PROJECT MANAGEMENT
CENTER FOR EXCELLENCE
A.J. CLARK SCHOOL OF ENGINEERING
Civil & Environmental Engineering Department

LIFE CYCLE COST OPTIMIZATION WITHIN DECISION MAKING ON ALTERNATIVE DESIGNS

Shiven Sompura, Aakash Goyal, Hakob Avetisyan

2018 Project Management Symposium

http://pmsymposium.umd.edu

Contents

- Introduction
- LCCA Model
- Optimizing the LCC
- Case Study
- Result and Analysis

Aakash Goyal

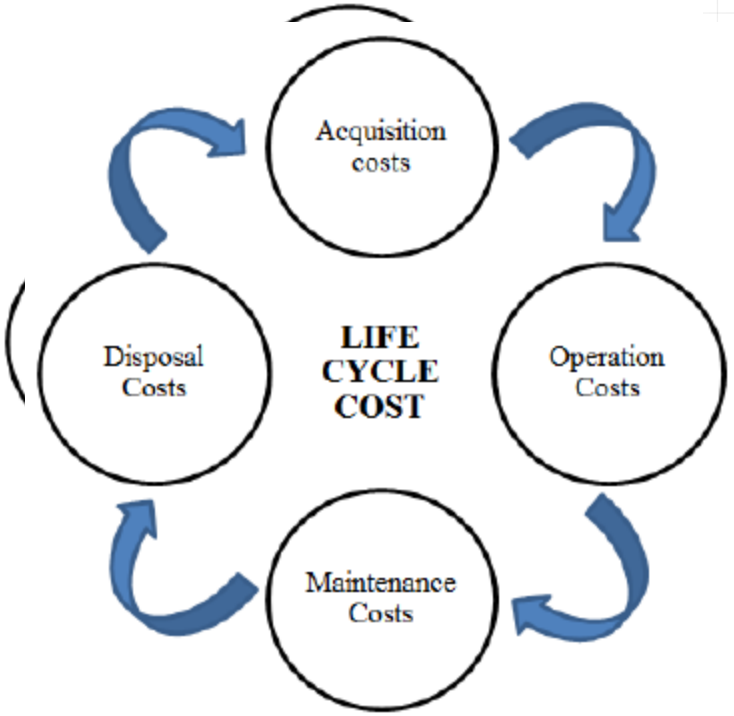
Introduction

- 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!



https://www.researchgate.net/figure/Life-cycle-cost-acquisition-phase_fig2_282464221

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).

Aakash Goyal

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.

Aakash Goyal


```
MODEL STATISTICS

BLOCKS OF EQUATIONS           7     SINGLE EQUATIONS            7
BLOCKS OF VARIABLES           7     SINGLE VARIABLES            7
NON ZERO ELEMENTS            13     NON LINEAR N-Z              6
DERIVATIVE POOL              20     CONSTANT POOL              16
CODE LENGTH                  20


GENERATION TIME      =        0.000 SECONDS      3 MB  25.0.3 r65947 WEX-WEI


EXECUTION TIME       =        0.000 SECONDS      3 MB  25.0.3 r65947 WEX-WEI
GAMS 25.0.3  r65947 Released Mar 21, 2018 WEX-WEI x86 64bit/MS Windows 05/02/18 23:56:12 Page 5
G e n e r a l   A l g e b r a i c   M o d e l i n g   S y s t e m
Solution Report     SOLVE LCCA Using NLP From line 27


               S O L V E      S U M M A R Y

     MODEL   LCCA                OBJECTIVE  z
     TYPE    NLP                 DIRECTION  MINIMIZE
     SOLVER  CONOPT              FROM LINE  27

**** 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
```

Aakash Goyal

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

Aakash Goyal


```
               S O L V E      S U M M A R Y

     MODEL   LCCA                OBJECTIVE  z
     TYPE    NLP                 DIRECTION  MINIMIZE
     SOLVER  CONOPT              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
CONOPT 3         25.0.3 r65947 Released Mar 21, 2018 WEI x86 64bit/MS Windows


    C O N O P T 3   version 3.17G
    Copyright (C)   ARKI Consulting and Development A/S
                    Bagsvaerdvej 246 A
                    DK-2880 Bagsvaerd, Denmark


                  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.

Aakash Goyal


```
               S O L V E      S U M M A R Y

     MODEL   LCCA                OBJECTIVE  z
     TYPE    NLP                 DIRECTION  MINIMIZE
     SOLVER  CONOPT              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
CONOPT 3         25.0.3 r65947 Released Mar 21, 2018 WEI x86 64bit/MS Windows


    C O N O P T 3   version 3.17G
    Copyright (C)   ARKI Consulting and Development A/S
                    Bagsvaerdvej 246 A
                    DK-2880 Bagsvaerd, Denmark


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


 ** Optimal solution. There are no superbasic variables.
```

Result

Initial Construction Quality	*NPV*
Low Quality	$2129900.37
Average Quality	$2741715.57
High Quality	$2910674.74

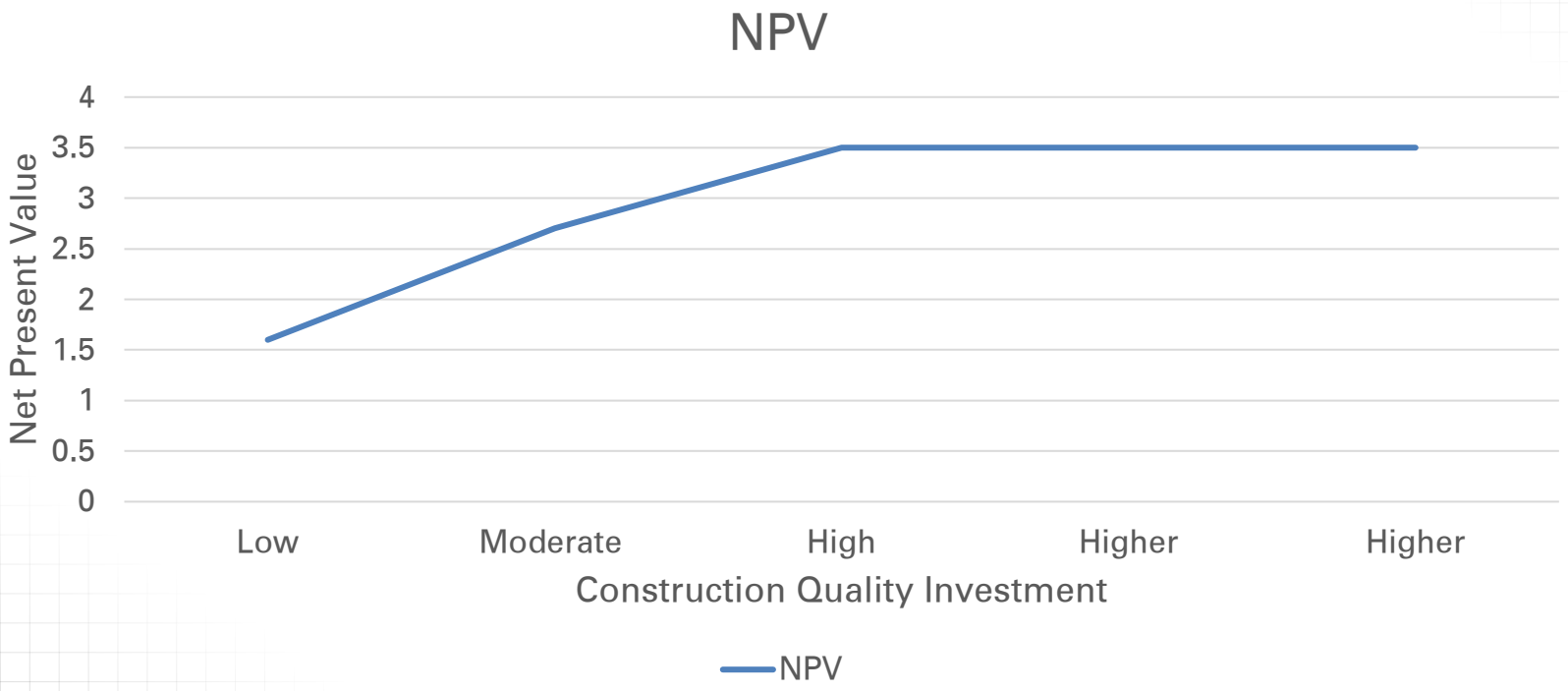
Aakash Goyal

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.

http://www.bodymindsoulcentre.com/counseling/analysis/

Analysis



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.

Aakash Goyal

Aakash Goyal