectors a minimum one-hour fire rating, opening new opportunities for mass-timber construction in buildings.

Fire Safety Treatments
Integration of Structure and Envelope

**H-Shaped Column**

Cross Sectional Area
Existing = Proposed

However,

**Bending Performance**

Existing < Proposed (20.9 %▲)

**Airtightness, Thermal break**

Existing < Proposed

Architecture
Durability and Resilience
Engineering
Integrated Performance
Energy
Embodied Environmental Impact
Occupant Experience
Comfort
Market Analysis
Conclusion

Existing Design (Square Column + Walls)

Cross-section
330mm x 330mm

Bending Performance

= 9882.68 x 10^6

Proposed Design (H-Shaped Column + Walls)

Cross-section
480mm x 40mm x 2
280mm x 250mm

Bending Performance

= 11946.13 x 10^6

H-Shaped Column
Connecting Hardware
Wooden Beam
Existing Column
High Strength Bolt
Stud

Existing Column

Existing = Proposed

Cross-sectional Area

Existing Column

Wooden Beam
Connecting Hardware
High Strength Bolt
Stud

H-Shaped Column

Existing Design

Proposed Design

Wooden Beam
Connecting Hardware
Wooden Beam
H-Shaped Column
High Strength Bolt
Composite Structured Insulation Panel
Column

Existing Design (Square Column + Walls)

Cross-section
330mm x 330mm

Bending Performance

= 9882.68 x 10^6

Proposed Design (H-Shaped Column + Walls)

Cross-section
480mm x 40mm x 2
280mm x 250mm

Bending Performance

= 11946.13 x 10^6
Local Supply of Recycled Materials

Hwacheon Wood Science Complex

Korea Forest Cooperative Federation
Wood Distribution Center – Deciduous wood wallboards, Board siding, Deciduous wood collecting boards

KYUNGMIN Industry – GLT / GLULAM

Embodied Environmental Impact

The number of waste wood recycling companies in Korea.
(Source: Korea Wood Recycling Association)

“25% CO2 Emission Reduction compared to RC”

“13% CO2 Emission Reduction compared to imported products”

25% CO2 Emission Reduction compared to RC

13% CO2 Emission Reduction compared to imported products

The number of waste wood recycling companies in Korea.
(Source: Korea Wood Recycling Association)
MEP Systems

- Hybrid Window Ventilation System
- UFAD (Underfloor air distribution)
- ERV (Energy Recovery Ventilator)
- ESS (Energy Storage System)
- LED lighting
- Chilled Beam
- BIPV
- Integrated Piping System
- Geothermal Heat Pump

- Apply to windows
- Apply to office floors
- Apply to basement MEP rooms
- Apply to ceiling lighting
- Apply to office ceiling
- Apply to roof, wall, shading louvers
- Apply to water sink
- Apply to basement MEP rooms

Architecture
Durability and Resilience
Engineering
Integrated Performance
Energy
Embodied Environmental Impact
Occupant Experience
Comfort
Market Analysis
Conclusion
Double Skin Facade

- T30 FIRE PLASTER BOARD
- T140 PLYWOOD
- ANTI-VIBRATION SYSTEM
- WOOD FINISHING
- VERTICAL SHADING LOUVER PIVOT
- SPIDER CLAMP
- PV-INTEGRATED VERTICAL LOUVER (SINGLE-AIXS)
- OUTSIDE: 6.4mm SINGLE PANE LOW-E GLASS
- INSIDE: 24mm DOUBLE PANE LOW-E GLASS (16mm ARGON FILLED CAVITY)
### Continuous Insulation Envelope

#### Construction Details

- Insulation (Glass wool)
- Glue Line Protection (GLP)
- Anright Tape
- Tri-Plex Glass System Windows
- Window Frame

#### Products

- Glass
- Insulation (Glass wool)

#### Integrated Performance

- Embodied Environmental Impact
- Energy
- Architecture
- Durability and Resilience
- Engineering
- Occupant Experience
- Market Analysis
- Conclusion

#### Energy

<table>
<thead>
<tr>
<th>Season</th>
<th>U-Value</th>
<th>Insulation Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summer</td>
<td>0.118 W/m²K</td>
<td>150mm</td>
</tr>
<tr>
<td>Winter</td>
<td>0.095 W/m²K</td>
<td>200mm</td>
</tr>
</tbody>
</table>

#### Integrated Performance

- Comfort
- Architecture

#### Embodied Environmental Impact

- Market Analysis
- Conclusion

#### Durability and Resilience

- Nature of Insulation

#### Architecture

- Integrated Performance
- Embodied Environmental Impact
- Comfort
- Durability and Resilience
- Market Analysis
- Conclusion

#### Engineering

- Energy
- Architecture
- Durability and Resilience
- Integrated Performance
- Embodied Environmental Impact
- Comfort
- Market Analysis
- Conclusion

#### Comfort

- Energy
- Architecture
- Durability and Resilience
- Integrated Performance
- Embodied Environmental Impact
- Market Analysis
- Conclusion

#### Market Analysis

- Energy
- Architecture
- Durability and Resilience
- Integrated Performance
- Embodied Environmental Impact
- Comfort
- Conclusion

#### Conclusion

- Energy
- Architecture
- Durability and Resilience
- Integrated Performance
- Embodied Environmental Impact
- Comfort
- Market Analysis

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**Comprehensive Structural Insulated Wall Panel (C-SIP)**

- OSB
- Fiberglass core insulation
- Epps foam

**U-Value according to wall insulation thickness**

- **Typical Thick Panel Wall**
  - 0.118 W/m²K
  - 150mm

- **SP Wall**
  - 0.095 W/m²K
  - 200mm

---

**Light Environment**

- Summer
- Winter

**Sound Environment**

- Wall - STC Sound Transmission Class ≥ 50
- Floor - Soundproof based

**Heat Environment / Moisture**

- C-SIP Wall THK 200: U-Value = 0.118 W/m²K
Applications of continuous insulation

Schock isokorb type s

THERM Simulation

Existing roof section
Existing balcony section
Existing foundation section

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IOT-Based Indoor Environmental Quality Monitoring

Data Collection & Transmission
- Light
- Temperature
- Sound
- Air

Data Visualization
- Indoor Dashboard
- Outdoor Dashboard

Data Storage & Post-Processing
- Local Data Storage
- Cloud Data Storage
- VR based Visualization
- Wearable Visualization
- AI based Data Optimization

IOT Application Scheme

Architecture
Durability and Resilience
Engineering
Integrated Performance
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Embodied Environmental Impact
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Daylighting Performance

- % of occupied hours with at least 300 lux
- % of floor area with at least 300 lux for 50% of the annual occupied hours
Thermal Comfort & Air Quality of UFAD

Architecture
Durability and Resilience
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Under Floor Air Distribution
Over Head Air Distribution

Temperature (deg F)

Contaminant (ppm)
PV Modules and Renewable Energy Generation

1. PV-Integrated Roof ver.1
   - Azimuth: 135°, Tilt: 30°
   - Area: 561.011 m²
   - Type: Thin Film
   - Efficiency: 10%
   - Array Type: Fixed
   - DC System Size (KW): 59.1

2. Atrium Roof PV Arrays
   - Azimuth: 135°, Tilt: 30°
   - Area: 465 m²
   - Type: Crystalline Silicon
   - Efficiency: 19%
   - Array Type: Fixed
   - DC System Size (KW): 88.35

3. Wall-mounted BAPVs
   - Azimuth: 135°/225°, Tilt: 90°
   - Area: 39.79 m²/92m²
   - Type: Crystalline Silicon
   - Efficiency: 19%
   - Array Type: Fixed
   - DC System Size (KW): 7.56/17.48

4. PV-Integrated Vertical Louvers
   - Azimuth: 90°/135°/225°/270°
   - Tilt: 90°
   - Area (m²): 12.9/74.1/38.8/11.5
   - Type: Crystalline Silicon
   - Efficiency: 19%
   - Array Type: 1-Axis Tracking
   - DC System Size (KW): 2.45/14.0/7.3/2.18

5. PV-Integrated Roof ver.2
   - Azimuth: 135°, Tilt: 30°
   - Area: 413.7 m²
   - Type: Crystalline Silicon
   - Efficiency: 19%
   - Array Type: Fixed
   - DC System Size (KW): 78.6

6. Solar Canopy
   - Azimuth: 225°, Tilt: 15°
   - Area: 492 m²
   - Type: Crystalline Silicon
   - Efficiency: 19%
   - Array Type: Fixed
   - DC System Size (KW): 93.48

BIPV + BAPV Renewable Energy Generation

- Roof Tile BIPV
- Wall-Mounted BIPV / SE
- PV Integrated Shading Device / E
- PV Integrated Shading Device / SW
- Solar Canopy
- Atrium PV Array
- Wall-Mounted BIPV / SW

381,493 KWh/yr
407,787 KWh/yr
92 KWh/m²/yr
98.3 KWh/m²/yr
Construction Cost Breakdown

$18,811,000
$422 per ft² or $4,538 per m²

Cost by Work Type

<table>
<thead>
<tr>
<th>Work Type</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction works</td>
<td>USD 13,544,064</td>
</tr>
<tr>
<td>Active equipment, Renewable energy systems</td>
<td>USD 3,574,128</td>
</tr>
<tr>
<td>Energy monitoring systems</td>
<td>USD 752,448</td>
</tr>
<tr>
<td>Civil engineering</td>
<td>USD 564,336</td>
</tr>
<tr>
<td>Disaster prevention equipment</td>
<td>USD 376,224</td>
</tr>
</tbody>
</table>

Total Cost: USD 18,811,201

( Total floor area: 44,527 ft² or 4,136 m² )
## Construction Cost Savings

### Cost Saving Projection

<table>
<thead>
<tr>
<th>Cost Saving by Plans</th>
<th>Savings</th>
<th>Cost Saving Projection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Using modular construction saved</td>
<td>USD 3,737,167</td>
<td>-20%</td>
</tr>
<tr>
<td>Energy savings</td>
<td>USD 4,671,459</td>
<td>-45%</td>
</tr>
<tr>
<td>Governmental subsidies</td>
<td>USD 125,365</td>
<td>-15~25%</td>
</tr>
</tbody>
</table>

**Total Savings**

USD 8,408,626

USD 188 per ft² (or USD 2,033 per m²)

### Cost Saving by Financial Resources

<table>
<thead>
<tr>
<th>Financial Resources</th>
<th>USD 8,408,626</th>
</tr>
</thead>
<tbody>
<tr>
<td>Using modular construction</td>
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</tr>
<tr>
<td>- α%</td>
<td></td>
</tr>
</tbody>
</table>

Using modular construction saved (2/3 of the construction cost, Max USD 125,365)

USD 3,737,167

USD 4,671,459

USD 125,365
Green space
Reduce the urban heat island effect and maximize the efficiency of water management

High-performing envelopes
Reduce energy loss by air-tightened insulation, composite structural insulation panels

Solar collectors
Reduce lighting energy by offering daylight into deep spaces

Recycled water loops
Reduce water usage by recycling rain water from gavelled roofs to porous pavements

Geothermal heat pump
Reduce heating and cooling energy by stable geothermal heat pumps through the year

Noise barrier walls
Block transportation noise transmission and generate the electricity from BAPV

Double skin facades
Reduce fan, heating/cooling, and lighting energy by improving natural ventilation and daylighting

Recycled CLT structure components
Reduce CO2 emission by recycled CLT columns and beams from local manufacturers

BIPVs and BAPVs
Generate the sufficient amount of electricity from roofs, walls, shadings of building envelopes

Modular systems
Reduce construction periods and costs by applying modular design and modular construction process

Aerogel glass facades
Improve glass façade performances by applying with highly-insulated glass materials

Thermal breaks
Minimize energy loss by designing thermal break boundaries between building structures and balconies

IOT-responsive controls
Maximize the efficiency of indoor environmental controls using IOT sensors and visualization

Earthquake-adaptive structures
Improve structural safety in case of growing earthquakes
Old & New: Architecture

Hybrid Hanok: OUN for Business Incubator Center
Collaboration with External Partners

CAMU Team

Faculty
- Jeewhan Lee, Ph.D.

- Uhjin Lee, Leader
- Seojong Jin
- Huyeol Lee
- Minkook Kim
- Taeeseok Kwon
- Joonyeok Seo
- Dahyun Lee
- JeongHun Cha
- MinYoung Kim
- Jaekyung Kim
- Hyunwoo Rho
- Hyeonuk Shin
- Hyunhong Kang
- Dageon Oh

External Partners

- Consulting for Timber Structure and Materials
- **CAMU Team**

- Consulting for Envelope Materials and Performances
- **AXIA materials**

- Consulting for Architecture Design
- **HAENGLIM**

- Consulting for MEP Systems
- **Han Kook Engineering Co., Ltd.**

- Consulting for Energy Performance and Simulation
- **나무텍**

- Consulting for Hanok Design and Structure

- Consulting for Architecture Design

- Consulting for Envelope Materials and Performances

- Consulting for MEP Systems

- Consulting for Energy Performance and Simulation

- Consulting for Hanok Design and Structure

- Consulting for Timber Structure and Materials

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Architecture

Durability and Resilience

Engineering

Integrated Performance

Embodied Environmental Impact

Occupant Experience

Comfort

Market Analysis

Conclusion

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Sep., 2021

- External Meeting w/ HANGLIM & MJ Hanok R&D Center
- External Meeting w/ HANGLIM
- External Meeting w/ AXIA Materials & MJ Hanok R&D Center
- External Meeting w/ HanKook Engr.
- External Meeting w/ Namoo Tech
- External Meeting w/ Namoo Tech & HANGLIM

April, 23 2022

- Internal Kick-off meeting
- Internal Discussion Period: 10/28/21–11/10/21
- Internal Design Period: 11/15/21–1/15/22
- Internal Intensive Production Period: 12/15/21–2/18/22

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Thank you for your listening!