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Technical requirement to facilitate recycling
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TRAFFIKVERKET
SWEDISH TRANSPORT ADMINISTRATION
Recycling – a short background

- Metallurgical slags used in construction works since 1970
- Blast furnace slag appr 500,000 tons a year
- Crushed concrete sparingly used
- Recycling of asphalt, close to 100% reuse
- Driving forces: economy and local interests
- Resistance:
  - Fear of environmental impact and lack of experience.
  - Lack of support in the technical specification
  - Time consuming administration
Requirement for alternative material

- Design and construction with alternative material should not be more difficult than with traditional material
- Consideration from the **construction managements** view
  1. Timetable
  2. Costs
  3. Environmental considerations etc.

Challenges

- Need for design parameters
- Construction procedures need to be defined
- Ensure that environmental consideration is taken
Requirements for
- material properties and environmental assessment
- design
- control/verification

Covering
- Blast furnace slag
- Crushed concrete
- Asphalt granules (RAP)

web address: www.trafikverket.se/tekniska
Functional properties for design of a construction

Instead of saying that the material can replace a layer in the construction, material gets its own properties which should be used in the design

Main properties:
• Stiffness
• Stability
• Durability
• Frost insulation
Solution

The same design system is used as for conventional material (Sweden has a mechanical empirical design system for bearing capacity and frost heave)

- **Stiffness**
  - Design values are given

- **Stability**
  - Optimize a gradation curve and physical properties for the material, binder content of asphalt granules (RAP)

- **Durability**
  - Physical properties (wear and fragmentation). Requirement for composition and content, sulfur content

- **Frost insulation**
  - Design values are given for calculating the frost heave
Solution
Crushed concrete

- For crushed concrete four quality classes are defined
- Each class has requirement for composition ($R_c$, $R_{cu}$, FL, X) and physical properties (MDv)
- For each class design properties are defined

<table>
<thead>
<tr>
<th>Quality Class</th>
<th>$R_c$</th>
<th>$R_{cu}$</th>
<th>FL</th>
<th>X</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$R_{c1}$</td>
<td>$R_{cu1}$</td>
<td>FL$_1$</td>
<td>X$_1$</td>
</tr>
<tr>
<td>2</td>
<td>$R_{c2}$</td>
<td>$R_{cu2}$</td>
<td>FL$_2$</td>
<td>X$_2$</td>
</tr>
<tr>
<td>3</td>
<td>$R_{c3}$</td>
<td>$R_{cu3}$</td>
<td>FL$_3$</td>
<td>X$_3$</td>
</tr>
<tr>
<td>4</td>
<td>$R_{c4}$</td>
<td>$R_{cu4}$</td>
<td>FL$_4$</td>
<td>X$_4$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Quality Class</th>
<th>$C$-value</th>
<th>$K$-value</th>
<th>$p$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$\leq 25$</td>
<td>$\geq C_{30/37}$</td>
<td>$\geq K_{40}$</td>
</tr>
<tr>
<td>2</td>
<td>$\leq 35$</td>
<td>$\geq C_{20/25}$</td>
<td>$\geq K_{25}$</td>
</tr>
<tr>
<td>3</td>
<td>$\leq 50$</td>
<td>$\geq C_{12/15}$</td>
<td>$\geq K_{12}$</td>
</tr>
<tr>
<td>4</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
Requirement on the material

• Make it clear for the producer/supplier which requirements are set on the material

• Material properties according to:
  – EN 13 242 (unbound aggregates)
  – EN 13 285 (unbound layers for roads)

• Example: “Resistance to wear” base course (micro Deval)
  • Crushed rock \( \leq 20 \)
  • Blast furnace slag \( \leq 20 \)
  • Crushed concrete \( \leq 25 \) (fines works as a binder)
  • Asphalt granules (RAP) No requirement (origin bound layers)
## Requirement on construction procedures

### Compaction

<table>
<thead>
<tr>
<th>Material</th>
<th>Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blast furnace slag</td>
<td>Method specification</td>
</tr>
<tr>
<td>Crushed concrete</td>
<td>Method specification</td>
</tr>
<tr>
<td>Asphalt granules (RAP)</td>
<td>End result specification (density)</td>
</tr>
</tbody>
</table>
Environmental restrictions

- Waste, by-product or product?
- Limit values: sulphur, contaminants
- Environmental assessment

Example:

<table>
<thead>
<tr>
<th>Soil</th>
<th>Risk of env impact</th>
<th>Need of protection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moraine</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>Coarse grain</td>
<td>Moderate [Drainage water may infiltrate to ground water]</td>
<td>Safety distance drinking water source</td>
</tr>
</tbody>
</table>
Environmental monitoring

• Blast furnace slag contains 1-2% sulphur
Summary

• Utilise specific properties of each material
• Give design values for analytical/empirical design methodology
• Procedures for design and construction as for rock material
• Environmental properties – tested and declared
• Consider site specific conditions

Conclusion

To make it easy and safe (low risk) to use alternative materials we need:
Technical and environmental requirements
Thank you!

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