Closing Seminar
14-15 May, 2012
Malmö

NordFoU

Use of LCC and LCA tools in actual bridge projects

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Agenda

Bridge Life Cycle Optimisation

- Working group, process – Birit Buhr
- Conclusion, perspectives
- Possible application of tools

- Presentation of bridge
- Use of LCC tool
- Results from LCC analysis
  - Recommendations

Agenda

Bridge Life Cycle Optimisation

- Use of LCA tool – Linda Høibye
  - Applicability of LCA tool in projects
  - Results from LCA analysis
  - Recommendations
- Optimisation based on LCA analysis – Kirsten Eriksen

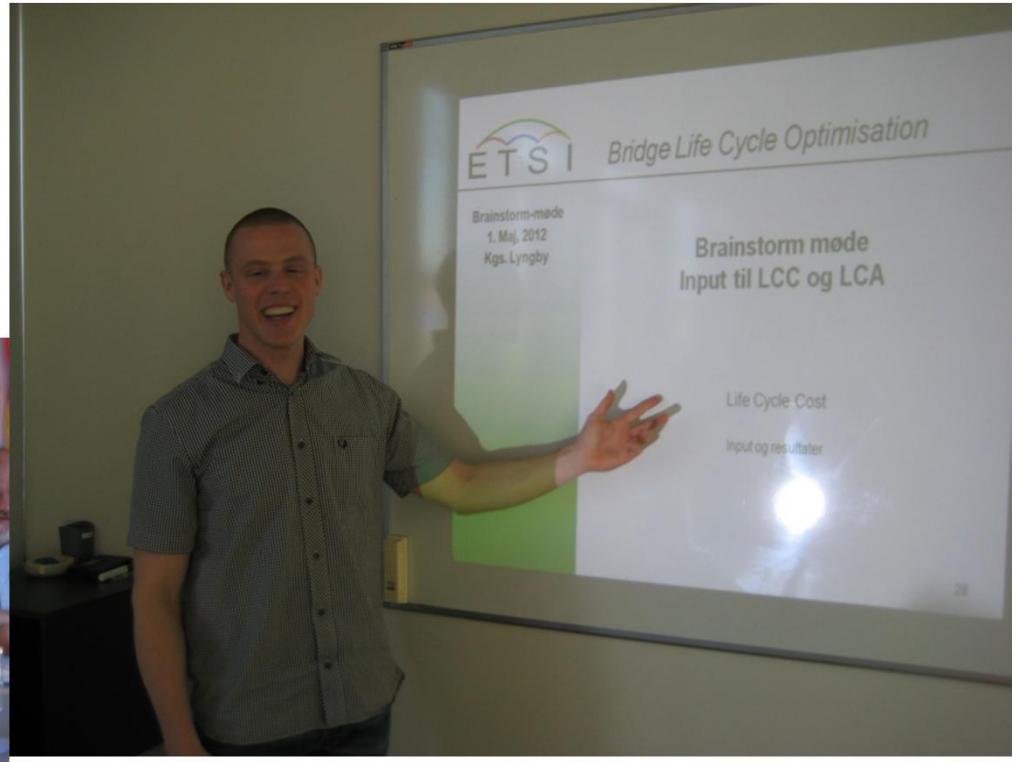
Working group on testing of tools:

Bridge Life Cycle Optimisation

- Anders Solgaard – Trafic models
- Anders Hasse Petersen – LCC and O&M plan
- Jens Thorup Laursen – Design responsible
- Kirsten Eriksen – Concrete and optimisation
- Kristian Kruse-Birch - designer
- Linda Høibye - LCA
- Birit Buhr Jensen - PM

Brainstorming on results and application possibilities

Bridge Life Cycle Optimisation



Participation of

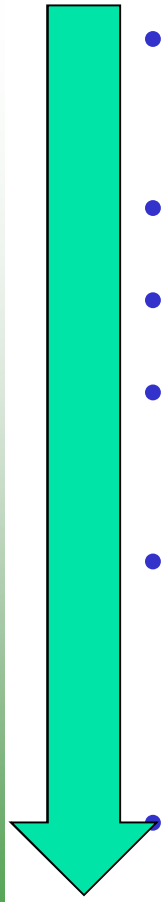
Bridge Life Cycle Optimisation

- Danish Road Directorate
  Design, O&M, procurement
- Contractor - Jorton
- Designer – COWI
- Supervision team – COWI
- Management - COWI

Possible application of tools

Bridge Life Cycle Optimisation

Level of detail



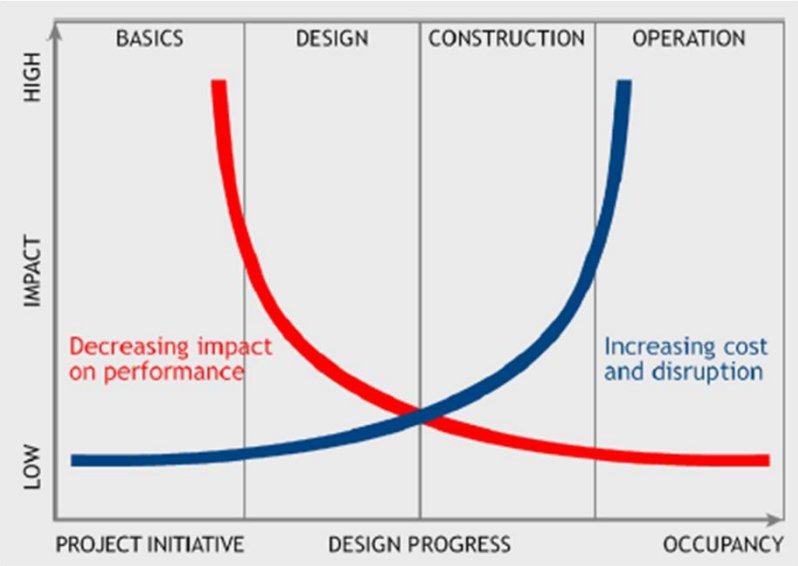
- EIA – different possible routes and connections (different bridge types, tunnels)
- Tender – architects – comparison of bridges
- **Tender – consultancy tender– optimisation**
- Tender – design and built contract – optimisation, monitoring
- Execution phase – monitoring/declaring especially on environmental issues

- Vindingevej – consultancy tender

Perspectives and recommendations

Bridge Life Cycle Optimisation

- Tools of high relevance
- Feasibility studies
  - Incoorporation of tools in EIA
  - Potential large influence and impact in early phases – comparing different design solutions
  - Tunnels, roads, elaboration on traffic models etc. could be incorporated



Bridge Life Cycle Optimisation

- Tender design phase – like Vindingevej
  - Support tool for different design solutions
  - Optimising material, durability and maintenance issues
  - Knowledge on setting the standard

Perspectives and recommendations

Bridge Life Cycle Optimisation

- Construction and O&M&R phase
  - Knowledge on actual environmental impact – input to requirements
  - Knowledge collection on O&M&R prices
  - Durability, service life
- Elaboration
  - Develop web based tool, flexibility
  - Getting familiarized with environmental factors
  - Evaluation of emission factors and weighing factors
  - Deterioration models, service life
  - Pilot projects for further possible implementation

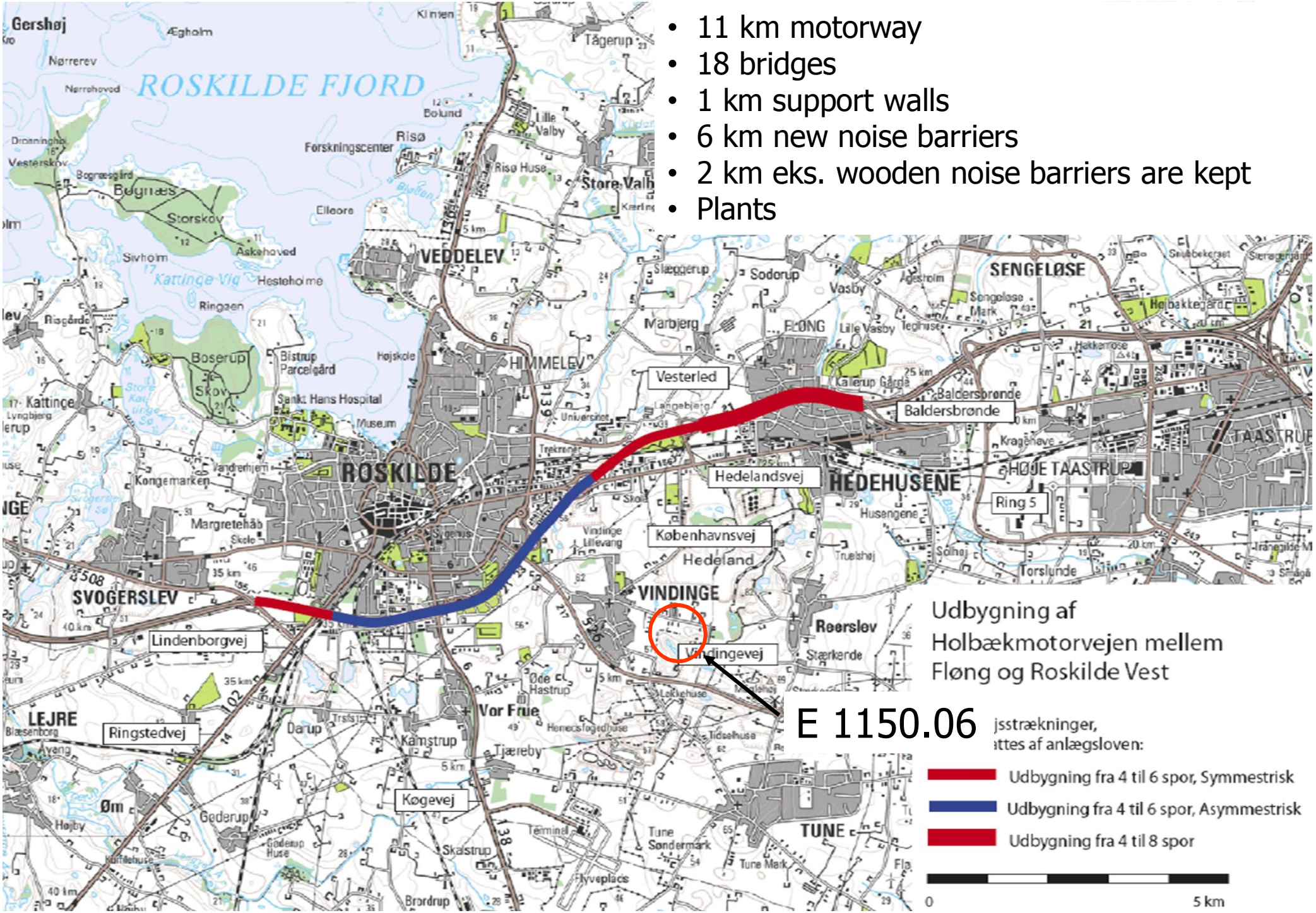
OF af Vindingevej

Bridge Life Cycle Optimisation

Entreprise 1150.06, bro 72,

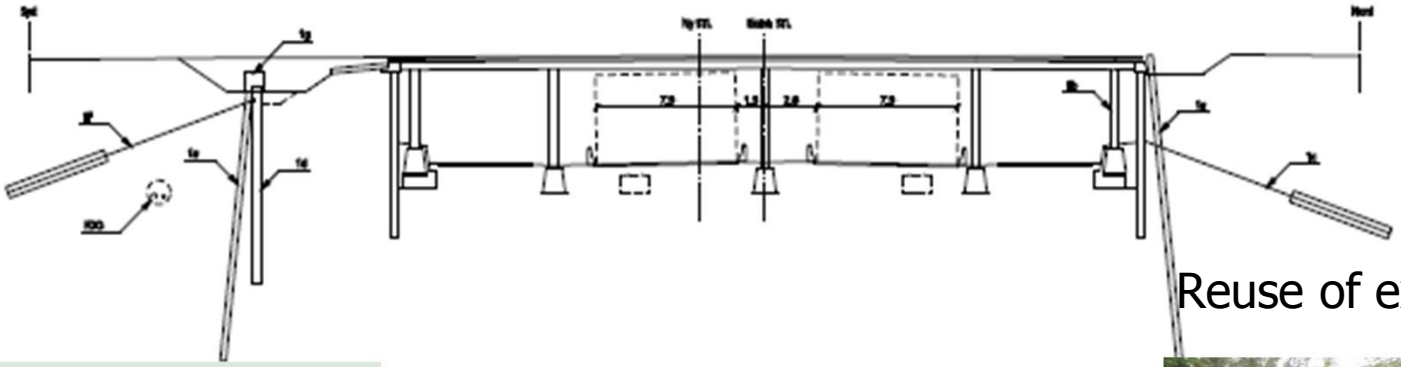
OF af Vindingevej

- 11 km motorway
- 18 bridges
- 1 km support walls
- 6 km new noise barriers
- 2 km eks. wooden noise barriers are kept
- Plants



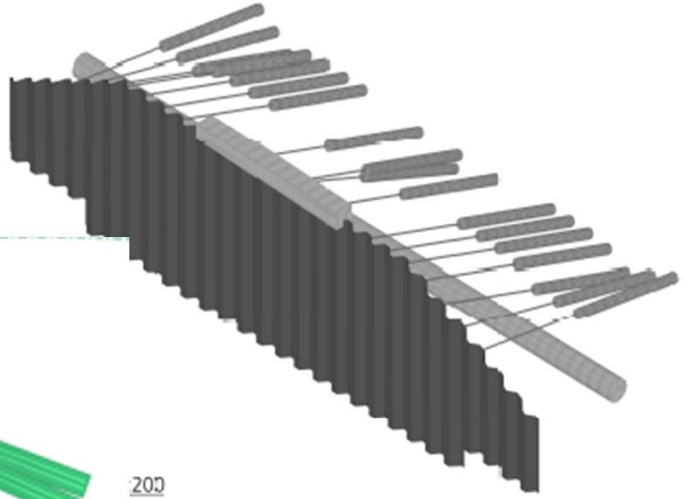
Bridge
In-situ cast,
post-tensioned bridge deck,
2-spans approx. 24 m

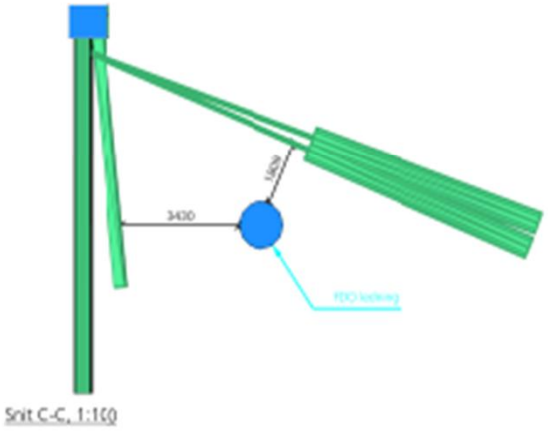
OF af Vindingevej, construction



Reuse of existing sheet pile

FDO pipelines adjacent to bridge





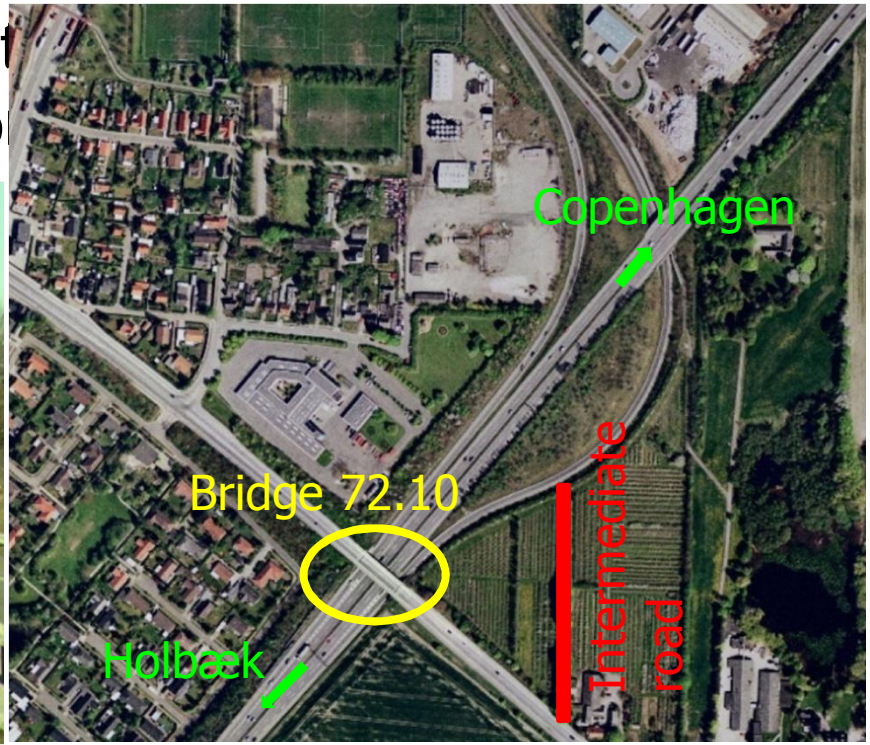
Description of bridge project

Bridge Life Cycle Optimisation

Existing bridge:

- Motivation: Expansion of motorway
- Consequences: Demolition of existing bridge across motorway
- Challenge: Maint
moto

Site:



OF af Vindingevej – trafic considerations

Bridge Life Cycle Optimisation

Inconveniences

- Closure of Vindingevej
- Restrictions on motorway

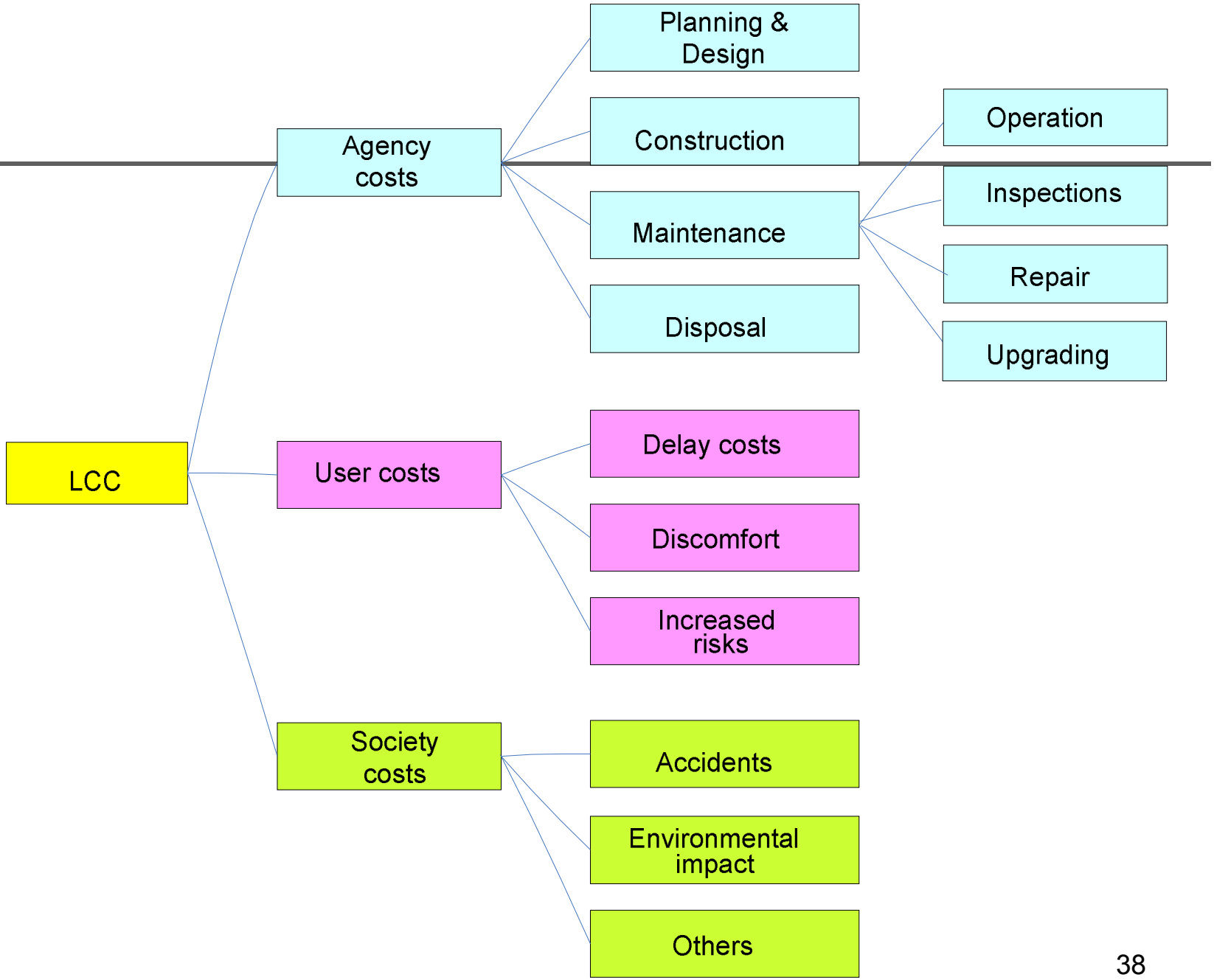
Suggestions for mitigations:

1. Built the bridge in elevated position – done
2. Built the bridge next to the motorway and push into locations – not done
3. Split the bridge into half and construct in two phases – not done
4. Temporary re-routing - done

Overall coordination of trafic

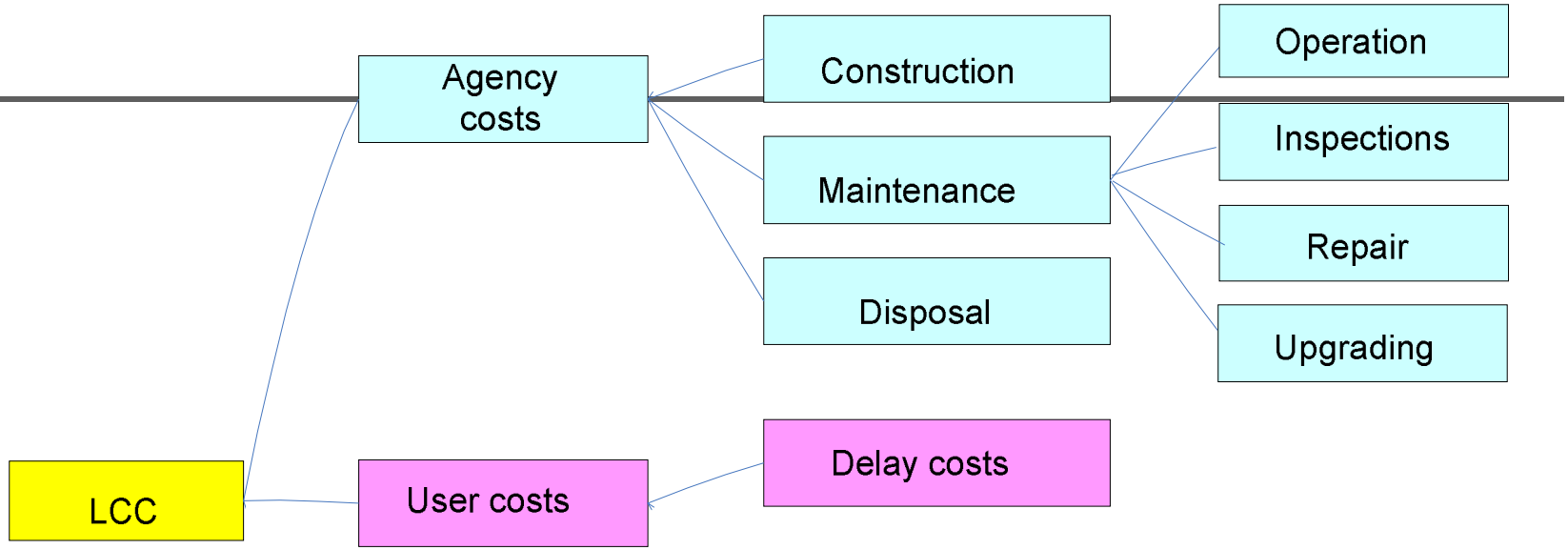
Bridge Life Cycle Optimisation

The ETSI LCC model



Bridge Life Cycle Optimisation

The ETSI LCC model



- Construction costs
- Operation, inspection and repair costs
- Disposal costs
- Delay costs

- All costs are calculated to NPV
  - *r = 5% (DK standard)*

Investment costs

- The investment costs include
  - Construction of the bridge (different elements and materials)
    - Construction materials
    - Costs for labor
- Areas for further development
  - Costs for demolition of existing bridge
  - Costs related to diversion of existing traffic
  - Only one price available per material

ETSI

Bridge Life Cycle Optimisation

Investment cost

	New construction costs Unit price	
formwork	1.274	CUR/m^2
concrete	1.395	CUR/m^3
steel (sheet piles)	8.588	CUR/ton
reinforcement	10.910	CUR/ton
cables	585	CUR/m
rammed piles	516	CUR/m
parapet	1.970	CUR/m
insulation	654	CUR/m^2
surfacing	988	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	31	54	6			294		331.994
pier & column	101	29	5					223.628
abutment + wing wall	589	177	17					1.182.476
sheet piles				78,3				672.300
ground anchors							873.500	873.500
Interim wall							92.000	92.000
backfill							162.065	162.065
SUPERSTRUCTURE								
cables					801			468.375
bridge deck + edge beams	993	553	52					2.603.202
superstructure others							53.720	53.720
BRIDGE DETAILS								
bearing							27.600	27.600
insulation							472.087	472.087
surfacing							713.660	713.660
railing or parapet							250.200	250.200
drainage system							81.040	81.040
bridge details others							85.528	85.528
OTHERS								
demolition of old bridge							306.112	306.112
ROAD PROJECT								
ground works							558.750	558.750
drainage system							194.250	194.250
gravel							148.500	148.500
surfacing							1.617.000	1.617.000
equipment							294.000	294.000
						Σ Investment cost/CUR		**11.411.987**

Bridge Life Cycle Optimisation

Investment costs

Investment cost

	New construction costs Unit price	
formwork	1.274	CUR/m^2
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Bridge Life Cycle Optimisation

Investment costs

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	formwork [m^2]	concrete[m^3]
SUBSTRUCTURE		
foundation slab	31	54
pier & column	101	29
abutment + wing wall	589	177
sheet piles		
ground anchors		
Interim wall		
backfill		

Operation and inspection costs

Bridge Life Cycle Optimisation

- The O&I costs include
  - Inspection
  - Surveillance
  - Maintenance

  } Incl. traffic

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
Maintenance of road lighting	625	CUR		1	0	0	0			625	12.405	0	0
Superficial inspection	30.000	CUR		5	0	0	0			30.000	107.759	0	0
Main inspection	75.000	CUR		10	0	0	0	1,0	0,1	75.000	118.350	1.796	2.834
Cleaning	0,76	CUR/m²	825	1	0	0	0			625	12.405	0	0
Cleaning of drainage system	625	CUR		1	0	0	0			625	12.405	0	0
										Σ present cost	263.324 kr	Σ present cost	2.834 kr

- Underpassing traffic
- Interval of O&I (frequency)
- Extent of O&I (quantities)

Operation and inspection costs

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 t

	MR&R unit cost & quantities			MR&R interval alt. Single year			
	unit costs		quantities	interval, year	action year	action year	action year
Maintenance of road lighting	625	CUR		1	0	0	0
Superficial inspection	30.000	CUR		5	0	0	0
Main inspection	75.000	CUR		10	0	0	0
Cleaning	0,76	CUR/m^2	825	1	0	0	0
Cleaning of drainage system	625	CUR		1	0	0	0

Repair costs

Bridge Life Cycle Optimisation

- Costs for repair is based on
  - Interval of repair work (planned)
  - Extent in repair work
  - ADT, salting, concrete properties, etc.

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			Repair cost		User cost	
	unit cost		quantities	interval, year	action year	action year	action year	days	length	salt exposure	concrete quality CX/37	cover qoutient	cost each time	tot cost	cost each time	tot cost
SUBSTRUCTURE																
Abutment, shotcrete repair, no rebar	5.500	CUR/m²	24		60								132.000	7.067	0	0
Abutment, shotcrete repair, with rebar	8.600	CUR/m²	6		60								51.600	2.762	0	0
Piers, shotcrete repair, no rebar	5.500	CUR/m²	17		60								90.750	4.858	0	0
Piers, shotcrete repair, with rebar	8.600	CUR/m²	6		60								47.300	2.532	0	0
SUPERSTRUCTURE																
Shotcrete repair of superstructure	7.300	CUR/m²	80		40	60	80						584.000	126.003	0	0
Replacement of edge beams	12.200	CUR/m	100	60				70,0	0,2				1.220.000	65.313	188.596	10.097
Shotcrete repair of edge beams	12.100	CUR/m²	32		60	100							384.780	23.525	0	0
BRIDGE DETAILS																
Replacement of bearings	24.000	CUR/item	3	50									72.000	6.826	0	0
Replacement of waterproofing system and surfacing	3.500	CUR/m²	722	40				112,0	0,2				2.526.930	409.925	301.754	48.951
Replacement of wearing course	600	CUR/m²	779		20	60	100	14,0	0,1				467.400	204.735	25.146	11.015
Replacement of bituminous sealing joint	2.100	CUR/m	28	20									58.800	35.295	0	0
Replacement of parapets (no strengthning of edge beams)	2.800	CUR/m	127		40								355.600	50.511	0	0
Regalvanizing of parapets	2.600	CUR/m	127		20	60	100						330.200	144.637	0	0
Replacement of lighting	50.000	CUR/item	1	25									50.000	20.793	0	0
													Σ present value	1.104.784 kr	Σ present value	70.063 kr

Repair costs

Bridge Life Cycle Optimisation

Repair cost

<Repair alt new part>

Dotted fields contain the default values evaluated

	Repair quantities and unit costs		
	unit cost		quantities
SUBSTRUCTURE			
Abutment, shotcrete repair, no rebar	5.500	CUR/m²	24
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SUPERSTRUCTURE			
Shotcrete repair of superstructure	7.300	CUR/m²	80
Replacement of edge beams	12.200	CUR/m	100
Shotcrete repair of edge beams	12.100	CUR/m²	32
BRIDGE DETAILS			
Replacement of bearings	24.000	CUR/item	3
Replacement of waterproofing system and surfacing	3.500	CUR/m²	722
Replacement of wearing course	600	CUR/m²	779
Replacement of bituminous sealing joint	2.100	CUR/m	28
Replacement of parapets (no strengthning of edge beams)	2.800	CUR/m	127
Regalvanizing of parapets	2.600	CUR/m	127
Replacement of lighting	50.000	CUR/item	1

Bridge Life Cycle Optimisation

- Total costs
- Results

Bridge Stand alone LCC Optimal new bridges - Life cycle analysis	
Life cycle cost Bridge at Vindingevej, across M11	
INVESTMENT COST	11,411,987
REPAIR COSTS	1,104,784
OPERATION AND MAINTENANCE	263,324
USER COSTS	207,429
DEMOLITION COST	8,678
SUM NET PRESENT VALUE	**12,996,202**
SUM NET PRESENT VALUE / BRIDGE AREA [CUR/m^2]	**15,751**

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Bridge Life Cycle Optimisation

Bridge Stand alone LCC Optimal new bridges - Life cycle analysis	
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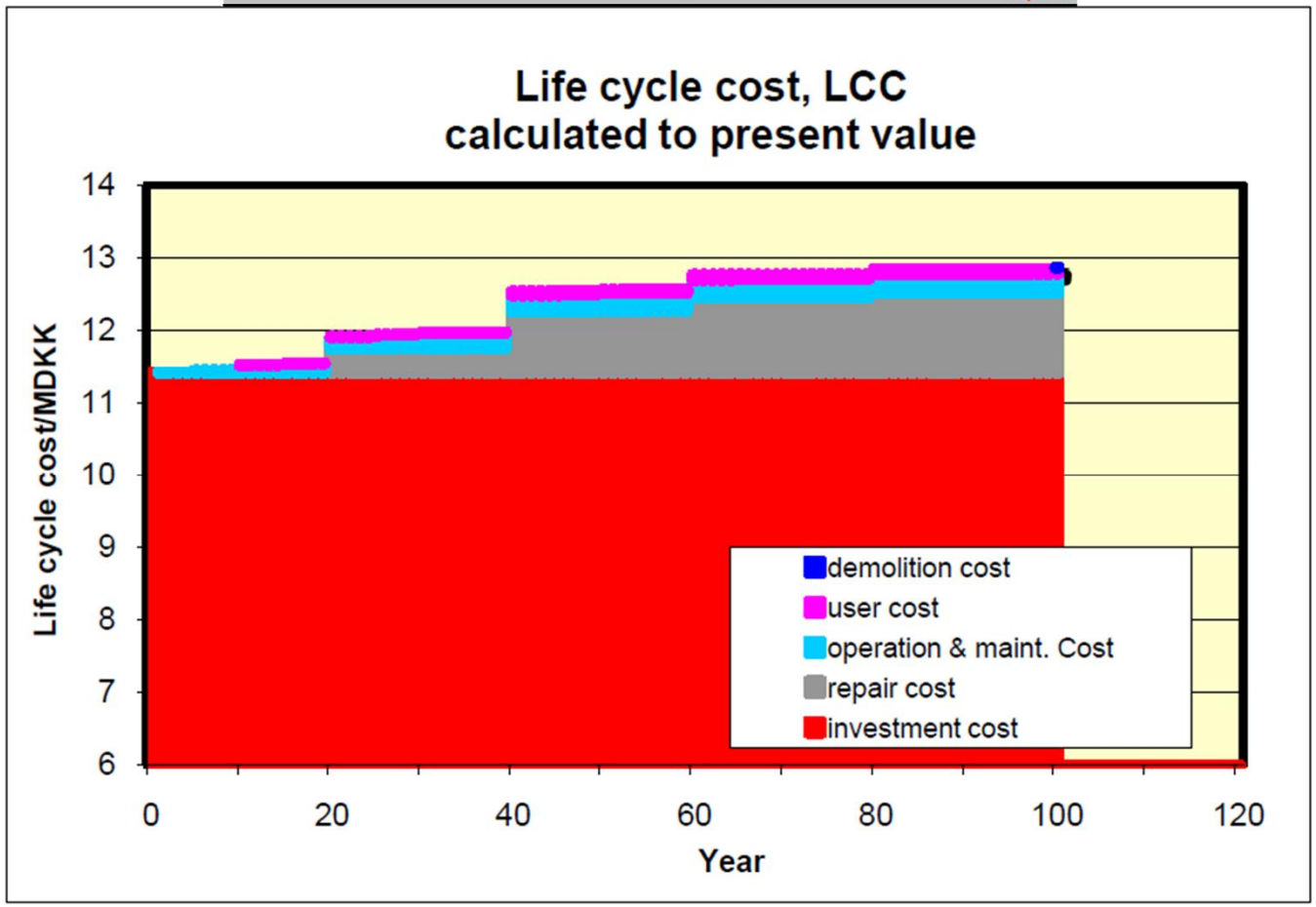
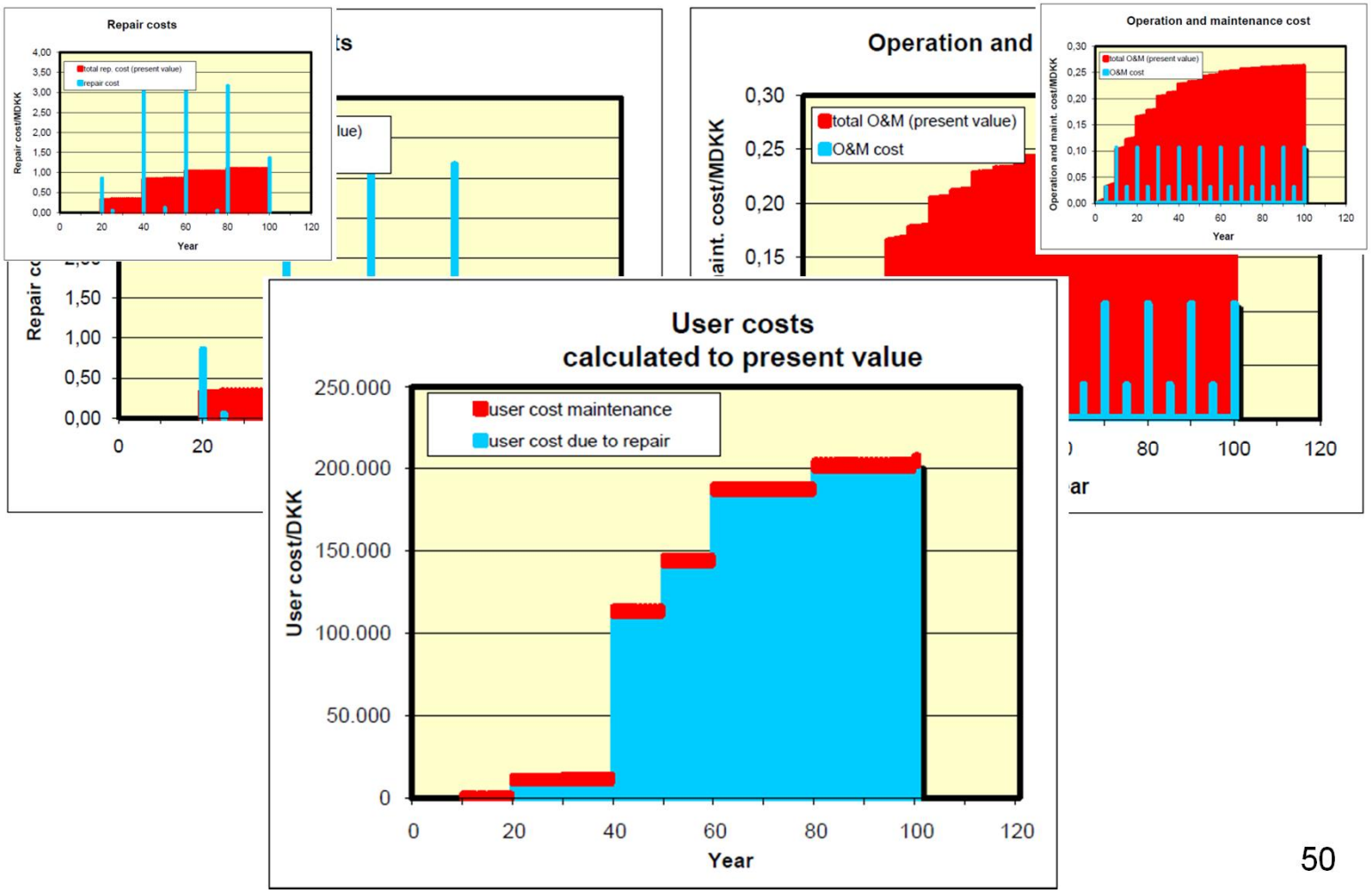


Results

Bridge Life Cycle Optimisation

- O&I and repair costs



Interpretation

Bridge Life Cycle Optimisation

- Cost drivers

Bridge Stand alone LCC
Optimal new bridges - Life cycle analysis

Life cycle cost
Bridge at Vindingevei, across M11

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

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	unit cost		quantities	cost each time	tot cost	cost each time	tot cost
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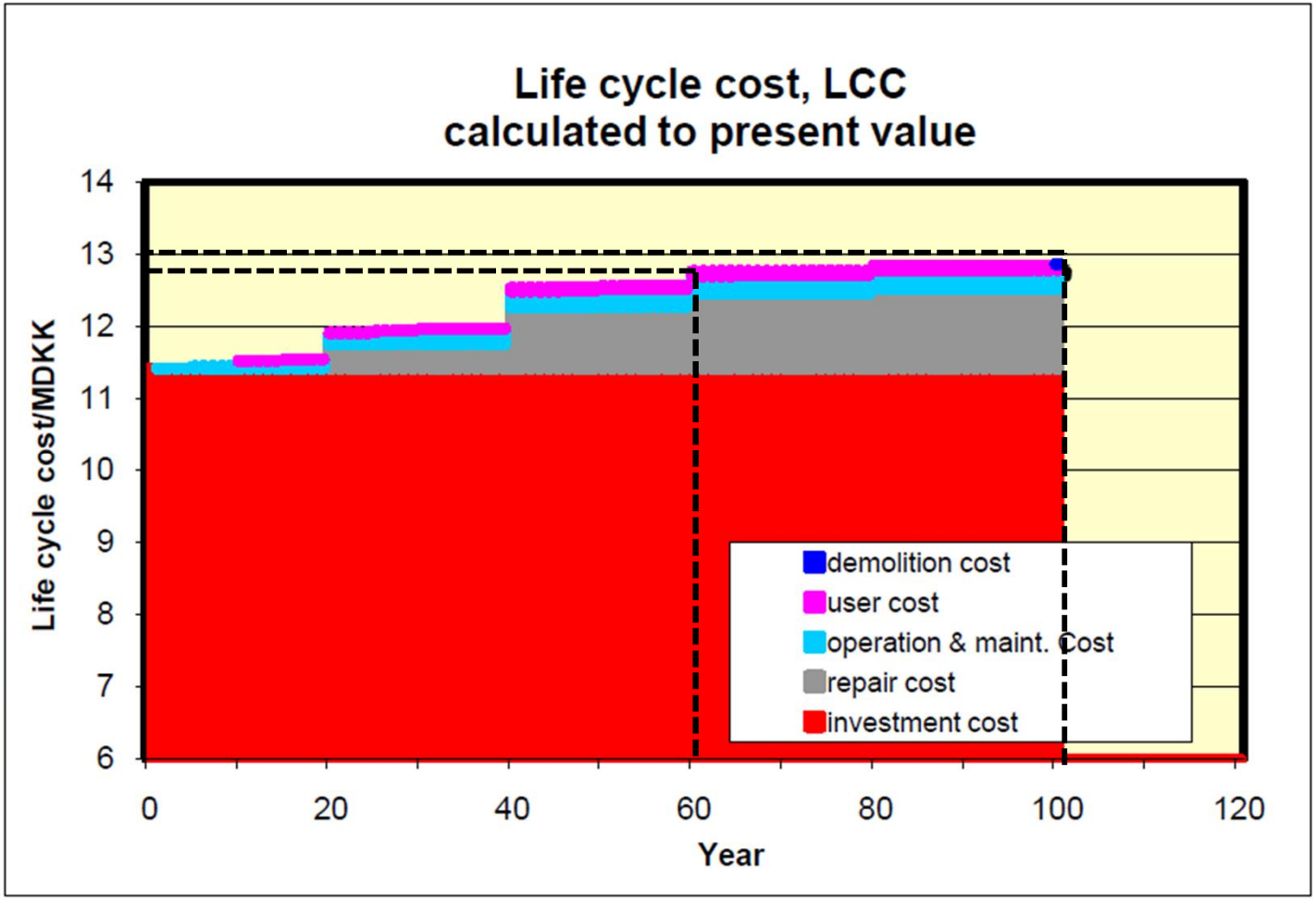
Regalvanizing of parapets	2,600	CUR/m	127	330,200	144,637	0	0
Replacement of lighting	50,000	CUR/item	1	50,000	20,793	0	0
				Σ present value	**1,104,784 kr**	**Σ present value**	**70,063 kr**

56%

86%

Discussion - Actual life span of motorway bridges

Bridge Life Cycle Optimisation



Conclusion and perspectives

- The use of the LCC tool
  - User friendly interface
  - Easy interpretation of calculation methods
  - Easy interpretation of results (graphs)
- Areas for improvement to enable VD use
  - Traffic
  - O&M and repair work
    - Intervals
    - Quantity
  - Nomenclature

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Bridge Life Cycle Optimisation