LIFE CYCLE COST OPTIMIZATION WITHIN DECISION MAKING ON ALTERNATIVE DESIGNS

Shiven Sompura, Aakash Goyal, Hakob Avetisyan

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• LCCA Model
• Optimizing the LCC
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Introduction

• Precast Concrete Pavements.
• Faster construction, thinner slabs and more durable life.
• Reduced construction cost.

http://www.concreteconstruction.net/projects/commercial-industrial/precast-concrete-pavement_o
INTRODUCTION

• What about the cost over its life?
• Will it be beneficial?
• How to decide where to invest more?
• The answer is, OPTIMIZING most feasible way!
LCCA Model

- The cost incurred over life of the pavement is the Life Cycle Cost including initial construction cost, maintenance cost, operational cost, user cost and salvage value.
Evaluation methods

• Net Present Worth (NPW).
• Internal rate of return method (IRR).
• Benefit-cost ratio (B/C).
• Equivalent Uniform Annual Cost (EUAC).
Net Present Worth

- The output of the NPW method is a lump sum of initial and future costs in present value.
- In our case assuming the value of one mile of pavement after ten years in terms of today’s scenario.

https://www.12manage.com/description_npvgo.html
Using Optimization for NPV

- Defining the purpose and scope of decision.
- Defining range and key parameters.
- Summarizing data to the evaluated alternatives.
- Economic evaluation of alternatives
- Selection of the optimum alternative.
Case Study

Case 1

- In the first case an average quality work was programmed.
- Initial construction cost was moderate for one mile of precast pavement.
- The NPV obtained was $2741715.57.
MODEL STATISTICS

<table>
<thead>
<tr>
<th>Blocks of Equations</th>
<th>7</th>
<th>Single Equations</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blocks of Variables</td>
<td>7</td>
<td>Single Variables</td>
<td>7</td>
</tr>
<tr>
<td>Non Zero Elements</td>
<td>13</td>
<td>Non Linear N-Z</td>
<td>6</td>
</tr>
<tr>
<td>Derivative Pool</td>
<td>20</td>
<td>Constant Pool</td>
<td>16</td>
</tr>
<tr>
<td>Code Length</td>
<td>20</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Generation Time = 0.000 SECONDS

Execution Time = 0.000 SECONDS

GAMS 25.0.3 r65947 Released Mar 21, 2018 WEX-WEI x86 64bit/MS Windows 05/02/18 23:56:12 Page 5
General Algebraic Modeling System
Solution Report SOLVE LCCA Using NLP From line 27

SOLVE SUMMARY

<table>
<thead>
<tr>
<th>Model</th>
<th>LCCA</th>
<th>Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>NLP</td>
<td>Direction</td>
</tr>
<tr>
<td>Solver</td>
<td>CONOPT</td>
<td>From Line</td>
</tr>
</tbody>
</table>

**** Solver Status | 1 Normal Completion
**** Model Status | 2 Locally Optimal
**** Objective Value | 2741715.5700

Resource Usage, Limit | 0.000 | 1000.000
Iteration Count, Limit | 4 | 2000000000
Evaluation Errors | 0 | 0
CONOPT 3 25.0.3 r65947 Released Mar 21, 2018 WEI x86 64bit/MS Windows
Case 2

- In this case, the quality of construction was highly compromised. It was reduced by 40%.
- The costs over the life of pavement increased significantly increased.
- NPV obtained was $2129900.3731
SOLVE SUMMARY

MODEL  LCCA
TYPE   NLP
SOLVER CONOPT

OBJECTIVE z
DIRECTION MINIMIZE
FROM LINE 27

**** SOLVER STATUS 1 Normal Completion
**** MODEL STATUS 1 Optimal
**** OBJECTIVE VALUE 2129900.3731

RESOURCE USAGE, LIMIT 0.000 1000.000
ITERATION COUNT, LIMIT 4 2000000000
EVALUATION ERRORS 0 0

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Pre-triangular equations: 0
Post-triangular equations: 3

** Optimal solution. There are no superbasic variables.
Case 3

- In the third case the Initial construction cost was increased significantly.
- High quality construction.
- The NPV obtained was $2910674.7417.
SOLVE SUMMARY

MODEL LCCA
TYPE NLP
SOLVER CONOPT

OBJECTIVE \( z \)
DIRECTION MINIMIZE
FROM LINE 27

**** SOLVER STATUS 1 Normal Completion
**** MODEL STATUS 1 Optimal
**** OBJECTIVE VALUE 2910674.7417

RESOURCE USAGE, LIMIT 0.000 1000.000
ITERATION COUNT, LIMIT 4 2000000000
EVALUATION ERRORS 0 0

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Pre-triangular equations: 0
Post-triangular equations: 3

** Optimal solution. There are no superbasic variables.
## Result

<table>
<thead>
<tr>
<th>Initial Construction Quality</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Quality</td>
<td>$2129900.37</td>
</tr>
<tr>
<td>Average Quality</td>
<td>$2741715.57</td>
</tr>
<tr>
<td>High Quality</td>
<td>$2910674.74</td>
</tr>
</tbody>
</table>

http://pmsymposium.umd.edu
Analysis

• This case study presents a model based on very small part of the pavements.
• The results obtained seem very close.
• In real world these numbers vary significantly.
Analysis

![Graph showing Net Present Value (NPV) analysis with different construction quality investment levels: Low, Moderate, High, Higher, Higher. The graph indicates an increase in NPV as the investment level increases from Low to Higher.]
Analysis

- The graph shows that the NPV after a certain limit goes constant.
- Which means that increasing the quality or construction cost beyond feasible region does not give any profit.
- The optimizing makes you decide the most profitable option inside the feasible region.
QUESTIONS?
THANK YOU