Radon resistance construction in Finland in 2007

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“The Radon Groke” in construction in Finland in 2007

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Figure: Moomins, the Groke - Tove Jansson
Mårran in Swedish, Mörkö in Finnish, Hufsa in Norwegian?

Radon in Finland

- Reference level for indoor radon concentration
  - existing dwellings 400 Bq/m³
  - new dwellings 200 Bq/m³
- 60,000 dwellings (3.6%) exceed 400 Bq/m³
  - 200,000 dwellings exceed 200 Bq/m³
- the new VARO study will update this information
- over wide areas (especially heavily populated southern Finland) 10-20% exceed 200 Bq/m³

National Building Code
part B3, substructures, 2004

- requires radon-technical design and radon-resistant structures in new building throughout Finland
- reference level 200 Bq/m³ for new buildings

Guidelines: Radon prevention
RT-10791 (LVI 37-10791)

- Guidelines for radon prevention in new building
- published 2003
- Key advice:
  - radon-resistant foundations are crawl-space and uniform concrete slab
  - slab on ground (most common foundation in Finland):
    1. seal the joint between the foundation wall and slab using bitumen felt (sockel, golvplatta)
    2. install sub-slab piping (“radon piping”)
Soil air

“Soil” contained about 40% of air.

“The Radon Groke” hides in soil air - and streams with it.

Soil air streams in soil - like wind in a very dense forest.

Comparison with water helps to understand its behaviour.

Soil air, contains radon

Indoor radon concentration

50 000 Bq/m³

leakage: 0.5 m³/h

Vent: 0.5 l/h

(or 125 m³/h)

area 100 m²,

volume 250 m³

The pressure difference due to

• temperature difference
• ventilation

Indoor warmth and lower pressure draws the Radon Groke.

In winter the Radon Groke gets fat!

• The Groke of Tove Jansson grew larger during the winter
• the pressure difference increases due to temperature difference -> radon is typically a harder problem in winter than in summer

Radon prevention

Block the entry - seal the gap between the foundation wall and the slab (floor)!

People do not sail with a leaking boat, why would they live in a leaking house?

Bitumen felt

foundation wall: concrete

light concrete blocks (porous material)

Bitumen felt and walls in contact with soil

• wall in contact with soil made of porous light-weight concrete blocks
• soil air penetrates easily
• plastering reduces penetration by a factor of 1000 (slamming)
• sealing with bitumen felt
Radon piping
1. suction (radon) piping
2. collector duct
3. air removal point
4. transmission duct
5. exhaust duct
6. damper
7. roof follow-through
8. exhaust fan
9. possible electrical regulator system for the fan

Piping depressurizes the sub-slab volume, when activated

Questionnaire
• selected 133 new buildings, completed in 2004 or later
• in Tampere, Kotka, Vantaa, Hyvinkää areas
• first radon measurement ordered and carried out by the owner occupants during 2004 - 2006
• questionnaire was sent, 101 responded
• questions mainly about foundations, materials, sealing, radon piping and ventilation
• new radon measurement during winter 2006 - 2007

Radon measurements and sealing
Dwellings with slab on ground:

<table>
<thead>
<tr>
<th>Sealing method</th>
<th>Number of dwellings exceeding 200 Bq/m³</th>
<th>mean Bq/m³</th>
<th>median Bq/m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bitumen felt</td>
<td>1 / 23</td>
<td>280</td>
<td>150</td>
</tr>
</tbody>
</table>

Quite many dwellings (7 of 23) in which bitumen felt was used still exceeded the reference level 200 Bq/m³. But the table does not indicate the entry points!

Hydrogen as a tracer
tracer gas: 95% N₂ 5% H₂

Results of the tracer studies:

<table>
<thead>
<tr>
<th>Leakage point and leakage severity</th>
<th># of affected dwellings (total of 11 dwellings with bitumen felt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead-throughs:</td>
<td></td>
</tr>
<tr>
<td>Significant leakage</td>
<td>10</td>
</tr>
<tr>
<td>Insignificant leakage</td>
<td>3</td>
</tr>
<tr>
<td>Joints of bitumen felt strips:</td>
<td>2</td>
</tr>
<tr>
<td>In corners</td>
<td>6</td>
</tr>
<tr>
<td>In the joint between the bearing separating wall and the slab</td>
<td>5</td>
</tr>
<tr>
<td>Close to doors</td>
<td>7</td>
</tr>
<tr>
<td>The joint between the wall and slab, straight segments of the walls:</td>
<td></td>
</tr>
<tr>
<td>Significant</td>
<td>1</td>
</tr>
<tr>
<td>Insignificant</td>
<td>5</td>
</tr>
<tr>
<td>Elsewhere</td>
<td></td>
</tr>
<tr>
<td>Close to electric wall sockets and plug points</td>
<td>3</td>
</tr>
<tr>
<td>Close to fireplace</td>
<td>1</td>
</tr>
</tbody>
</table>

Lead throughs:
Can be sealed afterwards - but not always easily.

protective pipings
Why do corners leak?

- Joints of bitumen felt strips not seamed!
  - mainly in corners
  - sealing with hot air, gas burner or with specific kind of sealing glue
  - maybe not the worst deficiency

No sealing at all...

- the joints between the wall and the slab often leak throughout the dwelling
- very hard to seal afterwards
- may disturb the activated radon piping

Radon piping

<table>
<thead>
<tr>
<th>Exhaust fan status</th>
<th>Number of dwellings</th>
<th>Mean Bq/m³ Before activation</th>
<th>Median Bq/m³ Before activation</th>
<th>Mean Bq/m³ After activation</th>
<th>Median Bq/m³ After activation</th>
<th>Average reduction in Rn concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>All dwellings</td>
<td>16</td>
<td>530</td>
<td>450</td>
<td>130</td>
<td>94</td>
<td>62%</td>
</tr>
<tr>
<td>With fan, below ref. lev</td>
<td>11</td>
<td>530</td>
<td>420</td>
<td>37</td>
<td>28</td>
<td>83%</td>
</tr>
<tr>
<td>With fan, above ref. lev</td>
<td>4</td>
<td>1000</td>
<td>1000</td>
<td>490</td>
<td>470</td>
<td>46%</td>
</tr>
</tbody>
</table>

- radon piping is commonly installed
- usually effective if activated with a fan; if not, sealing may improve
- efficiency of sub-slab depressurization may be defective in the case of high permeability sub-slab filling materials

Conclusions 1:

Radon piping
- commonly installed
- usually effective if activated with a fan; if not, sealing may improve
- efficiency of sub-slab depressurization may be defective in the case of high permeability sub-slab filling materials

Conclusions 2:

Sealing
- not as common as radon piping
- very hard to seal afterwards if problems arise
- non-sealed joints of the slab and the wall often leak throughout the dwelling
- lead-throughs are not sealed well enough
- joints of the bitumen felt strips should be seamed

More information: www.radon.fi