Consistent — A CEDR Trans-national Research Project

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CEDR Transnational Road Research Programme
Call 2013

Five programmes

- Ageing Infrastructure Management
- Traffic Management
- Safety
- Energy Efficiency
- Roads and Wildlife
Overview CONSISTEND

- **Call:**
  - Feasible, valid and cost effective measures to reduce use of energy during construction and operation

- **Aim:**
  - A tool to assess the impact of construction process quality on the performance of pavements and its implementation in tenders in order to extend performance life of pavements

- **Steps:**
  - Collect information that relates construction quality to service life, based on data and expert opinions.
  - Collect information about currently practiced and innovative quality control methods, managing strategies and enforcement.
  - Build a risk-based tool that presents the most important parameters that influence service life.
  - Explore the possible roles for the tool in a procurement procedure in consultation with National Road Authorities and road industry.
Objective of CONSISTEND

Development of a tool to assess the impact of construction process quality on the performance of pavements and its implementation in tenders.

Example MEAT
Most Economically Advantageous Tender

Contractor A: Normal good Quality
Contractor B: Extra Quality

<table>
<thead>
<tr>
<th></th>
<th>Contractor A</th>
<th>Contractor B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offer</td>
<td>1,000,000</td>
<td>1,050,000</td>
</tr>
<tr>
<td>Added value</td>
<td>0</td>
<td>100,000</td>
</tr>
<tr>
<td>Offer – added value</td>
<td>1,000,000</td>
<td>950,000</td>
</tr>
</tbody>
</table>

For this calculation we need a tool to estimate added value.
Information [WP1]

Quality Control Measures [WP3]

Expert opinions [WP1]

Model [WP2]

Expected lifespan

Implementation [WP4]

Outline of tool

Adjust tool (WP2)

Conclusions and reports

Use case (WP4)

Outline of tool (WP2)

Include QC in tool (WP2)

Information degradation (WP1)

Information QC (WP3)

Build the tool (WP2)

Information [WP1]
CONSISTEND model

Expected life span without QC

Expected life span with specific QC

WP2: Construction of a quality assessment tool

TNO
**Principle of the tool**

Based on project specific circumstances:
- Actual value of degradation factor $i$

Based on results questionnaire:
- Expected lifespan in years
- Change in lifespan
- Default value for degradation factor $i$
- Maximum lifespan in years

$L = A + B + C$

**Information in model**

**Input Project**

Based on project specific circumstances:
- Actual value of degradation factor $i$

**Model**

Introduced by model:
- Variety in lifespan that cannot be explained from degradation factors

**Expert opinions**

Based on results questionnaire:
- Expected lifespan in years
- Change in lifespan
- Default value for degradation factor $i$
- Maximum lifespan in years
WP1: Identification and evaluation of pavement construction process influencing parameters

TRL

**Literature review – objectives**

- Understand the key material properties that determine performance and durability;

- Available information on the impact of construction practices on the achievement of these properties;

- And the extreme values between which the key material parameters can vary.
Gather information on:
Transport
Laying
Compaction
One material per country

Questionnaire focused on most commonly used surface course mixtures across the four countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Material(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>England</td>
<td>BS EN 13108-4: HRA 35/14 F Surf 40/60</td>
</tr>
<tr>
<td>Ireland</td>
<td>NEN-EN 13108-7 ZOMB 16+ Porous Asphalt</td>
</tr>
<tr>
<td>The Netherlands</td>
<td>AC 11surf 650/70 for main roads and</td>
</tr>
<tr>
<td></td>
<td>SMA 8 (bit 45/60-65 for motorways)</td>
</tr>
</tbody>
</table>

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Questionnaire in more detail

<table>
<thead>
<tr>
<th>C25</th>
<th>C26</th>
<th>C27</th>
<th>C28</th>
<th>C29</th>
<th>C30</th>
<th>C31</th>
<th>C32</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Section 2: Please complete dark grey cells.

- Name
- Industry
- Surfaces Covered Type [based on EN 13324]
- Expected lifespan of the material [years]
- Maximum lifespan of chosen material [years]
- Minimum lifespan of chosen material [years]
- Area of expert knowledge

Section 3:

a. Please complete columns 7 to 13. Enter each cell with a single number rather than a range.

b. Please use the comments section if you wish to include additional explanation of your answer.

c. If you are not confident about answering a multiple-choice question, you can enter a value in the comments section and leave the answer cell blank.

d. The questionnaire asks to gather knowledge of personal experience. Please do not refer to literature for answers.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Phase 1</th>
<th>Phase 2</th>
<th>Phase 3</th>
<th>Optimum</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>T = Transport</td>
<td>L = Loading</td>
<td>C = Competition</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>160</td>
<td>160</td>
<td>160</td>
<td>160</td>
<td>160</td>
<td>160</td>
</tr>
<tr>
<td>2</td>
<td>120</td>
<td>120</td>
<td>120</td>
<td>120</td>
<td>120</td>
<td>120</td>
</tr>
<tr>
<td>3</td>
<td>80</td>
<td>80</td>
<td>80</td>
<td>80</td>
<td>80</td>
<td>80</td>
</tr>
</tbody>
</table>

Industry analysis

- Questionnaire was sent around
- Resulted in 25 received questionnaires in total
- Results to undergo statistical analysis
<table>
<thead>
<tr>
<th>Temperature of material</th>
<th>Weather</th>
</tr>
</thead>
<tbody>
<tr>
<td>.... Ambient Temperature (°C)</td>
<td>.... Wind Speed (km/h)</td>
</tr>
<tr>
<td>.... Ambient Temperature (°C)</td>
<td>.... Rainfall</td>
</tr>
<tr>
<td>.... Wind Speed (km/h)</td>
<td>.... Ambient Temperature (°C)</td>
</tr>
<tr>
<td>.... Rainfall</td>
<td>Compaction</td>
</tr>
<tr>
<td>.... Void Content (%)</td>
<td>.... Number of roller passes</td>
</tr>
</tbody>
</table>

| Expected Lifespan of the material (years) | Maximum lifespan of chosen material (years) | Minimum lifespan of chosen material (years) |

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Industry analysis – England & Ireland

Industry analysis – The Netherlands
WP3: Integration of Tool With Currently Practiced Quality Control Methods

ROD-IS

Objectives

- To collect information about available quality control methods, and their characteristics.

- To obtain information about practical aspects when applying quality management strategies and enforcement by contractors and road owners.

- Information to be implemented in tool.
Inventory

• An inventory of quality control methods has been compiled

• Categorised based on their application to:
  – Transport
  – Laying
  – Compaction

• Their effect on the critical construction parameters is of interest

Transport

• Insulated Trucks – Standard Practice
• Asphalt Logistics Information System (ALIS)
  – Helps ensure a constant supply
  – Live tracking of trucks (GPS)
  – Information on capacity of mill
  – On Iphone/Tablet
Laying

- Infrared monitoring of temperature
  - Temperature behind paver
  - Identify temperature issues
  - Displayed on paver
  - Linked to GPS coordinates

![Infrared temperature scanner](image1)

- Shuttle Buggy
  - Remixes material between truck and paver
  - Benefits:
    - Even of distribution of temperature and aggregate
    - No bumping of paver
    - Storage (up to 23 t) of material for constant supply
    - Supply multiple pavers

![Shuttle Buggy](image2)
Laying

- Echelon Paving
  - Construction of hot joints for improved quality

Compaction

- Intelligent Compaction
  - Infrared sensors for temperature
  - GPS for number of passes

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Transport, Laying & Compaction

- Workmanship – Appropriate training & supervision

- Weather station
  - Wind
  - Ambient temperature
  - Rain

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QC on temperature during laying

<table>
<thead>
<tr>
<th>Temperature during laying</th>
<th>Bandwidth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method 1</td>
<td>No method</td>
</tr>
<tr>
<td>ALS - Asphalt Logistics Information System</td>
<td>Optimum temperature +/- 25°C</td>
</tr>
<tr>
<td>Method 2</td>
<td>No direct effect</td>
</tr>
<tr>
<td>Shuttle buggy</td>
<td>For a single field study by Bjørnstad, a Shuttle Buggy/IRV reduces the standard deviation of the temperature behind the screed from 35°C to 5°C. However, it reduces the overall temperature of the mix by 5-10°C</td>
</tr>
<tr>
<td>Method 3</td>
<td>No direct effect</td>
</tr>
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WP4: Implementation of tool in practice

ZAG
Use cases

• Evaluate:
  – Tool results normal QC
  – Tool results extended QC
  – Tool results before and after
  – Asphalt quality after construction versus tool results

• Analyse use for tender evaluation
• Discuss extension of model for other asphalt types, etc.

Tool results

• 3 versions of tool tuned
  – Expert opinions are material and circumstance bound

• Tool adjusted due to use in pilot projects:
  – Two options in the tool: “during contract phase” and “after construction phase”
  – Tuning of the tool adjusted
  – Recommendations for further development
## Tool results, case Slovenia

<table>
<thead>
<tr>
<th>Contract phase</th>
<th>After const. ph. 1</th>
<th>After const. ph. 2</th>
</tr>
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<tbody>
<tr>
<td>• 15,8 year</td>
<td>• 15,4 years</td>
<td>• 14,1 years</td>
</tr>
<tr>
<td>• Optimal</td>
<td>• Same (optimal)</td>
<td>• Relatively large</td>
</tr>
<tr>
<td>conditions</td>
<td>conditions and</td>
<td>uncertainties</td>
</tr>
<tr>
<td>• No uncertainty</td>
<td>uncertainty</td>
<td>• Double transport</td>
</tr>
<tr>
<td>(where possible)</td>
<td></td>
<td>• Higher ambient</td>
</tr>
<tr>
<td></td>
<td></td>
<td>temperature</td>
</tr>
</tbody>
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## Tool results

- **Results as expected:**
  - Optimum circumstances => maximum life span
  - Changes in circumstances (not optimal) or larger uncertainty => life span decreases

- **Results remarkable:**
  - Large uncertainty in life span (according to experts)

- **Results less distinguishing than anticipated:**
  - Changes in expected life span due to non-optimal input and (especially) larger uncertainty do not lead to expected large changes in life span.

17/08/2016
Tool in procurement

- MEAT options:
  - Objective calculation of life span
  - Quantified values
  - Check after construction (objectively quantified)
  - Bonus – malus option to settle final payment

Example MEAT
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A CONSISTEND(T) assessment of the “added value”!
Future development

- Less degradation factors => larger influence of each factor
- Interdependency degradation factors => model / input should deal with this
- Country and material extension => specific tuned versions of the model

Dissemination CONSISTEND

- Interaction with NRA’s through case studies and workshops
- Interaction with other projects, e.g. SHARP 2 and ASPARI.
- End report, final power point presentation and tool.
- Paper at IALCCE 2016
- Website
- Conferences (FIRM, national opportunities)
CONSISTEND Summarized

- Assessment of service life of asphalt based on expert opinions
- To be specifically tuned (circumstances, country, type of asphalt)
- Depending on values of degradation factors
- Including QC measures
- Tuned for 3 countries and 4 types of asphalt
- Useful in procurement
- Large uncertainty in life span (according to experts)
- Well disseminated in workshop and presentations
- **Positive response to concept**
- Non-optimal input and (especially) larger uncertainty do not lead to the expected changes in life span
- Improvement recommended to trust outcome

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