Closing Seminar
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Malmö

NordFoU

LCC Tools
Description of programs and principles

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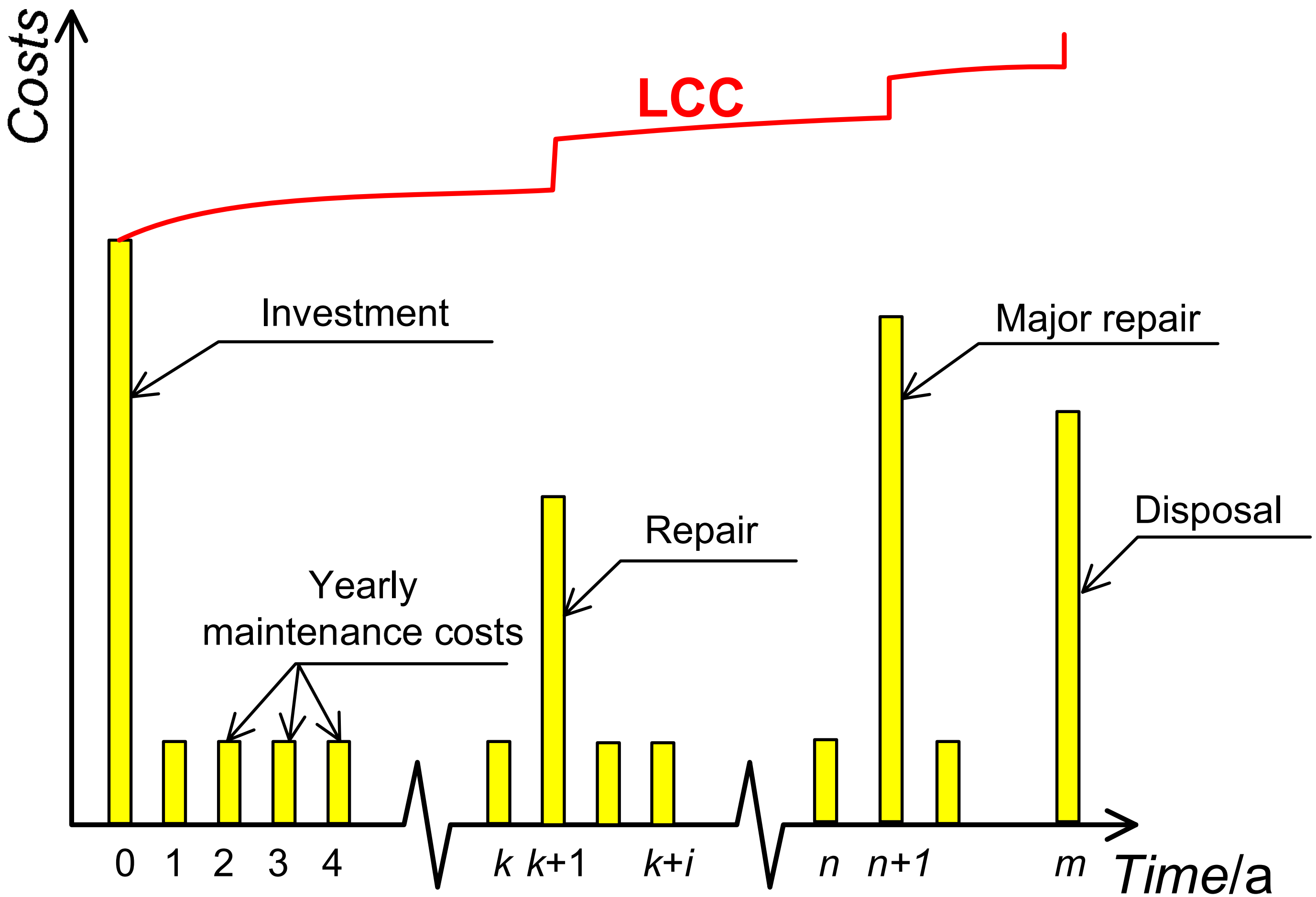
LCC general principle

Bridge Life Cycle Optimisation



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The costs are recalculated to one point in time usually the day of opening the bridge

Bridge Life Cycle Optimisation

$$LCC_{\mathrm{owner}} = \sum_{t=0}^{T} \frac{C_{\mathrm{t}}}{\left(1+r\right)^{t}}$$

- C_t the sum of all costs incurred at time *t*,
- *p* the real interest rate or a rate taking into account changes in the benefit of the structure and
- *t* the time period studied, typically for a structure for the infrastructure the expected life span.

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User cost delay

Bridge Life Cycle Optimisation

$$LCC_{\text{user,delay}} = \sum_{t=0}^{T} \left(\frac{L}{v_{\text{r}}} - \frac{L}{v_{\text{n}}} \right) ADT_t \cdot N_t \left(p_{\text{L}} w_{\text{L}} + (1 - p_{\text{L}}) w_{\text{D}} \right) \frac{1}{(1+r)^t}$$

L	length of affected roadway
v_r	the traffic speed during bridge work activity
v_n	the normal traffic speed
ADT_t	the average daily traffic, i.e. cars per day at time t
N_t	the number of days of road work at time t
p_L	the amount of commercial traffic
w_L	is the hourly time value for commercial traffic
w_L	the hourly time value for drivers
T	studied time interval T

User costs, operation

Bridge Life Cycle Optimisation

$$LCC_{\text{user,operating}} = \sum_{t=0}^{T} \left(\frac{L}{v_{\text{r}}} - \frac{L}{v_{\text{n}}} \right) ADT_t \cdot N_t \left(r_{\text{L}} (o_{\text{L}} + o_{\text{G}}) + (1 - r_{\text{L}}) o_{\text{D}} \right) \frac{1}{(1+r)^t}$$

New notations:

o_{L}	**operating cost for the commercial traffic vehicles**
o_{G}	**operating cost for transported goods**
o_{D}	**operating cost for cars**
T	**time interval**

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Societal costs, accidents

Bridge Life Cycle Optimisation

$$LCC_{\text{society, accident}} = \sum_{t=0}^{T} \left(A_{\text{r}} - A_{\text{n}} \right) ADT_t \cdot N_t \cdot C_{\text{acc}} \frac{1}{(1+r)^t}$$

Notations:

A_{n}	**the normal accident rate per vehicle-kilometres**
A_{r}	**the accident rate during roadwork**
C_{acc}	**the cost for each accident for the society**

Societal costs, failure

Bridge Life Cycle Optimisation

$$LCC_{\text{society, failure}} = \sum_{j=1}^{n} K_{\text{H},j} R_j \frac{1}{(1+r)^j}$$

R_j probability for a specified failure coupled to $K_{\text{H},j}$.
$K_{\text{H},j}$ cost for failure
(One value for ultimate limit state and one for serviceability limit state)
For normal bridges the probability of failure is so small that it could be omitted in the analysis!

Valuation

Bridge Life Cycle Optimisation

- Degradation models
- Knowledge on interest rents (100 year!!)
- Knowledge about the future of the traffic system! (will the traffic increase or decrease??)
- Knowledge of costs for
  - operation,
  - maintenance,
  - inspection and
  - repair

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Parameters needed for the LCC analysis

Bridge Life Cycle Optimisation

- Methodologies for dividing the bridge into different parts and giving measures of the components
- Costs for construction and repair different parts of the bridge
- Yearly operating costs
- Actions in time for MR&R actions
- Cost for disposal of the bridge
- User and societal costs

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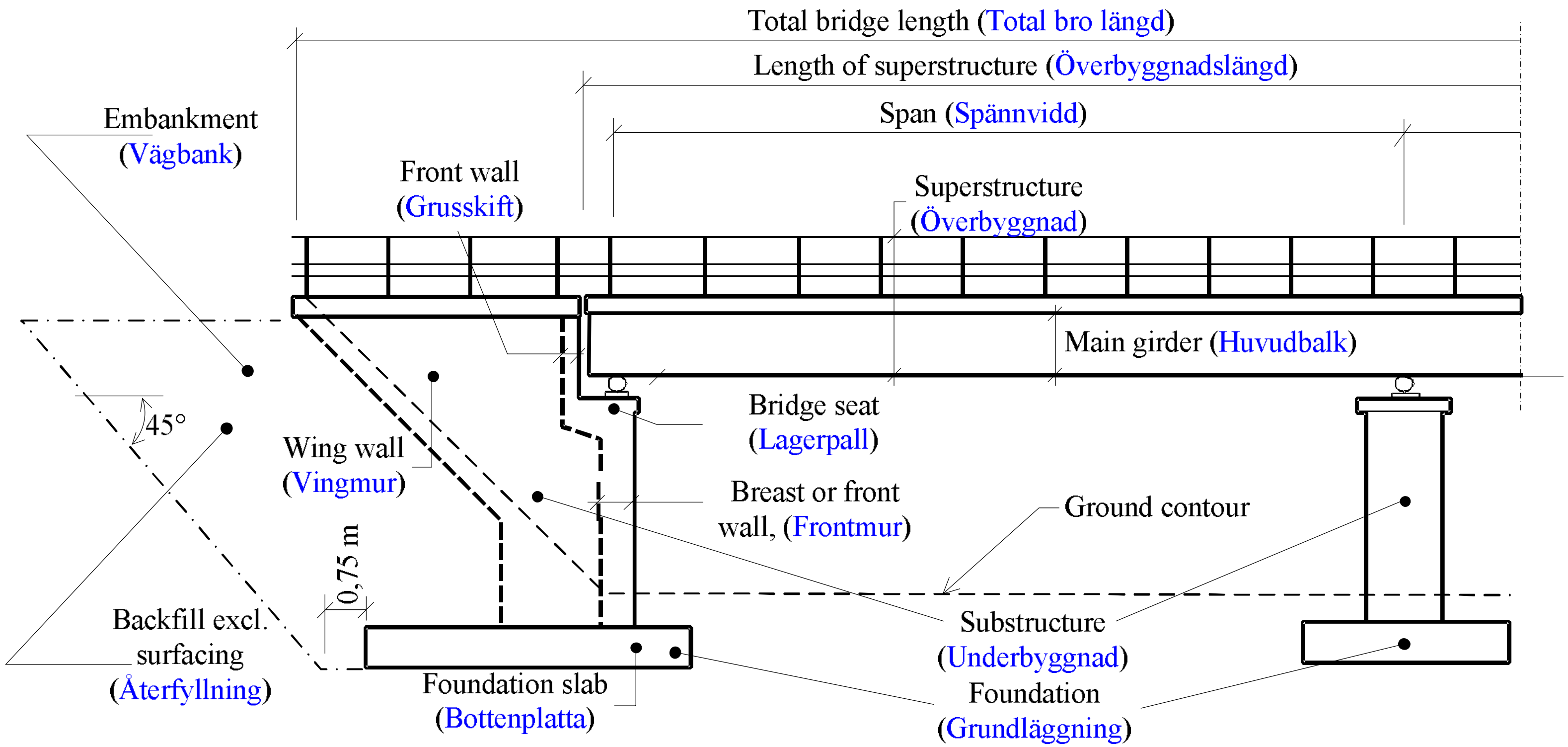
Dividing the bridge parts and elements

Bridge Life Cycle Optimisation

Foundation
Foundation slab, plinth, pile cap
Excavation, soil
Excavation, rock
Pile
Erosion protection
Slope and embankment
Embankment, embankment end, backfill
Soil reinforcement and slope protection
Abutments and piers
All concrete structures belonging to the substructure excl. foundation
Main load-bearing structure
Slab / deck
Beam
Truss
Arch, Vault
Cable system
Pipe, Culvert
Secondary load-bearing system
Secondary load-bearing beam, cross beam
Secondary load-bearing truss, Wind bracing
Equipment
Bearing and Hinge
Edge beam
Insulation, Water proofing
Surfacing
Parapet, Railing
Expansion joint
Drainage system

Bridge parts and measures

Bridge Life Cycle Optimisation



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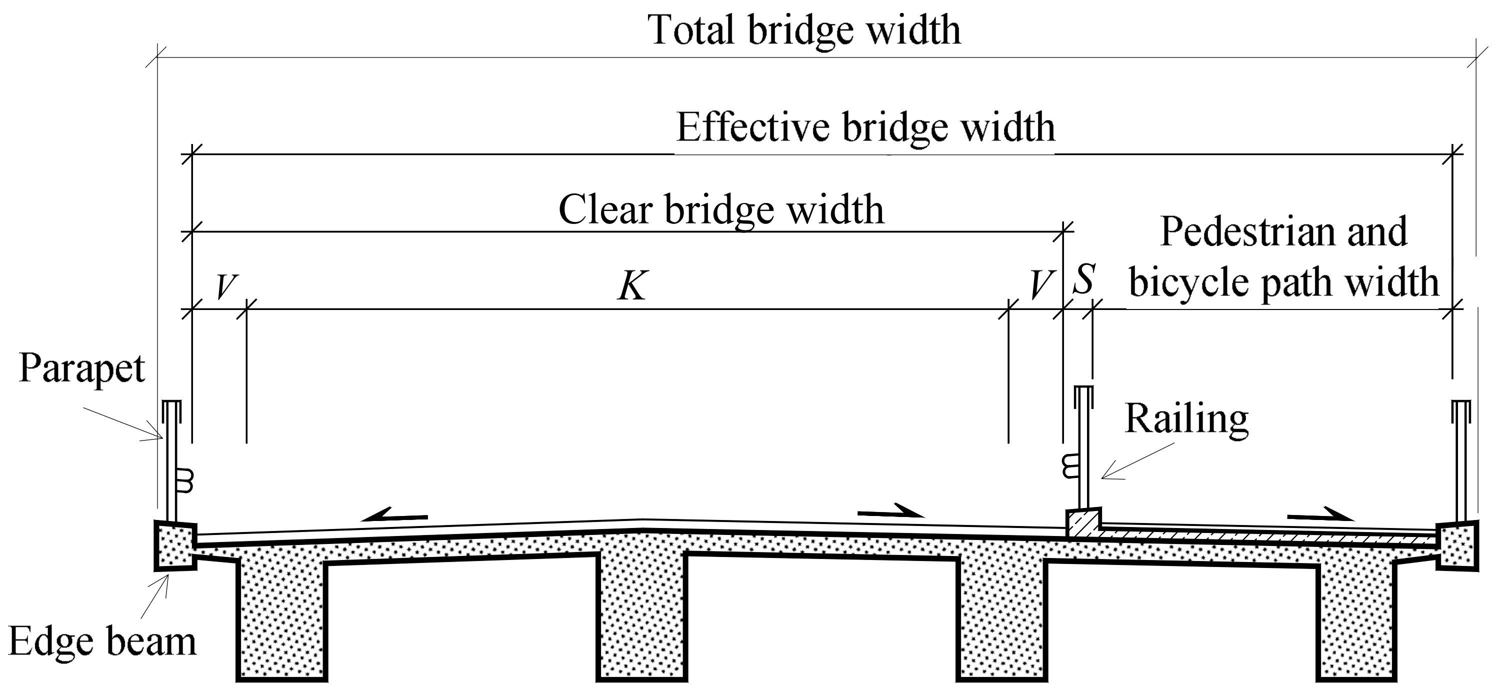
Cross-section definitions

Bridge Life Cycle Optimisation



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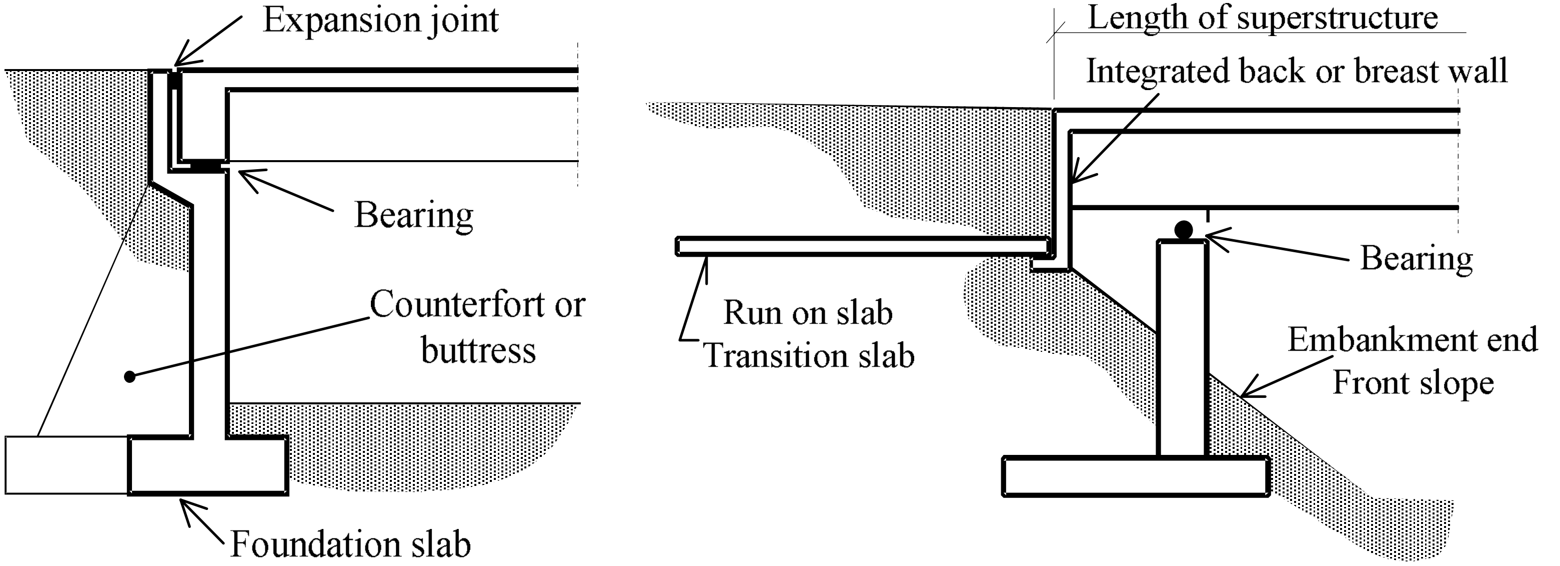
Foundation

Bridge Life Cycle Optimisation



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Materials for *LCC*

Bridge Life Cycle Optimisation

Material	Measure	Quality	Description
Concrete	m^3	C25[1]	Cylinder strength in MPa
Reinforcement steel	ton	500[2]	Yield strength in MPa
Steel for pre-stressing, tendons, cables	ton	1700	Yield strength in MPa
Steel	ton	350[3]	Yield strength in MPa
Sawn Timber	m^3		
Glue laminated timber	m^3		
Impregnated timber	m^3		
Backfill soil	m^3		
Pile	m	Type[4]	Directly coupled to the structural element

OBS, *LCA* requires added material definitions!

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Costs

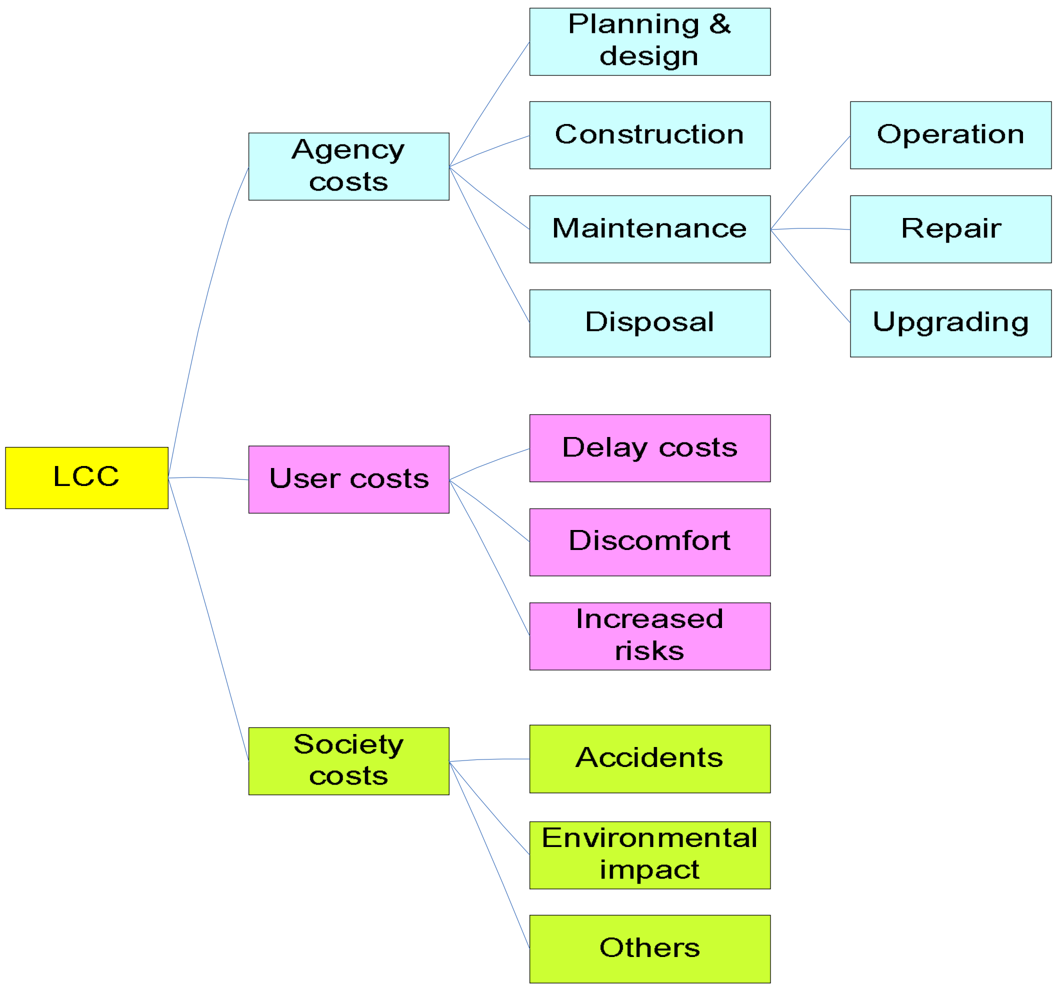
- Cost parameters should be given by the agencies hopefully in data bases updated every year!?
  - Costs for construction
  - Cost for MR&R actions
  - Parameters for calculating the user costs
  - Societal costs
  - …

Definition of actions

Bridge Life Cycle Optimisation

- Management
- Operation
- Inspections
- Repair
- Upgrading
- Final demolition and disposal

LCC scheme



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Different definitions of LCC

Bridge Life Cycle Optimisation

LCC_{agency} is the part of the total LCC cost that encumbers the owner of the project. This cost can in turn be divided into different parts

$LCC_{agency} = LCC_{acquision} + LCC_{MR\&R} + LCC_{consequence}$

$LCC_{acquision}$ (sometimes denoted *LCCA*) is the cost for acquisition of the project **including** all relevant costs for programming and design of the project, by the net present value calculated to a specified time usually the opening of the bridge.

$LCC_{MR\&R}$ (sometimes denoted *LSC* Life Support Cost) is the cost for future operation, maintenance, repair and disposal of the bridge, by the net present value calculated to a specified time usually the opening of the bridge.

$LCC_{consequence}$ is the future costs for possible negative consequences, by the net present value calculated to a specified time, usually the opening of the bridge. This kind of costs could possibly be a part of the user (LCC_{user}) or the society costs

$LCC_{society}$ is the future costs for possible negative consequences for the society, by the net present value calculated to a specified time, usually the opening of the bridge.

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Remember that it must for each case be discussed what to include in the LCC

- In the investment part
  - Planning and design
  - The owners internal cost
  - Investment part for maintenance
    - Spare parts and material
    - Documentation needed for the maintenance
    - instrument, tools, vehicles that is needed for inspection and maintenance
    - Hire and education of personnel
- In the MR&R
  - The owners cost for personnel
  - The owners own work for keeping the bridge inventory, the planning and other actions to manage the bridge stock. Usually this work can be assigned as percentage of the actual value to re-build the bridge stock.

Examples of operation (yearly) actions

Bridge Life Cycle Optimisation

Examples of "operation maintenance actions". In the Swedish system this is called "Egenskaper" or "properties"

Action	**Frequency**	**Aim**	**Remark**
Regular inspection	Often	Detect acute damages	
Cleaning of the bridge	Once a year	Removal of de-icing salt	
Rodding of dewatering system	Once a year		
Cleaning of expansion joints	Once a year		
Removal of plants and bushes,…	Once a year		
…			

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Time between different MR&R actions

- Needed parameters:
  - Life span
  - Yearly operation actions
  - Time interval between inspections
  - Time between maintenance and repair

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Design life span

Bridge Life Cycle Optimisation

- Concrete and steel bridges

  80 - 120 years

- Timber bridges

  40 - 80 years

- Steel culverts Soil-Steel composite

  40 - 80 years

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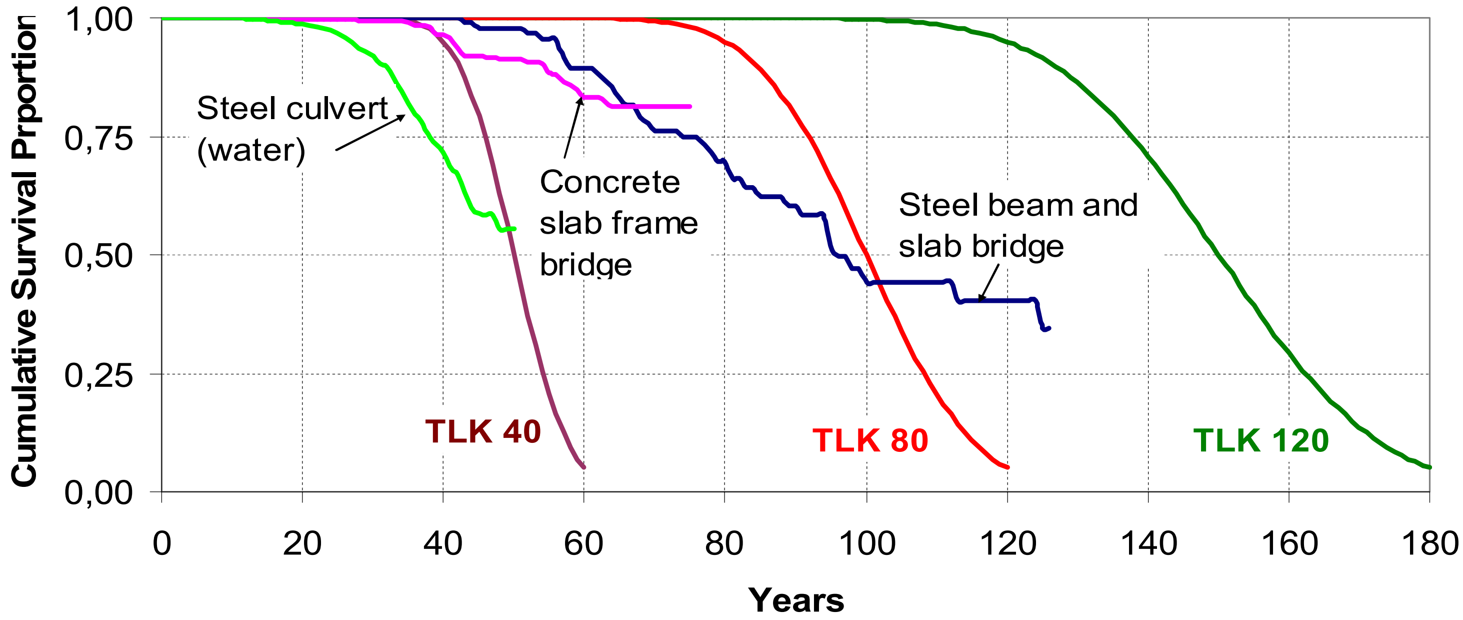
Real life-span of bridges

Bridge Life Cycle Optimisation



Bridge type	Min (p=0.95)	Median (p=0.5)	At the end of the curve
Steel beam bridge	57 år	96 år	126 år (p=0.35)
Slab frame bridge	41 år	n/a	75 år (p=0.81)
Steel culvert in water	27 år	n/a	50 år (p=0.56)
Steel culvert on land	n/a	n/a	46 år (p=0.98)

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Within the ETSI project two LCC programs have been developed

Bridge Life Cycle Optimisation

- The WebLCC bridge program.
  - This program is in theory very versatile an effective because almost everything can be defined dynamically.
  - No program has to be stored in the individual computer. Everything is stored in a server.
  - **But** even if we have put a lot of effort and cost on programming we have not been able to develop a stable and safe system.
  - This is something for the future, but special programming resources have to be hired!
- A stand-alone EXCEL program
  - It is on the USB stick!

Start page

Bridge Life Cycle Optimisation

ETSI Bridge LCC

Optimal New Bridges - Life cycle cost analysis (LCCA)

Version 2.3 [2012-05-07], ETSI

This program was first developed by Raid Karoumi (Royal Institute of Technology, Structural Engineering & Bridges, raid.karoumi@byv.kth.se)
The work was funded by the Swedish Road Administration (SRA), and this is a prototype for testing. The program is intended only to compare the LCC of the alternative bridge solutions, which means that all factors that influence the LCC are not considered (e.g. costs of the design, land purchase and administration). This version 2.3 in English has been developed in the ETSI project

NOTE
- Never feed a space in a non-current cell. Instead, please state 0 (i.e. zero).
- Repair interval entered will be adjusted depending on the chosen concrete quality, ADT, climate zone, salt quantity, placement on the bridge, and concrete cover.
- Repair intervals should be chosen to receive a maximum of about 3 - 4 major steps in the bridge lifetime and at least 10 years apart.
- Quantities specified for calculating the cost of repair need not to be equal to investment quantities. I.e. you can choose to repair some of the concrete in bridge deck rather than replace the whole.
- If no data is entered for the calculation of investment cost, the investment cost will be chosen as the cost given in the current tender (entered during the pre- subsidence) to allow the calculation of the total LCC.
- The program includes road user costs only in the form of restrictions on traffic benefits for the time work is underway on the bridge and restricts accessibility for road users.
- Many of the listed "default" values of the rates and intervals are guessed by the author of the program and could therefore be wrong.
- Always save the file xxx.xls under a new name before making changes / inputting of a new project.
- Boxes with a small red triangle in the upper right corner contain help text. The text is visible by setting the mouse pointer over the box

BRIDGE LIFE CYCLE OPTIMISATION

OK

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General conditions

Bridge Life Cycle Optimisation

General conditions

Name of bridge:	New composite bridge bridge to X
Project number:	1234-15
Administrator:	Raid Karoumi & Håkan Sundquist
Date:	2012-05-02

Climate zone:		Lower north Sweden
Road salting		Normal salt spreading
Investment cost according to tender	CUR	0
Demolition cost in % of investment cost	%	10,0
Calculus period	years	100
Yearly real interest rent	%	3,0
Average daily traffic, ADT		10 000
Percentage of trucks	%	14,0
Allowed speed on the bridge	km/h	90
Reduced speed due to repair actions	km/h	50
Hourly cost, car	CUR/h	85
Hourly cost, truck	CUR/h	400
Total bridge length	m	165,0
Length of superstructure	m	149,2
Lengths of edge beams	m	330
Effective bridge width	m	10,5
Total bridge width	m	11,3
Bridge area	m^2	1686
Area of surfacing	m^2	1567
Painted area (steel beams etc)	m^2	1033
Number of railings (parapets)	no.	2
Total length of railings(parapets)	m	330

	Weighting factor	inputted default intervals own factor
Climate zone	1,0	0,0
Average daily traffic, ADT	0,8	0,0
Saltning	1,0	0,0
Construction part subjected to salt action	1,0	0,0
Concrete quality > C30/C37	1,0	1,0
Concrete cover > Standard	1,0	0,0

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E T S I

Investment

Bridge Life Cycle Optimisation

	New construction costs	
	Unit price	
formwork	1 300	CUR/m^2
concrete	4 000	CUR/m^3
steel	55 000	CUR/ton
reinforcement	40 000	CUR/ton
cables	6 000	CUR/m
rammed piles	1 800	CUR/m
parapet	5 000	CUR/m
insulation	500	CUR/m^2
surfacing	900	CUR/m^2

Dotted fields contain the default values evaluated with the help of previously entered data. You have the possibility to input your own values in the fields.

	Quantities for calculation of investment cost							
	formwork [m^2]	concrete[m^3]	reinf. [ton]	steel [ton]	cables [m]	piles [m]	others, total cost	cost
SUBSTRUCTURE								
foundation slab	121	492	43			1472		6 508 460
pier & column	0	0	0			0		0
front wall	0	0	0					0
wing wall	0	0	0					0
bridge seat	0	0						0
upper front wall								0
backfill							1000000	1 000 000
substructure others								0
SUPERSTRUCTURE								
main beams				300,7				16 538 500
cross beams				0				0
truss								0
arch								0
pylon or tower								0
cables								0
bridge deck	1686	502	110,1					8 603 748
edge beam,	0	0	0					0
superstructure others								0
BRIDGE DETAILS								
bearing							208000	208 000
insulation							783300	783 300
surfacing							1409940	1 409 940
railing or parapet							1492000	1 492 000
expansion joint							452000	452 000
drainage system								0
bridge details others								0
OTHERS								
aesthetics							0	0
other construction costs								0
							Σ Investment cost/CUR	**36 995 948**

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Operation & Maintenance

Bridge Life Cycle Optimisation

Operation and Maintenance cost

dotted fields contain the default values evaluated with the help of previously entered data. You have the possibility to input your own values in the fields.

	MR&R unit cost & quantities			MR&R interval alt. Single year				Traffic disturbance		MR&R cost		User cost	
	unit costs		quantities	interval, year	action year	action year	action year	days	length	cost each time	tot cost	cost each time	tot cost
yearly surveillance	110 988	CUR		1	0	0	0	0,0	0,0	110 988	3 507 094	0	0
superficial inspection		CUR		3	0	0	0	0,5	0,3	0	0	1 721	17 569
main inspection	168 596	CUR		6	0	0	0	0,5	0,3	168 596	817 936	1 721	8 351
cleaning (removal of salt etc.)	1	CUR/m²	1 686	1	0	0	0	0,5	0,2	1 686	53 274	1 148	36 261
rodding of drainage system		CUR		0	0	0	0	0,0	0,0	0	0	0	0
impregnation of edge beams	300	CUR/m	330	10	0	0	0	5,0	0,1	99 000	272 882	8 561	23 597
maintenance of parapets, patch painting	1 100	CUR/m	330	0	0	0	0	3,0	0,1	363 000	0	5 136	0
maintenance of bridge seat	5 000	CUR		0	0	0	0	10,0	1,0	5 000	0	114 756	0
maintenance of expansion joints	3 000	CUR/m	23		0	0	0	4,0	0,1	67 800	0	6 849	0
backfilling and restoration of erosion protection	12 000	CUR		0	0	0	0	0,0	0,0	12 000	0	0	0
painting patching	500	CUR/m²	1 033	0	0	0	0	5,0	1,0	516 400	0	57 378	0
dehumidification device, el + maintenance	25 000	CUR/a		0	0	0	0	0,0	0,0	25 000	0	0	0
edge beam rep 0 - 30 mm/m²	3 000	CUR	418	0	0	0	0	20,0	0,8	1 254 000	0	183 609	0
change of rubber in expansion joint	3 000	CUR	23		13	63	0	5,0	0,1	67 800	56 700	5 738	4 798
adjustment of wearing course	400	CUR	1 567		0	0	0	0,0	0,0	626 640	0	0	0
bearings minor repair + painting	7 000	CUR	8	0	0	0	0	0,0	0,0	56 000	0	0	0
										Σ present cost	4 707 888	Σ present cost	90 576

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Repair

Bridge Life Cycle Optimisation

Repair cost

<Repair alt new part>

Dotted fields contain the default values evaluated with the help of previously entered data. You have the possibility to input your own values in the fields.

	Repair quantities and unit costs			MR&R interval alt. Single year				Traffic disturbance		Input for weighting of time interval		
	unit cost		quantities	interval, year	action year	action year	action year	days	length	salt exposure	Concrete quality CX/37	cover qoutient
SUBSTRUCTURE												
bottom slab intermediate piers	1 000	CUR/m²	0	0	0	0	0	0,0	0,0		30	1
piers	4 000	CUR/m²	121		50	0	0	0,0	0,0	x	50	1,25
intermediate support cross beams		CUR/m²										
Other		CUR										
bottom slab abutments		CUR/m²										
front wall	4 000	CUR/m²	158		50	0	0	0,0	0,0		30	1
wing wall	2 800	CUR/m²	150		50	0	0	0,0	0,0		30	1
bearing seat	2 000	CUR/m²	10		0	0	0	0,0	0,0		30	1
upper front wall	2 800	CUR/m²	60		0	0	0	0,0	0,0			
backfilling	900	CUR/m³	130		0	0	0	0,0	0,0			
SUPERSTRUCTURE												
main beams re-painting	2 500	CUR/m²	1 033			50	0	0,0	0,0		60	1
cross beams, re-painting	1 300	CUR/m²	8		0	0	0	0,0	0,0		60	1
main beams patch painting	500	CUR/m²			25	75						
edge beam partial repair	3 000	CUR/m	418		25	63		15,0				
Bridge deck partial repair		CUR/m²										
truss	1 300	CUR/m²	0		0	0	0	0,0	0,0			
arch	1 300	CUR/m²	0		0	0	0	0,0	0,0			
pylons	1 300	CUR/m²	0		0	0	0	0,0	0,0			
cables	4 000	CUR/m	0		0	0	0	0,0	0,0	x		
bridge deck	4 000	CUR/m²	1567		0	0	0	25,0	0,2		40	2
edge beam replacement	9 000	CUR/m	330	0	50		88	22,0	0,2	x	40	2
BRIDGE DETAILS												
bearings	7 000	CUR/item	8		37	75	0	3,0	0,2			
insulation	1 800	CUR/m²	1567		37	75	0	25,0	0,2			
surfacing	600	CUR/m²	1567	0	37	75	0	25,0	0,2			
parapets and noise barriars, partial painting	1 100	CUR/m	298	13				15,0	0,1			
expansion joints	30 000	CUR/m	23	0	37		88	5,0	0,1			
parapets replacement	5 000	CUR/m	298			50						
surfacing, partial repair	400	CUR/m²	1567	13				10,0	0,1			
expansion joints, change of rubber sealing	3 000	CUR/m	23	13				3,0	0,2			
drainage system	2 500	CUR/item	4	0	0	0	0	0,0	0,0			
MISCELLANEOUS												
aesthetics	100 000	CUR		0	0	0	0	2,0	0,1			
other repair actions (total cost)	50 000	CUR		0	0	0	0	1,5	0,8			
other repair actions (total cost)	10 000	CUR		0	0	0	0	0,0	0,0			

	weighting									Repair cost		User cost	
	climate zone	ADT	saltning on road	part exposed	concrete quality	concrete cover	original interval	weighted interval	own interval	cost each time	tot cost	cost each time	tot cost
SUBSTRUCTURE													
bottom slab intermediate piers	1,0	1,0	1,0	1,0	1,0	1,0	0	0	0	0	0	0	0
piers	1,0	0,8	1,0	1,0	1,0	1,3	0	0	0	482 400	110 039	0	0
intermediate support cross beams	1,0	0,8	1,0	1,0	1,0	1,0	0	0	0	0	0		
Other	1,0	0,8	1,0	1,0	1,0	1,0	0	0	0	0	0		
bottom slab abutments	1,0	0,8	1,0	1,0	1,0	1,0	0	0	0	0	0		
front wall	1,0	0,8	1,0	1,0	1,0	1,0	0	0	0	630 000	143 707	0	0
wing wall	1,0	1,0	1,0	1,0	1,0	1,0	0	0	0	420 000	95 805	0	0
bearing seat	1,0	0,8	1,0	1,0	1,0	1,0	0	0	0	20 000	0	0	0
upper front wall	1,0	1,0	1,0	1,0	1,0	1,0	0	0	0	168 000	0	0	0
backfilling	1,0	1,0	1,0	1,0	1,0	1,0	0	0	0	117 000	0	0	0
SUPERSTRUCTURE													
main beams re-painting	1,0	1,0	1,0	1,0	1,0	1,0	0	0	0	2 582 000	588 972	0	0
cross beams, re-painting	1,0	1,0	1,0	1,0	1,0	1,0	0	0	0	10 400	0	0	0
main beams patch painting	1,0	1,0	1,0	1,0	1,0	1,0	0	0		0	0	0	0
edge beam partial repair	1,0	1,0	1,0	1,0	1,0	1,0	0	0		1 253 400	793 321	0	0
Bridge deck partial repair	1,0	1,0	1,0	1,0	1,0	1,0	0	0		0	0	0	0
truss	1,0	0,8	1,0	1,0	1,0	1,0	0	0	0	0	0	0	0
arch	1,0	0,8	1,0	1,0	1,0	1,0	0	0	0	0	0	0	0
pylons	1,0	0,8	1,0	1,0	1,0	1,0	0	0	0	0	0	0	0
cables	1,0	0,8	1,0	1,0	1,0	1,0	0	0	0	0	0	0	0
bridge deck	1,0	0,8	1,0	1,0	1,0	2,0	0	0	0	6 266 400	0	53 505	0
edge beam replacement	1,0	0,8	1,0	1,0	1,0	2,0	0	0	0	2 970 000	897 812	47 084	14 233
BRIDGE DETAILS													
bearings	1,0	1,0	1,0	1,0	1,0	1,0	0	0	0	56 000	24 860	6 421	2 850
insulation	1,0	0,8	1,0	1,0	1,0	1,0	0	0	0	2 819 880	1 251 824	53 505	23 752
surfacing	1,0	0,8	1,0	1,0	1,0	1,0	0	0	0	939 960	417 275	53 505	23 752
parapets and noise barriars, partial painting	1,0	0,8	1,0	1,0	1,0	1,0	13	10	0	328 240	904 757	25 682	70 790
expansion joints	1,0	0,8	1,0	1,0	1,0	1,0	0	0	0	678 000	277 417	8 561	3 503
parapets replacement	1,0	1,0	1,0	1,0	1,0	1,0	0	0	0	1 492 000	340 336	0	0
surfacing, partial repair	1,0	1,0	1,0	1,0	1,0	1,0	13	13	0	626 640	1 246 648	17 122	34 062
expansion joints, change of rubber sealing	1,0	1,0	1,0	1,0	1,0	1,0	13	13	0	67 800	134 882	6 421	12 773
drainage system	1,0	1,0	1,0	1,0	1,0	1,0	0	0	0	10 000	0	0	0
MISCELLANEOUS													
aesthetics	1,0	0,8	1,0	1,0	1,0	1,0	0	0	0	100 000	0	1 712	0
other repair actions (total cost)	1,0	0,8	1,0	1,0	1,0	1,0	0	0	0	50 000	0	13 771	0
other repair actions (total cost)	1,0	0,8	1,0	1,0	1,0	1,0	0	0	0		0	0	0
										Σ present value	7 227 656	Σ present value	185 716

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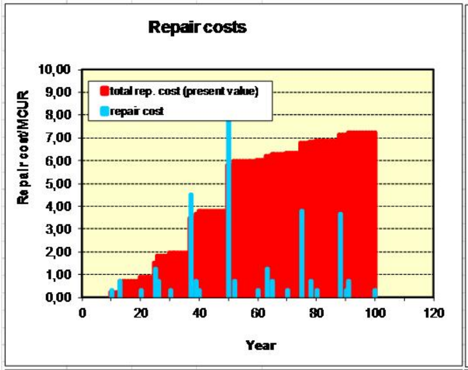
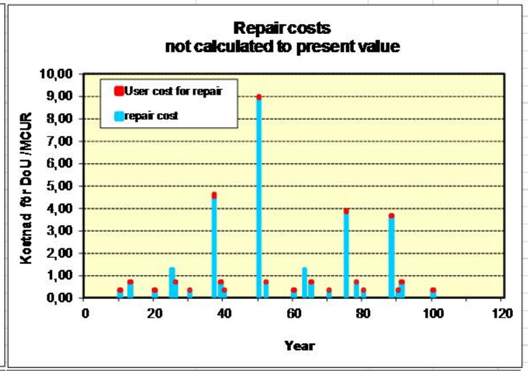
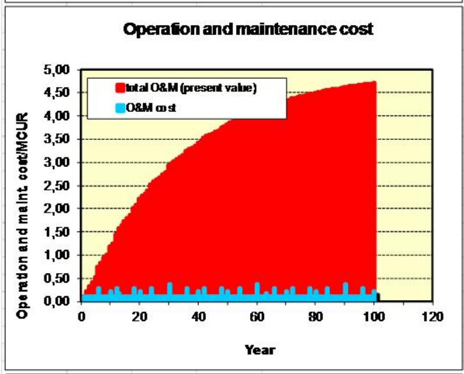
Result

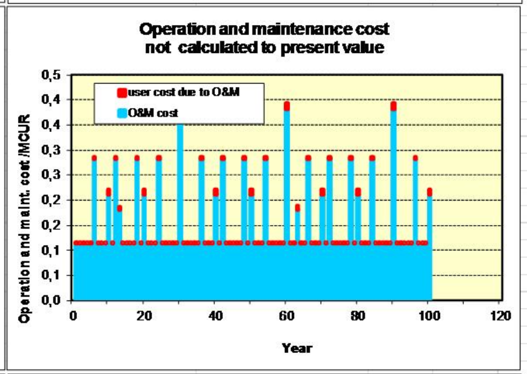
Bridge Life Cycle Optimisation

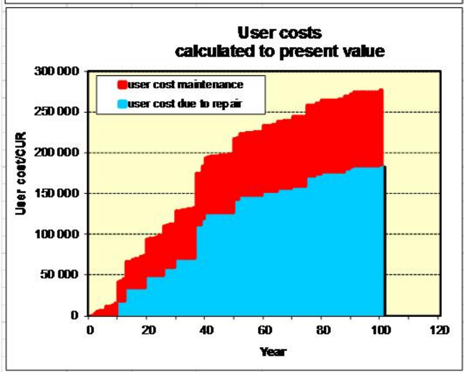
ETSI, Bridge Stand alone LCC Optimal new bridges - Life cycle analysis	
Life cycle cost New composite bridge bridge to X	
INVESTMENT COST	36 995 948
REPAIR COSTS	7 227 656
OPERATION AND MAINTENANCE	4 707 888
USER COSTS	276 293
DEMOLITION COST	192 500
SUM NET PRESENT VALUE	49 400 284
SUM NET PRESENT VALUE / BRIDGE AREA [CUR/m^2]	29 301

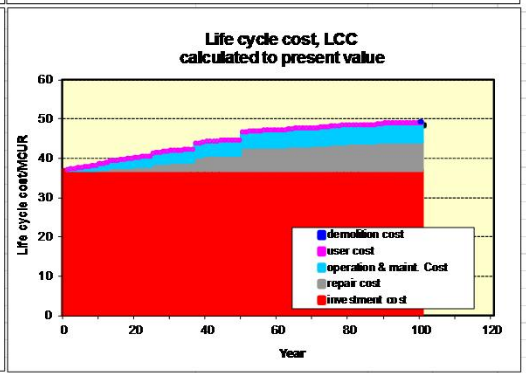












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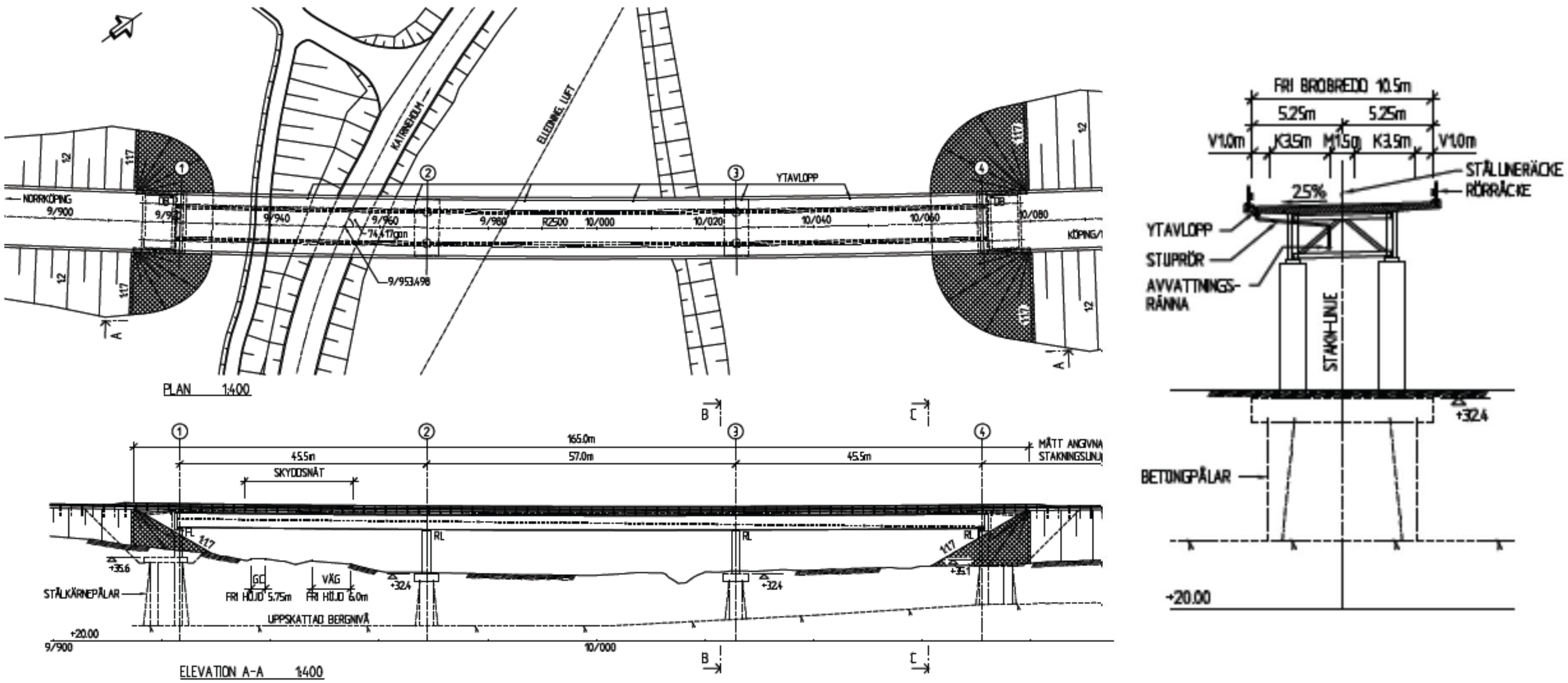
When you open the program

- You will find the example presented in the Proceedings.
- When starting your own calculations save the file under a new name!
- Everything is presented in the new invented currency ”CUR” that can represent NOK, DKK, SEK, €, …

The example

- A Steel-Concrete Composite Bridge



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Quantities and costs

Bridge Life Cycle Optimisation

- In principle from a Power Point Presentation from the Finnish Transport Agency, based on
- material Quantity and Cost Estimation Models for the Design of Highway Bridges", *Acta Polytechnica Scandinavia* – Civil Engineering and Building Construction Series, No. 90, 1988
- I have made some modifications for the sub-structure
- Costs are based on two current bridges in the Stockholm area
- Happens to be almost exactly the cost for this type of bridge in Sweden 22 000 SEK/m^2

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MR&R costs

Bridge Life Cycle Optimisation

- The MR&R actions and costs are from a current project in Stockholm
- Right or wrong…
- As I have said before ”the only thing we now about the future is that we don’t know anything”

Håkan Sundquist

Result

Bridge Life Cycle Optimisation

ETSI, Bridge Stand alone LCC
Optimal new bridges - Life cycle analysis

Life cycle cost
New composite bridge bridge to X

INVESTMENT COST	36 995 948
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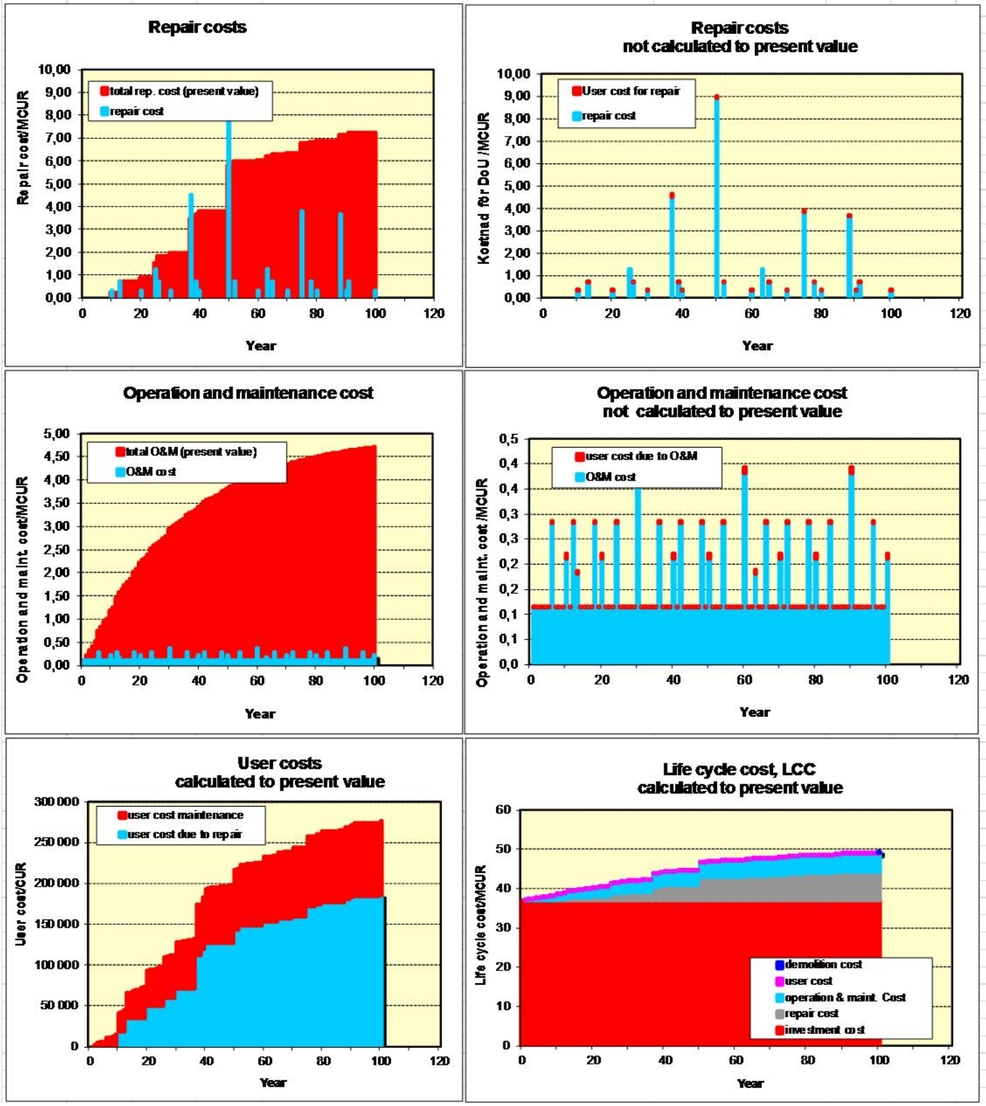

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The most complicated factor in a LCC analysis

- Degradation rate and thus:
  - Time between inspections
  - Time between regular maintenance
  - Time between remedial actions
    - Repair
    - Strengthening
    - Upgrading
    - …
- Future interest rates

- To-morrow we will hear more about a method for predicting future times for actions and their costs based on data-base research in BaTMan!
- In the earlier ETSI Proceedings other methods for predicting the time for actions
- Also the chapter on Life Cycle Plan contains some discussion on time between actions

ETSI

Bridge Life Cycle Optimisation

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I hope there will lots of discussion on the LCC issues at the end of this session

Thank you!