BMS with an Integrated Comprehensive LCC Tool

Mohammed Safi, PhD Student
Division of Structural Engineering and Bridges
KTH Royal Institute of Technology
Introduction

• Generally, bridge investment and management decisions are multi-alternative-oriented.

• Although many bridge management systems (BMSs) contain some form of life-cycle costing (LCC), the use of LCC in bridge engineering is scarce.

• LCC in many BMSs has mainly been applied within the bridge operation phase to support decisions related to existing bridges.

• Even though BMSs and LCC are interrelated, many bridge management researches have treated them as separate aspects; therefore, neither may lead to the best usable decision-support tools.
Aim and Scope

The project aims at enhancing the bridge investment and management decisions by upgrading and expanding the use of LCC in the Swedish Bridge and Tunnel Management System (BaTMan).

- Address the possible LCC applications for bridges
- Supported with detailed case studies, demonstrate the LCC implementation on whether to **repair or to replace a bridge**, (Paper I and II).
- Supported with a detailed case studies, demonstrate the LCC implementation on whether to **repair or to replace a specific bridge structural member**, (Paper III).
The Swedish Bridge and Tunnel Management System (BaTMan)

https://batman.vv.se/batman/
Sweden has a long tradition in bridge management. Since 1944, information about the condition of the national road network has been documented and stored in different archives.

The Swedish Transport Administration (Trafikverket) is the largest bridge manager in Sweden. The latest update of Trafikverket’s BMS is called a Bridge and Tunnel Management system (BaTMan), which was introduced in 2004.

BaTMan is recognized as the best-known software-based digital BMS in Europe.

All information is given on repair, strengthening, and maintenance, including their costs.

Furthermore, the system consists of a separate navigation tool (WebHybris) that can access the BaTMan’s database and answer any related question for any research or management purposes.
BaTMan Navigation Tool (WebHybris)
The Swedish Bridge Stock

### Bridge Function Type

<table>
<thead>
<tr>
<th></th>
<th>Roadway</th>
<th>Railway</th>
<th>Pedestrian &amp; Bicycle</th>
<th>Other</th>
<th>Total No. Of Bridges</th>
<th>Bridge Total Area (m²)</th>
<th>Bridge Total Length (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BaTMan’s Bridges</strong></td>
<td>23,848</td>
<td>4,411</td>
<td>1,619</td>
<td>251</td>
<td>30,129</td>
<td>7,644,208</td>
<td>668,381</td>
</tr>
<tr>
<td><strong>Trafikverket’s Bridges in BaTMan</strong></td>
<td>20,050</td>
<td>3,179</td>
<td>207</td>
<td>14</td>
<td>23,450</td>
<td>5,858,570</td>
<td>528,905</td>
</tr>
</tbody>
</table>

### Bridge Construction Material

- **Concrete**: 19%
- **Steel**: 28%
- **Timber**: 26%
- **Stone**: 7%
- **Special Material**: 8%

### Length Range

- **L < 5m**: 19%
- **5m ≤ L < 10m**: 28%
- **10m ≤ L < 20m**: 26%
- **20m ≤ L < 30m**: 8%
- **30m ≤ L < 50m**: 8%
- **50m ≤ L < 100m**: 3.76%
- **100m ≤ L < 200m**: 1.02%
- **200m ≤ L < 500m**: 0.14%
- **500m ≤ L < 1000m**: 0.03%
- **1000m ≤ L**: 2.56%
Comprehensive Integrated LCC Implementation Scheme

A decision on whether or not to undertake the project

Whole-life costing, WLC

Life-cycle costing, LCC

Tender documents
Contract
Inauguration

Early Planning & Initial Study
Feasibility Study
Building Doc. Design Plan
Bidding & Tendering
Detail Design & Construction
Operation & Maintenance
End of Life

Idea

Get a preliminary bridge LCC & specify the most cost-effective road corridor

Propose an optimal conceptual design
Specify the optimal bridge’s structural member
Specify the optimal repair strategy
Specify the optimal structural member’s replacement alternative

Decide whether to repair or to renew a bridge

Specify the optimal bridge’s design proposal

LCC Saving Potential

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BaTMan-LCC

Specify in which bridge investment phase are you now & What do you want to do

- Early Planning & Initial Study
- Feasibility Study
- Building Document Design Plan
- Bidding & Tendering
- Detail Design & Construction
- Operation & Maintenance
- End of Life

Get a preliminary bridge LCC & specify the most cost-effective road's corridor

Propose an optimal conceptual design

Specify the optimal bridge design proposal

Specify the optimal bridge's structural member

Specify the optimal bridge repair strategy

decide whether to repair or to renew a bridge

Evaluate the bridge aesthetic & cultural value

Specify the optimal structural member’s replacement alternative

Specify the optimal bridge’s replacement alternative

BaTM an-LCC

Bridge Life-Cycle Cost Optimization

Version 1 [2011-11-11]

Developer:
Mohammed SAFI, PhD Student, KTH
mohammed.safi@byv.kth.se

Supervisors:
Prof. Håkan SUNDQUIST, KTH
Prof. Raid KAROUMI, KTH
Dr. George RACUTANU, Trafikverket

Program Map & Analysis Steps

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BaTMan-LCC relation with BaTMan

Detailed Info., price etc. (N/A in BaTMan)

WebHybris

BaTMan-LCC (KTH)

NVDB

NATIONELL VÄGDATABASES

SKOGSNÄRINGEN, KOMMUNER OCH LANDSTING, LANTMÄTERIET, INFRASTRUKTURVERKET, TRANSPORTSTYRELSEN

28 July 2015

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Benefit of Using BaTMan’s Records

The average real initial costs of the Swedish bridges different types, based on cost data for 2,508 bridges constructed between 1980 and 2011.
Benefit of Using BaTMan’s Records

The inflation rate for the Swedish bridges initial costs

\[ Y = 458.37X - 904726 \]

\[ R^2 = 0.9189 \]
Case-Studies & Pilot Projects

Construction Year: 1934

Construction Year: 1929

(Residual service life is not more than three years, if no action is taken CC2)
## Case-Studies & Pilot Projects

<table>
<thead>
<tr>
<th>Proposal No.</th>
<th>Description</th>
<th>Similar &amp; Reference Bridges</th>
<th>Cross-Section Details</th>
<th>Average Constr. Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Trafikverkets proposal: One bridge, Continuous two steel boxes, two bearing per box</td>
<td>11-788-2, 22-1455-1, 22-1106-1, 22-999-1, 22-1125-1, 14-1817-1</td>
<td>(Trafikverket conceptual design)</td>
<td>2.3m</td>
</tr>
<tr>
<td>2</td>
<td>One bridge, Continuous two steel boxes, one bearing per box</td>
<td></td>
<td></td>
<td>2.3 m</td>
</tr>
<tr>
<td>3</td>
<td>Two bridges, Continuous, two I-steel Beams, One bearing per beam</td>
<td>18-1017-1, 14-1506-1, 3-339-2, 22-1533-1, 20-1220-1</td>
<td>Haunch beam Max. 3.2m Min. 1.8m</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Two bridges, Continuous, one Pre-Stressed Concrete box per bridge, two bearings per box</td>
<td>7-674-1, 19-841-1</td>
<td></td>
<td>2.8 m</td>
</tr>
<tr>
<td>5</td>
<td>Two Bridges, Integral Pre-Stressed Cantilever Continuous, one concrete box per bridge</td>
<td>18-767-1</td>
<td>Haunch beam Max. 3.4m Min. 1.3m</td>
<td></td>
</tr>
</tbody>
</table>
Large-Scale Feasibility

• Repair or Replace a Bridge:
  - The opportunity loss is equal to 241 SEK/year/m²
  - Trafikverket is responsible for 6,268 bridges older than 70 years, total bridge area of 619,944 m².
  - Trafikverket can save/might los 74.7 million SEK/year, 1.49 billion SEK during the coming 20 years.

• New Investment:
  - The opportunity loss is equal to 275 SEK/year/m²
  - Trafikverket is approximately building 55,000 m²/year.
  - Trafikverket can save/might los 15 million SEK/year, 1.5 billion SEK/100 years.
Thesis Structure

• Part I: Extended Summary
  1) Introduction
  2) The Swedish BMS
  3) Bridge Life-Cycle and the Possible LCC Applications
  4) LCC Analysis Tools and Techniques
  5) Case Studies
  6) BaTMan-LCC
  7) Conclusion

• Part II: Appended Papers
Thank You

Questions?