Evacuation Dynamics of Children

-Walking speeds, flow through doors in daycare centers

Ph.D. Student Aldís Rún Lárusdóttir
Ph.D., Associate Professor Anne Dederichs
Agenda

- Introduction
- Method
- Results
- Conclusion
- Questions and Comments
Introduction

• Motivation
  – Performance based fire codes.
  – Evacuation models.
    • Mainly data on healthy adults.
    • More focus coming on vulnerable groups.
    • Very limited data on children.

• Aim of the study.
  – Collect data on children’s evacuation.
  – Compare to existing fire evacuation theory.
  – Bring focus to the subject.
Method

• Daycare centers in Denmark.
  – Younger children, 0-2 years.
  – Older children, 3-6 years.

• 16 full scale evacuation experiments.
  – Fire alarm.
  – Verbal warning.

• Data collection.
  – Filming
  – Measurements
  – Interviews
  – Observations
Results

• Walking speed.
  – In horizontal plane.
  – In stairs.

• Flow through doors.

• Other interesting findings.
Walking speed – horizontal plane

- Measured at low person densities.

- Average walking speed.
  - 0.52 m/s for 0-2 year olds.
  - 0.84 m/s for 3-6 year olds.

- Running towards exits.
  - 40% of older children.
  - 5% of younger children.
Walking speed – horizontal plane (continue)
Walking speed - stairs

- Three spiral stairs.
- Used by 3-6 year old children and their teachers.
- Similar dimensions.
- Different design.

Data on three spiral stairs.

<table>
<thead>
<tr>
<th>Stair</th>
<th>Width (m)</th>
<th>Slope (°)</th>
<th>Average speed (m/s)</th>
<th>Standard deviation (m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stair 1</td>
<td>0.80</td>
<td>33</td>
<td>0.58</td>
<td>0.31</td>
</tr>
<tr>
<td>Stair 2</td>
<td>0.87</td>
<td>33</td>
<td>0.38</td>
<td>0.07</td>
</tr>
<tr>
<td>Stair 3</td>
<td>0.91</td>
<td>30</td>
<td>0.13</td>
<td>0.06</td>
</tr>
</tbody>
</table>
Walking speed – stairs (continue)

- Stair 1 (3-6 year old children)
- Stair 2 (3-6 year old children)
- Stair 3 (3-6 year old children)
- Frantzich (spiral stair, adults)
Flow through doors

- Flow unit: person/s m.
  - Effective width of door = width of door opening

- Density unit: person/m$^2$.
  - Densities up to 6 pers/m$^2$ obtained naturally.
  - Extra experiments to obtain higher densities.
Flow through doors (continue)

- **Flow [pers/s m]**
- **Person density [pers/m²]**

Graph showing flow through doors for:
- 0-2 year old children (measurements)
- Trend, 0-2 year olds
- 3-6 year old children (measurements)
- Trend, 3-6 year olds
Flow through doors (continue)

- 0-2 year old children (measurements)
- Trend, 0-2 year olds
- 3-6 year old children (measurements)
- Trend, 3-6 year olds
- Nelson and Mowrer (adults)
Flow through doors (continue)

Flow [pers/s m²]

Person density [pers/m²]

- 0-2 year old children (measurements)
- Trend, 0-2 year olds
- 3-6 year old children (measurements)
- Trend, 3-6 year olds
- Nelson and Mowrer (adults)
- Predtechenskii and Milinskii (children)
- Predtechenskii and Milinskii (adults)
Other interesting findings

- The children were good at following instructions.
- Used to rules and routines.
- Majority of the older children evacuated on verbal command.
- Most of the younger children needed some physical assistance.
Conclusions

• Walking speed in horizontal plane was slower than for adults.

• More of the older children ran during the evacuation.

• Walking speed on spiral stairs varied greatly between the stairs.

• Important factors affecting evacuation time.
  – Familiarity with evacuation route.
  – Design of route.

• Today’s evacuation models do not present children.
Questions and Comments