Digitaliserad projektering för industrialiserad produktion

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Agenda

- NCC bridge concepts
- Parameterization and automatization of models & calculations
- Set-based design method for bridges
- Examples
- Challenges/opportunities

NCC Montagebro

- Standardised bridge concept with high-level of prefabrication
- Short construction time
- Reduced and lighter work activities on-site

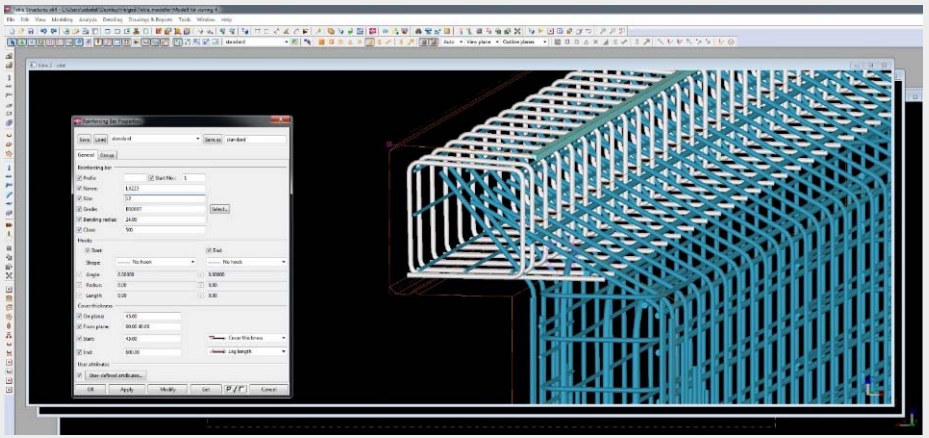
NCC Composite bridge

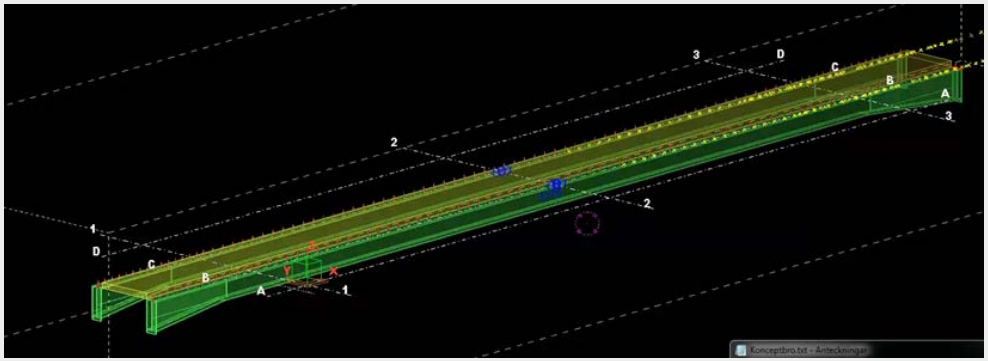
- Girders in high-strength stainless steel
- Integrated abutments
- Low maintenance
- Fast construction through standardization

Parameterization and automatization

- Calculations
- Generation of VDC/3D model, FE-model
- Managing files and interface between different software
- Documentation

➢ Reduce time and costs of planning for concept bridges



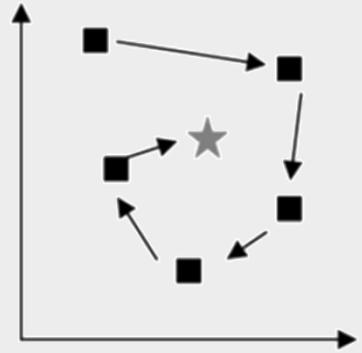


```
deflectionaux=[]
LoadCombinations=LoadCombinations*numCases
for i in xrange(1,LoadCombinations+1):
    frame = odb.steps['Traffic Load'].frames[i]
    dispField = frame.fieldOutputs['U']

    disp=[]
    for i in range(0,len(dispField.values)):
            a=dispField.values[i].data[1]
            disp.append(a)
    deflength=min(disp)
    deflectionaux.append(deflength)

deflection=min(deflectionaux)
if abs(deflection)>L/float(400):
    Feasible=False
    FailReason+=' Deflection'
```

Parameterization of Finite Element model

Point-based design vs. Set-based design

Point-Based Design

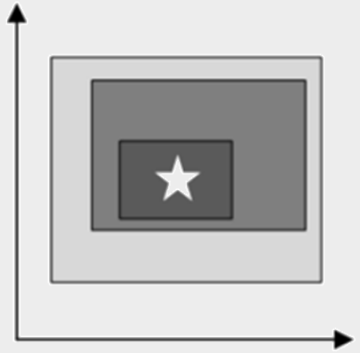


+ Traditional approach / common practice
+ Faster if satisfactory solution found on the first try

- Single solution studied, rework if unsatisfactory
- Decisions mostly based on designer's judgment

- Understanding of one solution
- Few alternatives tested

Set-Based Design



- Not well-established
- More effort required the 1st time

= Redundant calculations

+ Sets of solutions, rework avoided
+ Suitable for involving other stakeholders in decision process during design
+ Learning from all the considered solutions
+ Optimal solution among the many alternatives considered

Set-based design method for bridges

BRIDGE DESIGN INEFFICIENCY FACTORS

- Low repeatability
- Standard checks / sectional design
- Traffic loads
- Fatigue and dynamic assessment
- Single solution, if unfeasible, rework
- Few alternatives tested

POTENTIAL IMPROVEMENTS

✓ Continuous development of flexible methods/solutions, bridge concepts

✓ Automatic implementation, generation and calculation

✓ Large amount of alternatives

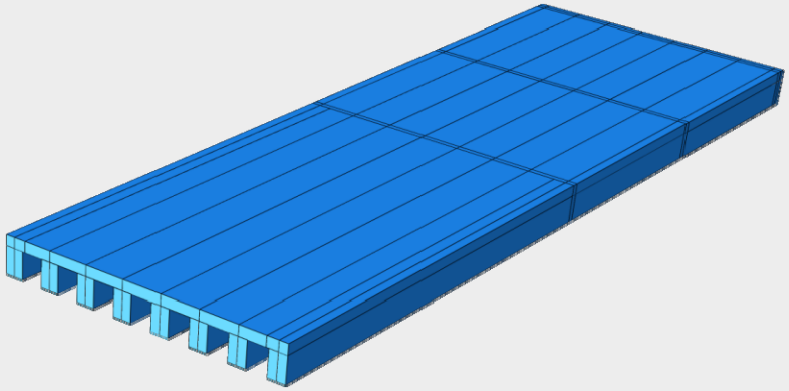
✓ Sets of solutions, rework avoided

✓ Wider decision-making process

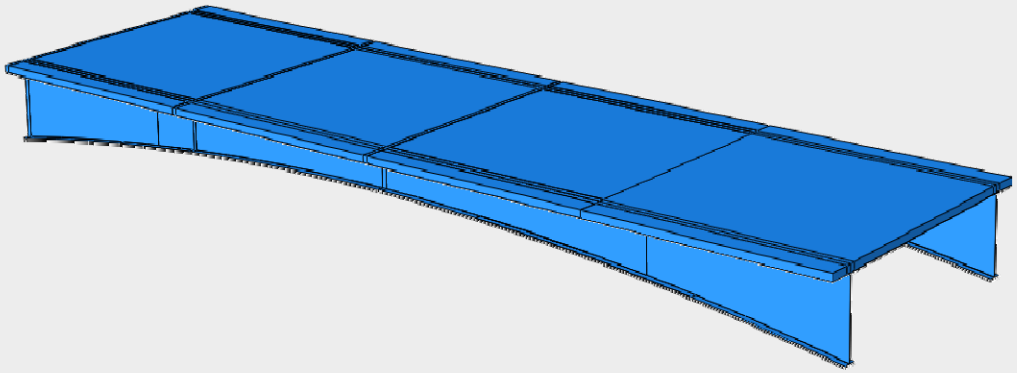
✓ Optimal solution

PROJECT SPECIFIC DATA | PARAMETERS | SET OF ALTERNATIVES | STRUCTURAL ASSESSMENT | MULTI CRITERIA ANALYSIS | OPTIMAL BRIDGE SELECTION

NCC Montagebro



NCC Composite concept



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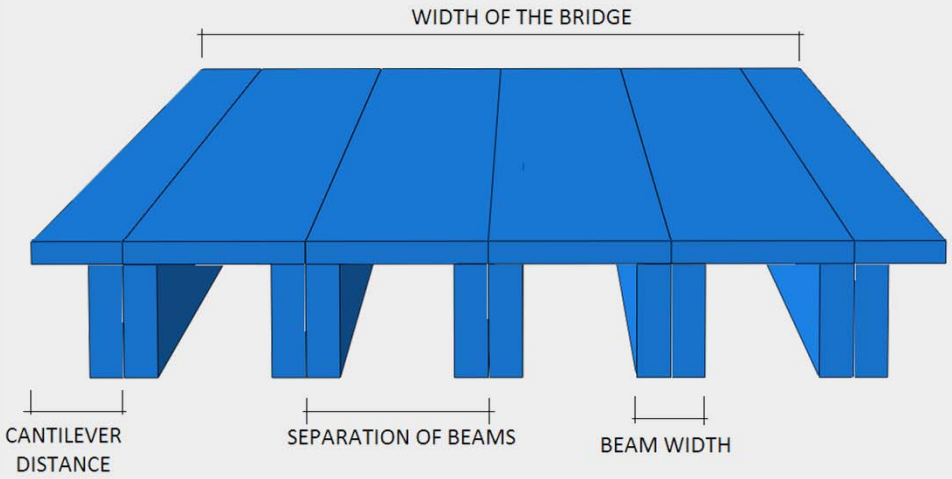
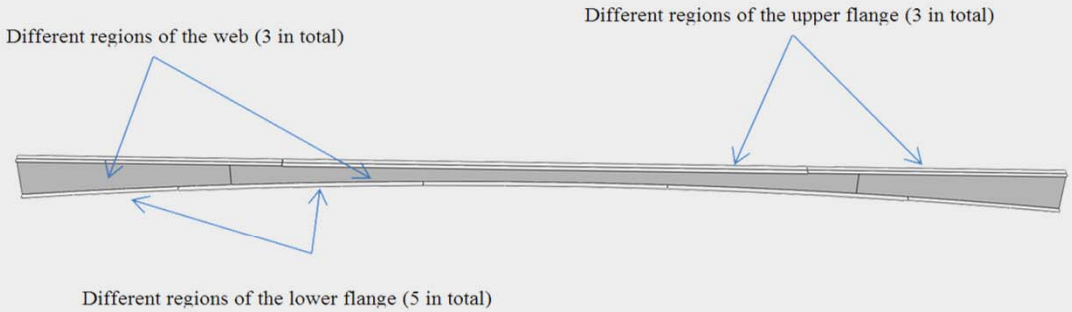
NCC Montagebro



NCC Composite concept



- Length and width of the bridge
- Number/position of beams
- Beams parameters (cross sections, curvature. etc.)
- Thickness of the concrete deck
- Diameter of reinforcement bars
- Material strengths

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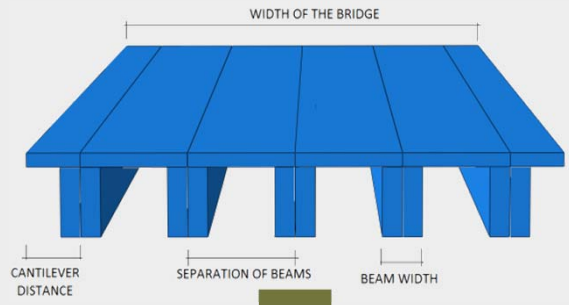
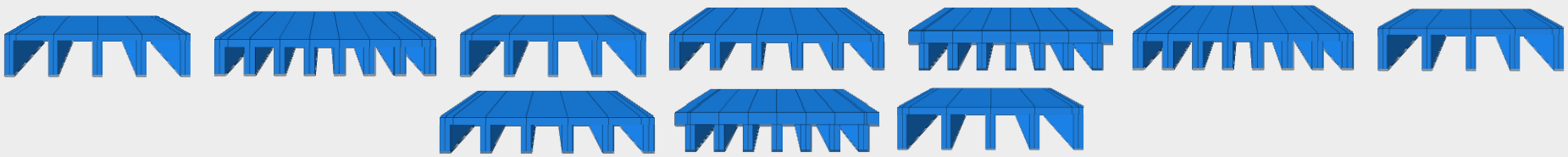



```
Lrange=[20,25,30,35,40,45]
thicknessrange=[0.2,0.225,0.25,0.275,0.3]
thicknessbeamrange=[0.3,0.4,0.5,0.6,0.75,1]
heightrange=[0.5,0.75,1,1.25,1.5]
cantileverrange=[0,0.2,0.4]
numbeams=[6,7,8,9,10,11,12]
```

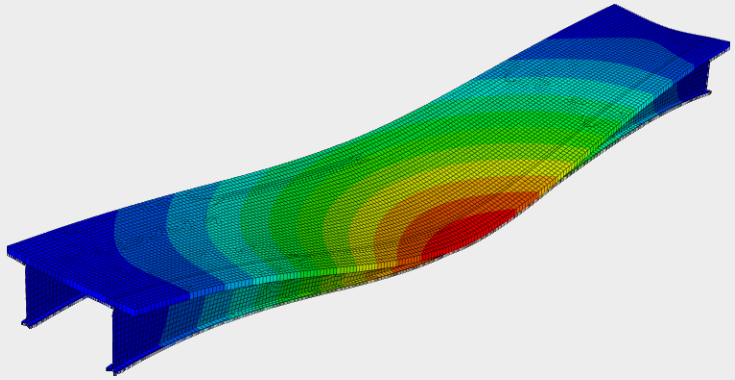
18900 GEOMETRIER ANALYSERAS

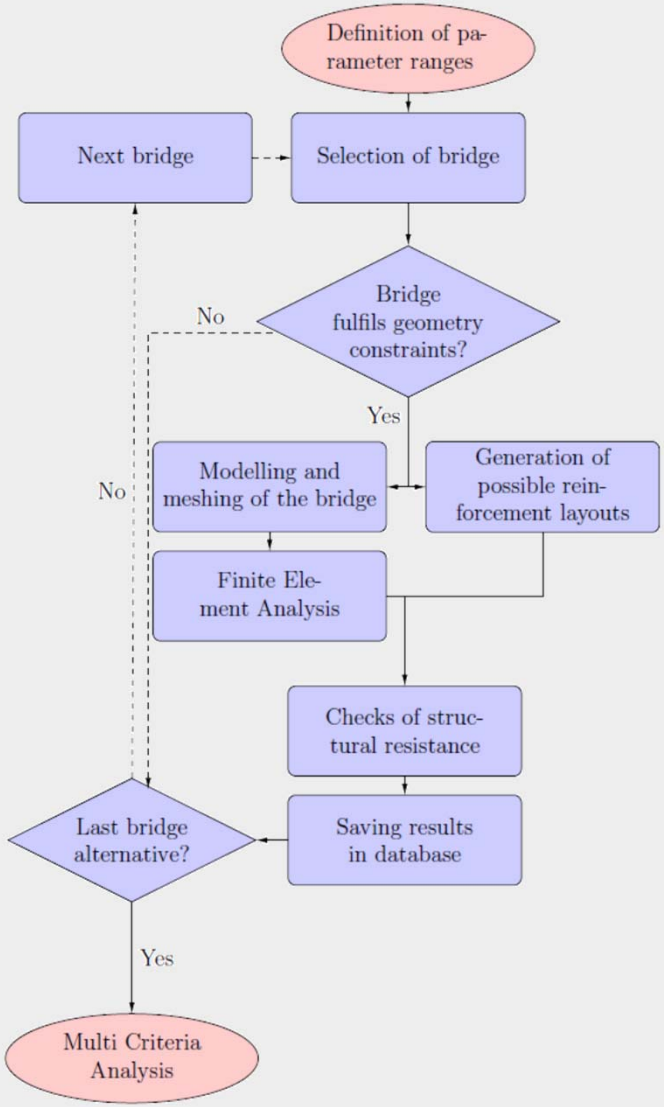


PROJECT SPECIFIC DATA | PARAMETERS | SET OF ALTERNATIVES | STRUCTURAL ASSESSMENT | MULTI CRITERIA ANALYSIS | OPTIMAL BRIDGE SELECTION

Technical structure

- Python code -> Expandable
- ABAQUS libraries -> FEA
- Ready for cluster processing





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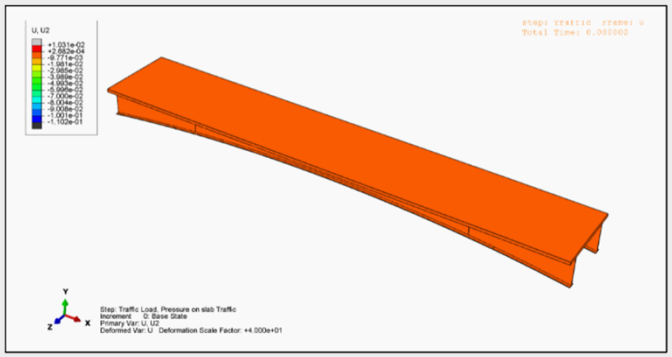
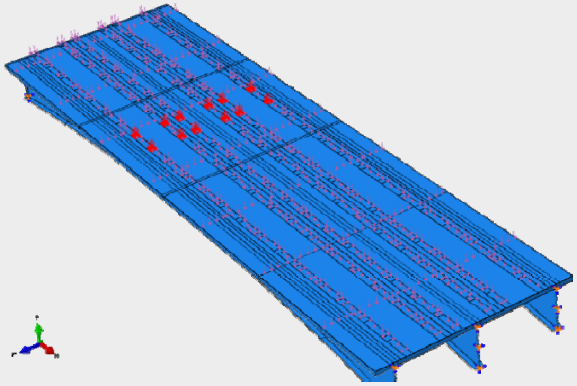
Traffic loads

- Implemented as moving loads



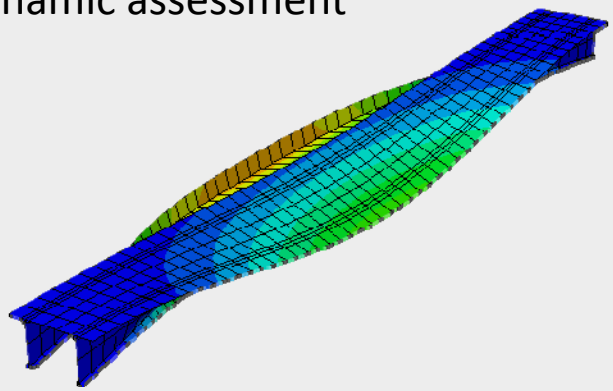
- 3 lanes, 8 positions
- 8^3 load cases -> 512



Design

- Full control according to Eurocode (ULS, SLS)
- Reinforcement design: different layouts, different regions
- Consideration of construction stage

- Fatigue design
- Dynamic assessment



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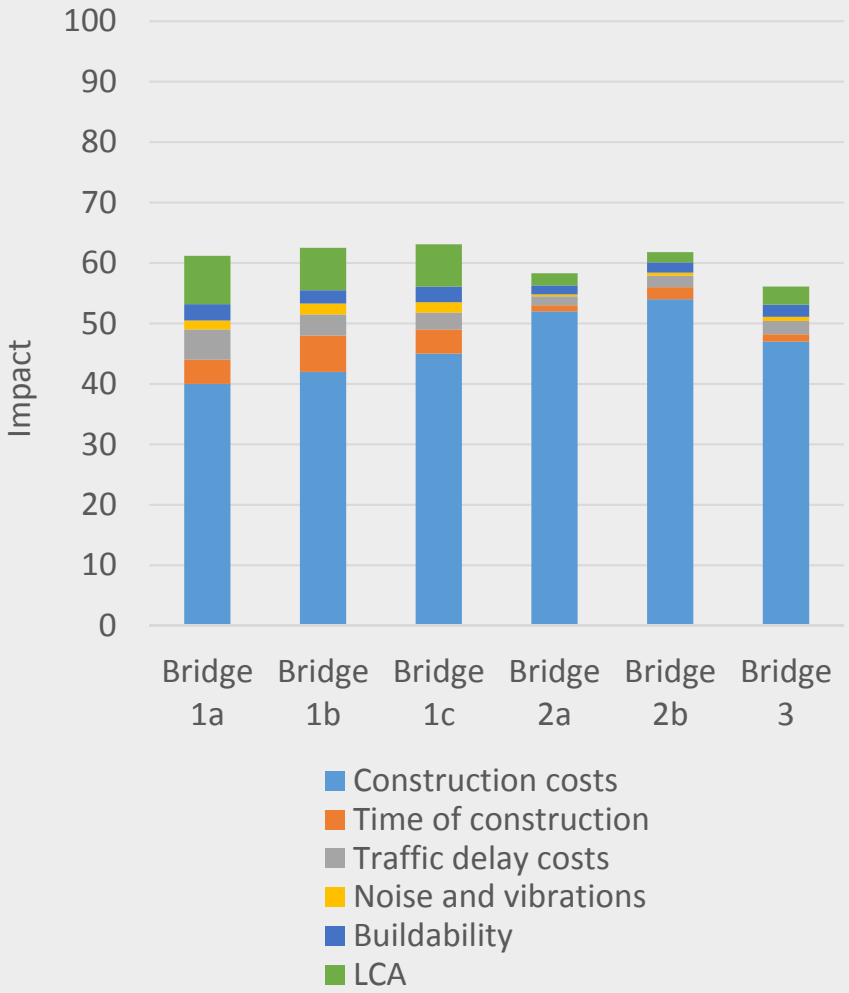
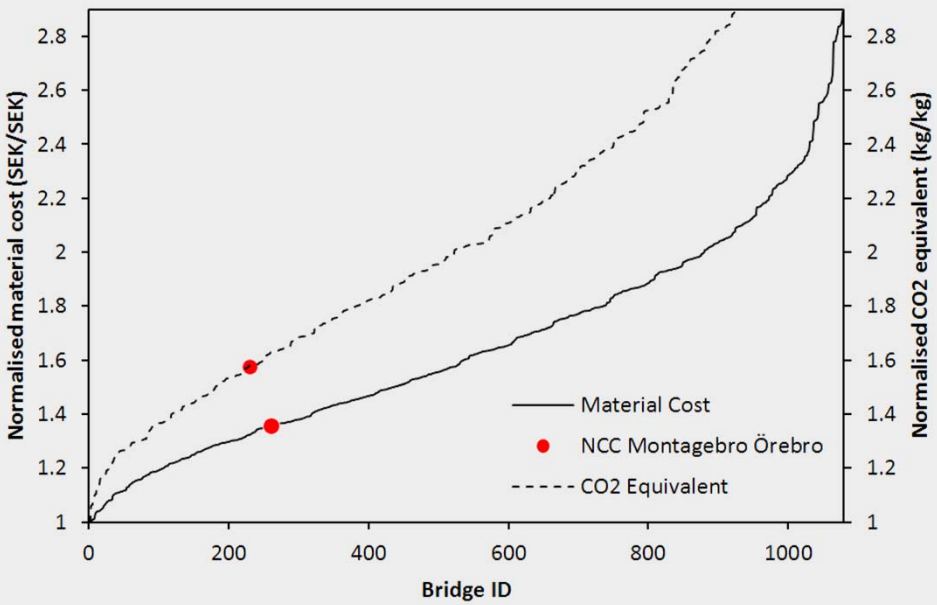


Examples

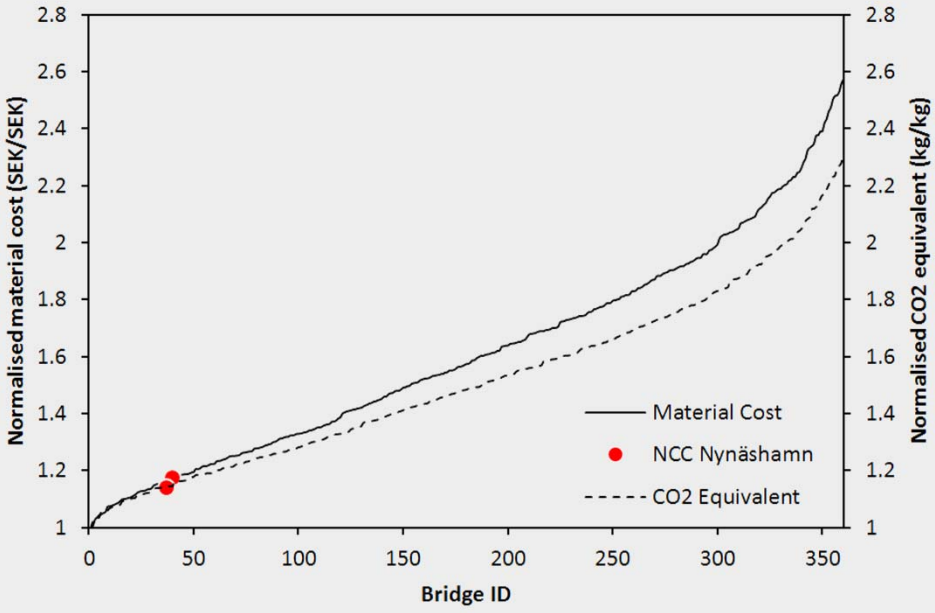
NCC Montagebro: Örebro

Parameter	Value
Bridge length	20.00 m
Bridge width	7.00 m
Slab thickness	0.20,0.25,0.30 m
Beam thickness	0.30,0.50,0.75,1.00 m
Beam height	0.50,0.75,1.00,1.25,1.50 m
Number of beams	6,7,8,10,11
Reinforcement diameter	10,14,16,20,25,28,32 mm



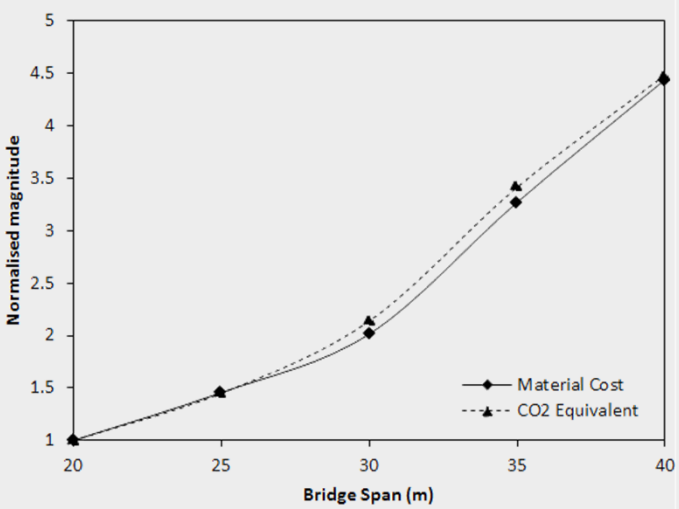
NCC Composite concept: Nynäshamn

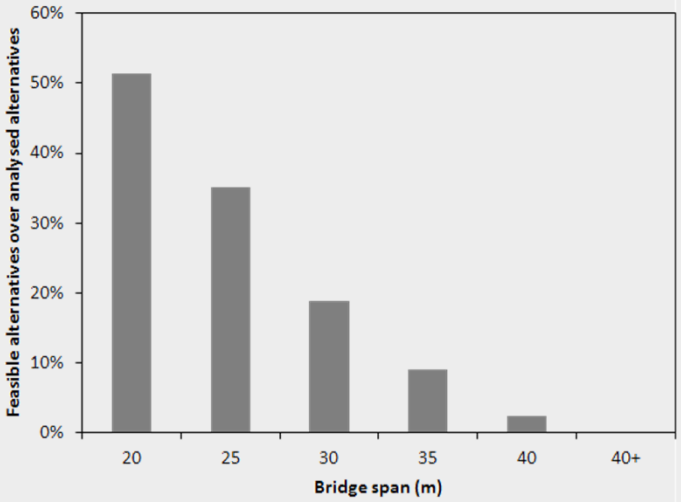
Parameter	Value
Bridge length	40 m
Bridge width	7 m
Slab thickness	0.25,0.30 m
Beam height at supports	1.8,2.2,2.5,2.8,3.5 m
Beam height at mid span	1.0,1.2,1.5 m
Number of beams	2,3
Web thickness at supports	16,20,25 mm
Lower flange thickness at supports	40,50 mm



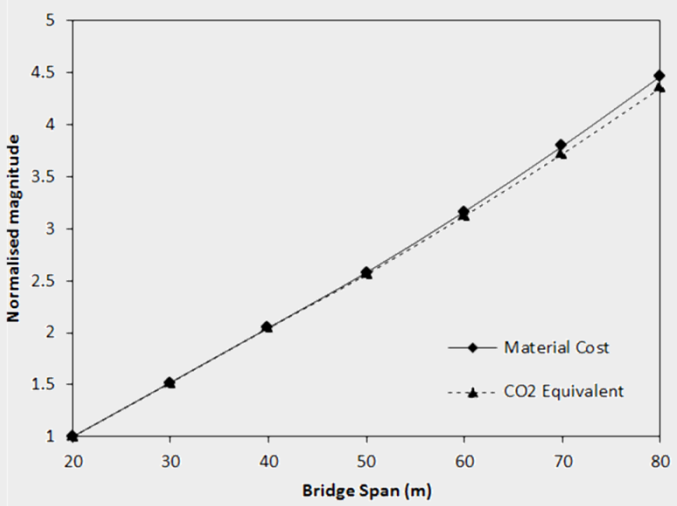
Examples

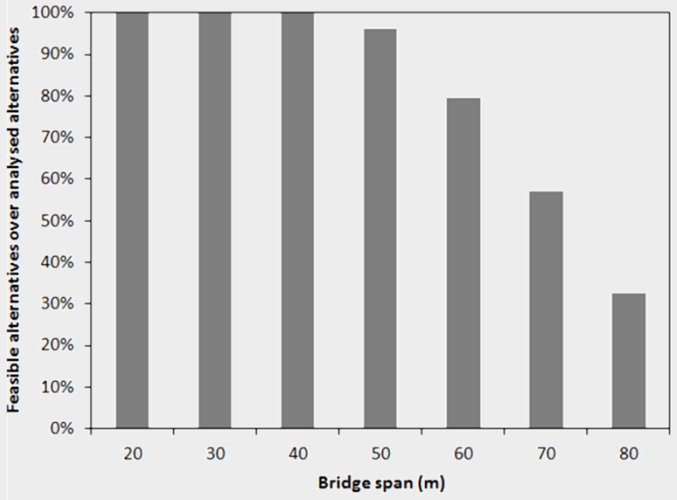
NCC Montagebro: Örebro

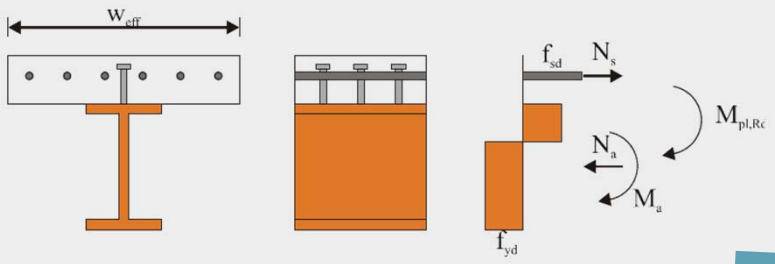




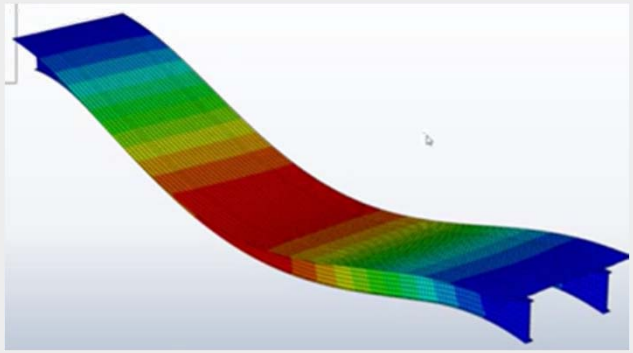
NCC Composite concept: Nynäshamn



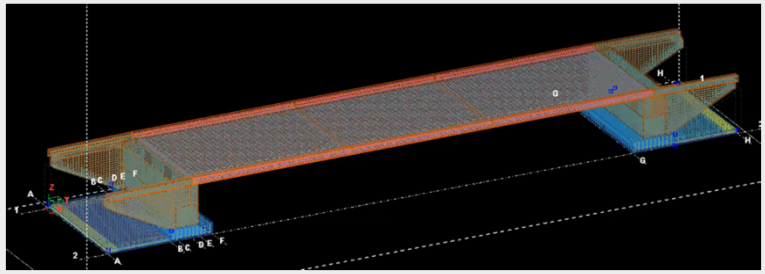




Sectional design



Structural analysis

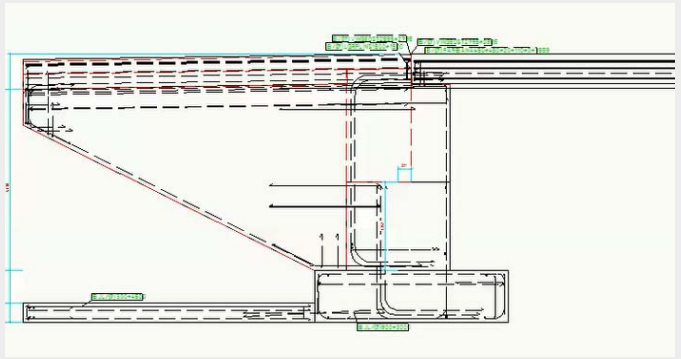


VDC-model

Reinforcement

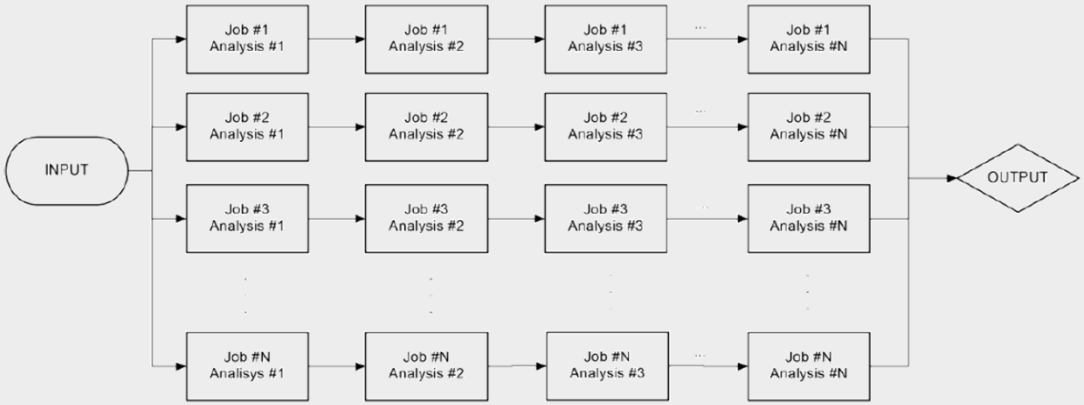
Documentation

Drawings



Some of the challenges/opportunities:

- Large amount of data generated
- Traffic load cases
- Missing functionalities for automatization and parallel processing in software used in structural engineering
- Licensing systems for design softwares
- Many different software required
- High Performance Computing, cloud computing services
- Use in combination with Machine Learning
- Programing skills




NCC