ReUse Loppu Seminar at Tampere University of Technology

Potential for cascading wood from building

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Background

What is cascading?

Longer sequential process for products

Figure 1. Cascading flow for wood products

Reuse or reprocessing

Material recycle

Energy recovery

Höglmeier et al, 2013, p.82
Why cascading wood in Finland?

EU Target 2020

A lot of wooden buildings in Finland
Why cascading wood from building?

Resource for secondary products

Longer carbon storage

Saving energy consumption during manufacturing

Reduction of construction and demolition waste
Background  C&DW and wood waste in Finland

![Bar chart showing waste quantities](image)

- **70% of C&DW waste is wood waste**

Figure 2. Amount of waste from different source (Kojo and Lija, 2011)
Objective

Cascading?

http://www.colourbox.com

https://www.quanex.com
Material  Case study building

Building name:  Näsin Päiväkoti (Kindergarten)
Location:  Porvoo
Built year:  1977 (newest renovation in 1996)
Floor area:  864 m²  Mainly with wood structure
**Method**

**Detail of wall**

**Section detail of wall**

W1: Interior wall
- Framing Stud 2”x3”

W2: Partition wall
- Framing Stud 2”x3”

W3: Exterior wall
- Framing Stud 2”x3”

*Button span is two types: 500,300,1400,300,500mm (with opening) 1000,1000,400,400mm (without opening)

**Cross-section**

- 1” x 4”
- 1” x 6”
- 2” x 2”
- 2” x 3”
- 2” x 4”

**Figure 4. Wall detail**
Method

Detail of floor and ceiling

Section detail of floor

Section detail of ceiling and roof part

Cross-section

Figure 5. Floor and ceiling detail
Method

Detail of roof

Section detail of roof

Cross-section

1” × 4”  2” × 4”  2” × 5”

Figure 6. Roof detail
Result  Amount of wood in cross-section

Figure 10. Amount of wood in cross-section

High possibility for reuse, reprocessing, recycling

Not large amount but high possibility for chipping
Result  Amount of wood in element

Figure 11. Amount of wood in element
Result  Amount of wood in cross-section and element

Figure 12. Amount of wood in cross-section and element

How much bigger cross-section can be recovered?

How much "2×8" can be recovered without damage?

What kind of condition smaller cross-section will be?
Material

View of demolition
To gather detailed information regarding wood recovered from building
## Method

### Classification criteria

#### Classification

<table>
<thead>
<tr>
<th>Cross section</th>
<th>Clean and extent of damage</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. 2”×8” ≤ D</td>
<td>A: Minimal (N&lt;10 nails/m)</td>
<td>D: Contaminated</td>
</tr>
<tr>
<td>2. 2”×4”≤ D &lt; 2”×8”</td>
<td>B: Less (10≤N≤20 nails/m)</td>
<td>Recycle</td>
</tr>
<tr>
<td>3. D &lt; 2”×4”</td>
<td>C: Damaged (20 nails/m≤N)</td>
<td>Recovery</td>
</tr>
</tbody>
</table>

**Table 1. Classification criteria**

### Damage extent by crack

**Cross section**

- Crack: D
- 2D ≥ total crack length

**Longer surface**

- Crack: L
- L/3 ≥ total crack length

**Figure 8. Criteria for damage by crack**
Method
Examined area

Randomly pick up 10 wood pieces in each cross-section

Figure 9. Demolished area in the case study building
Result Loss in length after demolition

Figure 14. Loss in length after demolition

A lot of the original length in damage expected.
**Result** Percentage of damage extent in cross-section

Figure 15. Percentage of damage extent in cross-section

- **Class 1**: Large cross-section
- **A**: Minimal
- **B**: Less
- **C**: Damaged
- **D**: Contaminated
- **2”×8”**: Yellow
- **4”×4”**: Light purple
Result  Percentage of damage extent in cross-section

Figure 15. Percentage of damage extent in cross-section

- Class 1: Large cross-section
  - 82% of all belong to class D
  - Low possibility for cascading

Legend:
- A: Minimal
- B: Less
- C: Damaged
- D: Contaminated
- 2” × 8”
- 4” × 4”
**Result** Percentage of damage extent in cross-section

[Diagram showing percentage distribution]

- 18% Class 1 Large cross-section
- 40% Wood belong to class A & B
- 60% High possibility for cascading
- 82%

4” × 4”

Figure 15. Percentage of damage extent in cross-section

<table>
<thead>
<tr>
<th>A: Minimal</th>
<th>C: Damaged</th>
<th>D: Contaminated</th>
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<tbody>
<tr>
<td>B: Less</td>
<td></td>
<td></td>
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</table>

2” × 8”

4” × 4”
**Result**  Percentage of damage extent in cross-section

![Percentage of damage extent in cross-section](image)

Figure 15. Percentage of damage extent in cross-section

- A: Minimal
- B: Less
- C: Damaged
- D: Contaminated

<table>
<thead>
<tr>
<th>2”×4”</th>
<th>2”×5”</th>
</tr>
</thead>
</table>

Aalto University
Result  Percentage of damage extent in cross-section

Wood equally belong to class A, B & C

A variety of possibility for cascading

Figure 15. Percentage of damage extent in cross-section

Aalto University
Result  Percentage of damage extent in cross-section

Wood belong to class A & B

High possibility for cascading

Figure 15. Percentage of damage extent in cross-section

A: Minimal  C: Damaged  B: Less  D: Contaminated

2”×4”  2”×5”
**Result**  Percentage of damage extent in cross-section

Figure 15. Percentage of damage extent in cross-section

- A: Minimal  C: Damaged
- B: Less  D: Contaminated
- 1”×4”  1”×6”Painted  2”×3”
- 1”×4”Painted  2”×2”
**Result**  Percentage of damage extent in cross-section

Figure 15. Percentage of damage extent in cross-section

1” × 4”

All belong to class A

High possibility for cascading

- A: Minimal
- C: Damaged
- B: Less
- D: Contaminated
- 1” × 4”
- 1” × 6” Painted
- 2” × 3”
- 1” × 4” Painted
- 2” × 2”
**Result**  Percentage of damage extent in cross-section

![Pie chart showing percentage of damage extent in cross-section](image)

- 1”× 4” painted
- All belong to class D
- Low possibility for cascading

Figure 15. Percentage of damage extent in cross-section

- A: Minimal
- C: Damaged
- B: Less
- D: Contaminated
- 1”×4”
- 1”×6”Painted
- 2”×3”
- 1”×4”Painted
- 2”×2”
Result  Percentage of damage extent in cross-section

1”× 6” painted

All belong to class D

Low possibility for cascading

Figure 15. Percentage of damage extent in cross-section

- A: Minimal
- B: Less
- C: Damaged
- D: Contaminated

- 1”×4”
- 1”×6” Painted
- 2”×3”
- 1”×4” Painted
- 2”×2”
Result  Percentage of damage extent in cross-section

Figure 15. Percentage of damage extent in cross-section

- **Class 3**: Small cross-section
- **2”×2”**: Wood belong to class A, B & C
- **Possibility for cascading but cross-section is small**

Legend:
- A: Minimal
- B: Less
- C: Damaged
- D: Contaminated
- 1”×4”
- 1”×6” Painted
- 2”×3”
- 1”×4” Painted
- 2”×2”
Result: Percentage of damage extent in cross-section

2” × 3”

Wood belong to class B & C

↓

Low possibility for cascading

Figure 15. Percentage of damage extent in cross-section

A: Minimal  C: Damaged
B: Less      D: Contaminated

1” × 4”  1” × 6” Painted  2” × 3”
1” × 4” Painted  2” × 2”
**Result** Definition of “Location”

1. **Roof**
   Whole part of roof

2. **Unit**
   Prefabricated part (wall, floor)

3. **Cladding**
   Additional part (Exterior)
Result  Percentage of damage extent in location

By Location

- Cladding
- Roof
- Unit

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<tbody>
<tr>
<td>B: Less</td>
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<td>2”×2”</td>
</tr>
<tr>
<td>2”×8”</td>
<td>1”×4” Painted</td>
<td></td>
</tr>
</tbody>
</table>

Aalto University
Result  Percentage of damage extent in location

Figure 16. Percentage of damage extent in location

High possibility for cascading

Most wood belong to A & B

Aalto University
Result  Percentage of damage extent in location

Most wood belong to B, C & D

Low possibility for cascading

Figure 16. Percentage of damage extent in location
**Result** Percentage of damage extent in location

All wood belong to class D

Least possibility for cascading

Figure 16. Percentage of damage extent in location
**Result**

Amount of recovered wood in cross-section

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Figure 17. Amount of recovered wood in cross-section

- **Largest amount but not suitable target for cascading**
- **Good recovered condition. Good target for cascading**
- **Belonging to class D due to the paint, but well recovered**

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Aalto University
Result

Amount of recovered wood in location

Figure 18. Amount of recovered wood in location

A lot of wood can be recovered with less damage. Damage extent is higher than other parts. All belong to class D due to the paint on surface.
Discussion  Potential of 1” × 4” and 1” × 6” with paint

- Almost no loss in the length and good recovered condition
- Potentially 3 to 6 $ for cascaded T&G flooring *2

High cascading potential even though the surface is painted

*2 Janowiak et al (2005)
Discussion

Potential cascading flow $1'' \times 4''$ and $1'' \times 6''$

Figure 20. Potential cascading flow for $1'' \times 4''$ and $1'' \times 6''$
Discussion Improvements on the potential

Figure 21. Views for brace 1”× 4” and roof part

- Brace is broken in the joint part with roof pillar
- Wood is damaged when it is grabbed by the machine
**Discussion**

Improvements on the potential

- Joint with metals
- Wood joint

Hybrid joint for cascading

*Figure 22. Existing joint options and Japanese joint*
Discussion

Potential cascading flow $2'' \times 2''$ and $2'' \times 3''$

Figure 22. Potential cascading flow for $2'' \times 2''$ and $2'' \times 3''$
Discussion  Improvements on the potential

Figure 21. Views 2” × 3” and effort to take attached materials

- It will be grabbed as one element by the machine
- It requires effort to take the attached materials in an element
Discussion  Improvements on the potential


Figure 22. Design concept for modular and element design
Potential cascading flow 4” × 4”

Figure 22. Potential cascading flow for 2” × 2” and 2” × 3”
**Discussion**

Extension of target for cascading wood

![Bar chart showing waste percentage of single wooden family house by Kuusakoski Oy](chart.png)

- **Wooden exterior**
- **Brick exterior**

Figure 22. Waste percentage of single wooden family house by Kuusakoski Oy
Conclusion
1. Potential should be considered from both the size and location
2. Independent part has higher potential for cascading
3. 
Even small cross-section 1” × 4” and 1” × 6” had high potential
4.
Small improvements could enhance cascading potential
5. The target for cascading could be extended to different types of building
Future topics

• Suitable demolition method for cascading
• LCA including whole process
• Accurate cost comparison
• Social acceptance
Thank you!
References


