5Dinitiative

Lake Constance 5D-Conference 2016

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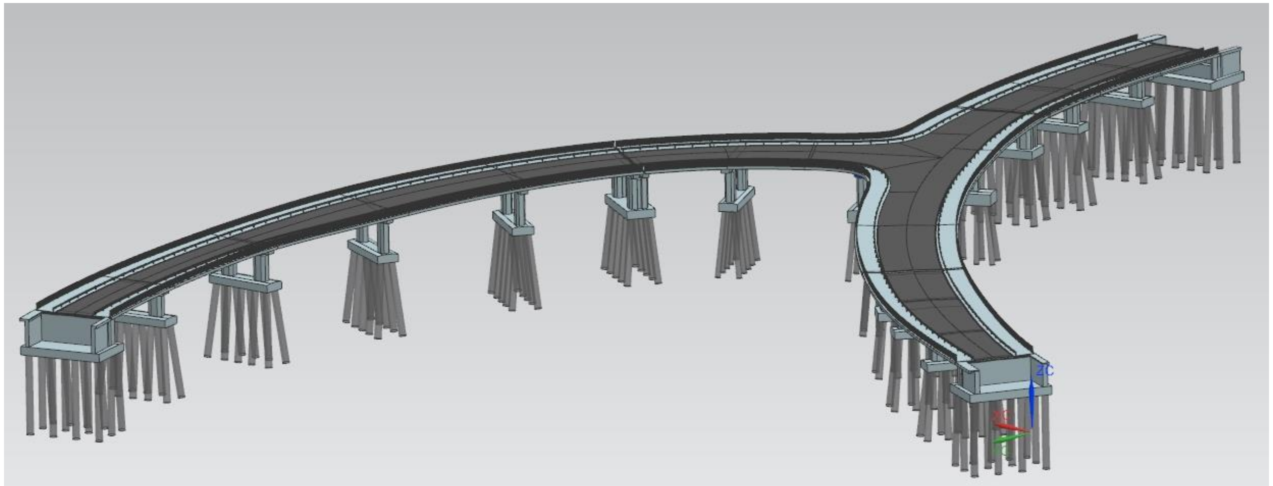

Schüßler-Plan
Ingenieurgesellschaft für Bau- und Verkehrswegeplanung mbH
Sankt-Franziskus-Straße 148
40470 Düsseldorf

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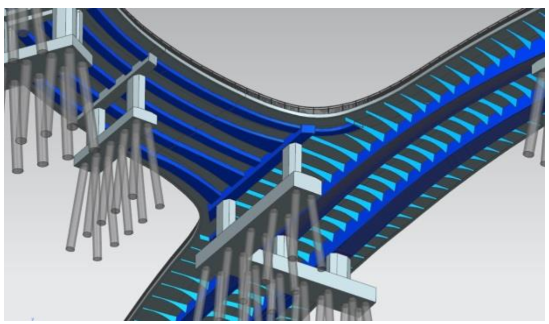
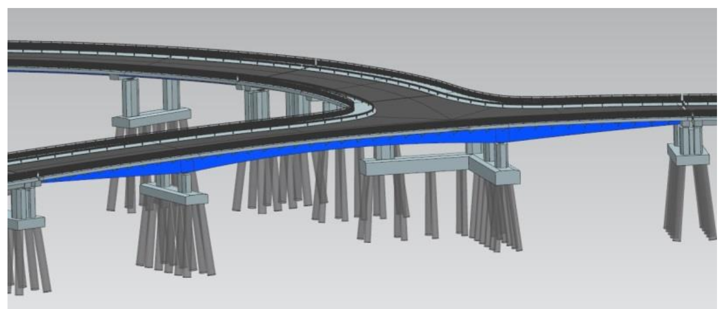
TH Köln





BIM in Bridge Design – 3D-Modeling, Design Embedded FE-Simulation and Drawings, A large scale project in Hamburg´s Port Area

Markus Nöldgen, Cologne University of Applied Sciences, TH Köln
Andreas Bach, Schüßler-Plan Ingenieurgesellschaft mbH, Düsseldorf

Agenda

1 **Project**

2 3D-Modeling

3 (Semantic) Data Integration

4 Design Embedded 2D/3D-Drawings

5 Design Embedded 3D-FE-Simulation

6 Conclusions and Discussion

Project – Flyover with Intersection in a Port Area

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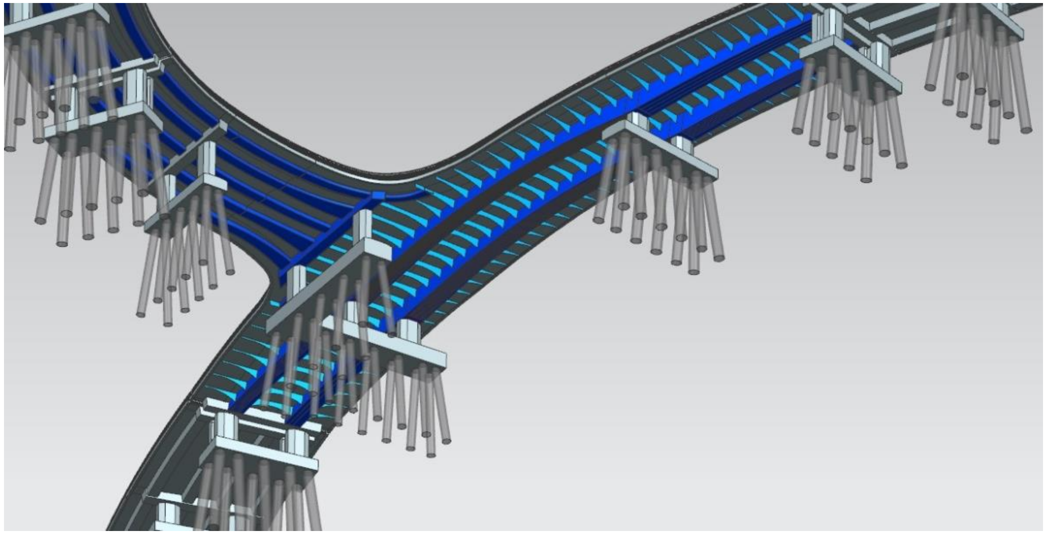
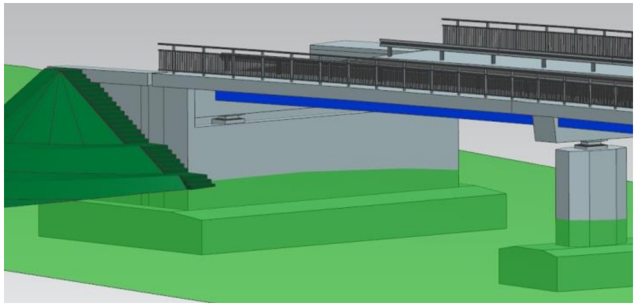
Project name
Flyover Road Crossing in a Port Area
Lifecycle classification
Draft Design, LoD200/300, Technical Drawings, Structural FE-Simulations
Project-phases with BIM/5D methods/technologies
Draft Design, Derived standardized drawings and Finite-Element Simulation
The measurable benefit founded in these methods
Improvements in change management (Adaptability, Associativity)
Improvements in FE-Simulation techniques (design embedded, effort reduction, automation in pre-processing)
Improvements in model, drawing and simulation coincidence (major increase in quality!)
Difficulties as a result of the use of BIM/5D methods and chosen solutions
Find new 2D and 3D drafting techniques
Close GAPs in interfaces BIM2FEM
Increase relevance of BIM in infrastructure projects

Project – Important Structural Characteristics





T-interchange bridge structure – 3D-Modeling

- Bridge deck variability
- Geometrically complex deck and superstructure (double curved)
- 3 fields with pre-stressed girders + composite girders at intersection
- Long structure (∑~1km bridge deck)

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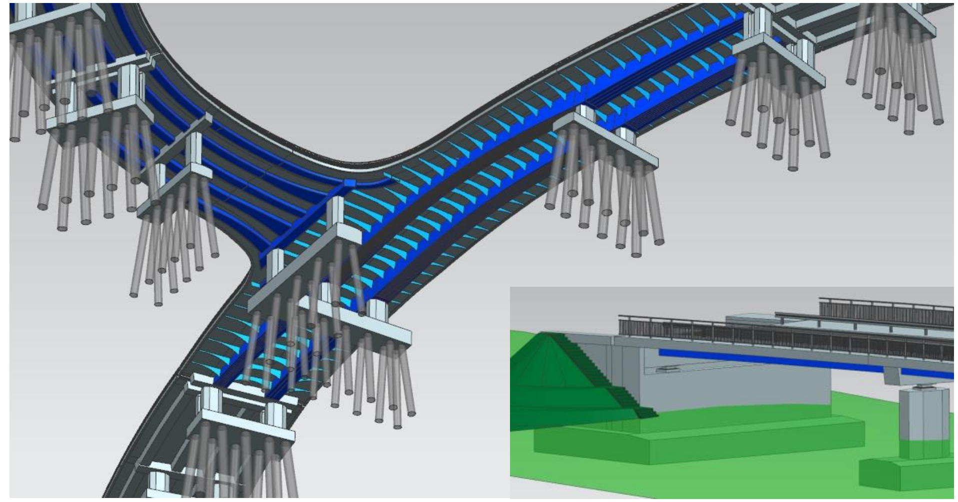
Prestressed RC-Structure at intersection with entlargement into RC-steel composite girders at junction



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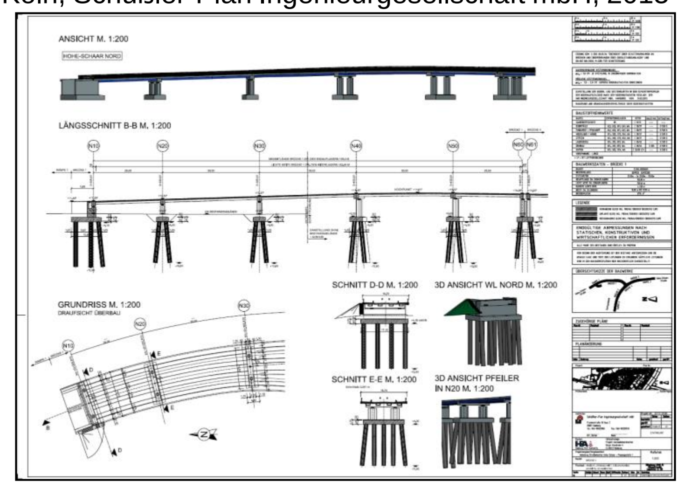
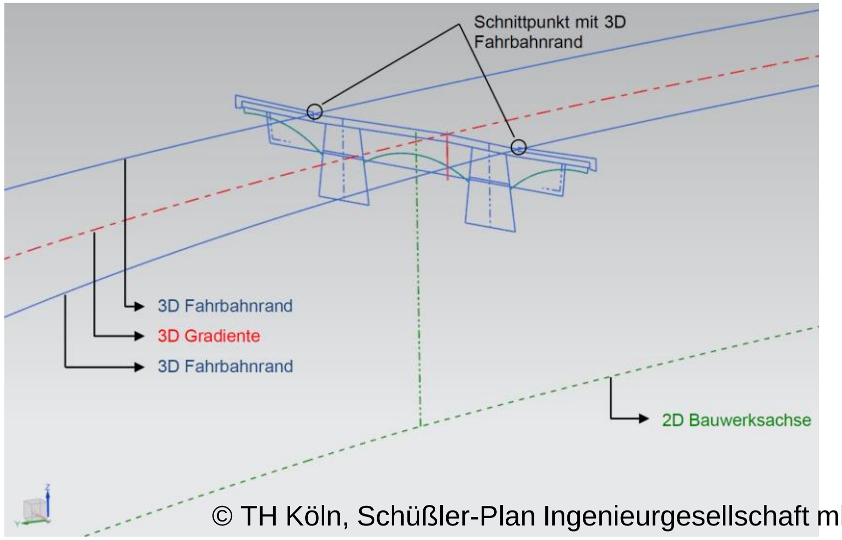
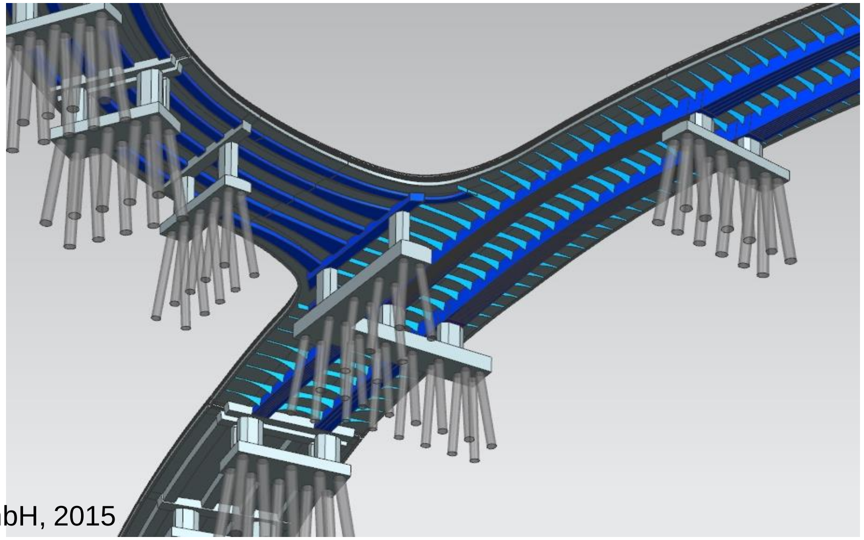


- **Design using 4 independent space curves (splines)**
- **Variable extrude (sweep)**
- **Coupling of intersecting free form surfaces and curves**
- **Top-Down-Modelling for adaptive variation studies**
- **Drawings generated according to design standards**

Parametric Controling



Top-Down-Modelling



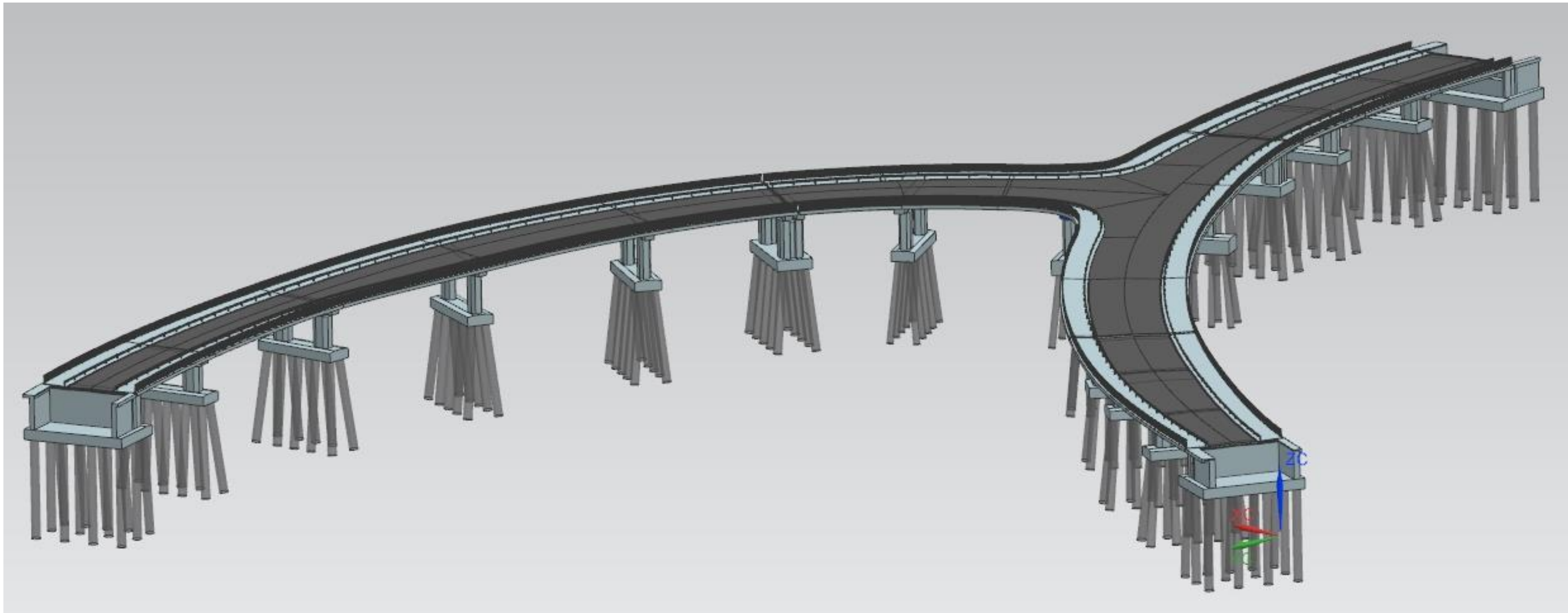
Parametric Controling

- Parametric Cross-Section
- Guide curve
- Constraint surfaces

Sweep along alignments

- Variable extrusion → B-REP
- Boolean operation with freeform bodies

Accuracy of curves and model



- Alignments are approximated by **N**on-**U**niform-**R**ational-**B**-**S**plines
- **Splines transition constraints:** G0–„common point“, G1–„common tangents“, G2–„common curvature“
- **The Quality of the Model is determined by the quality of the curves**

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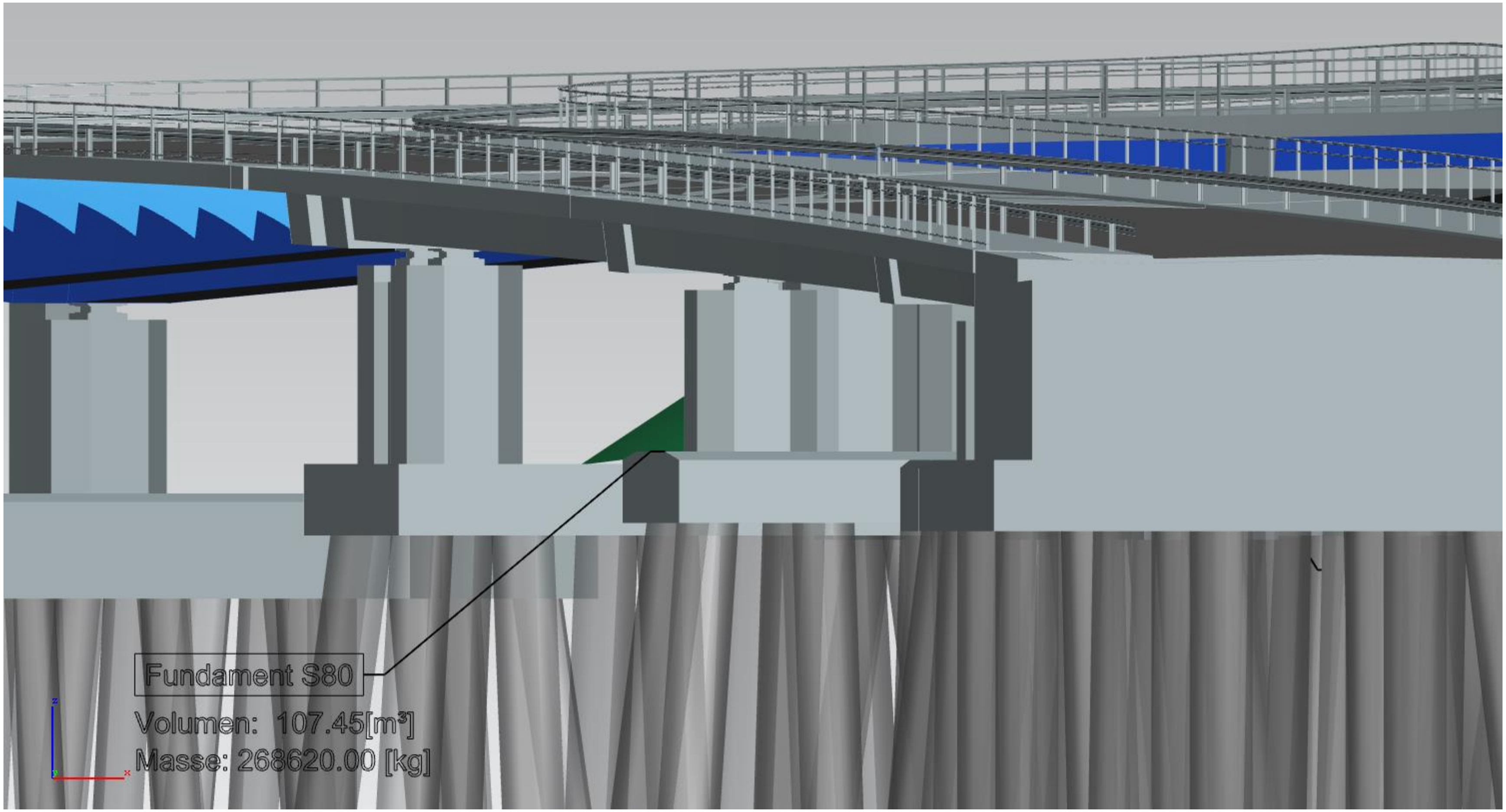
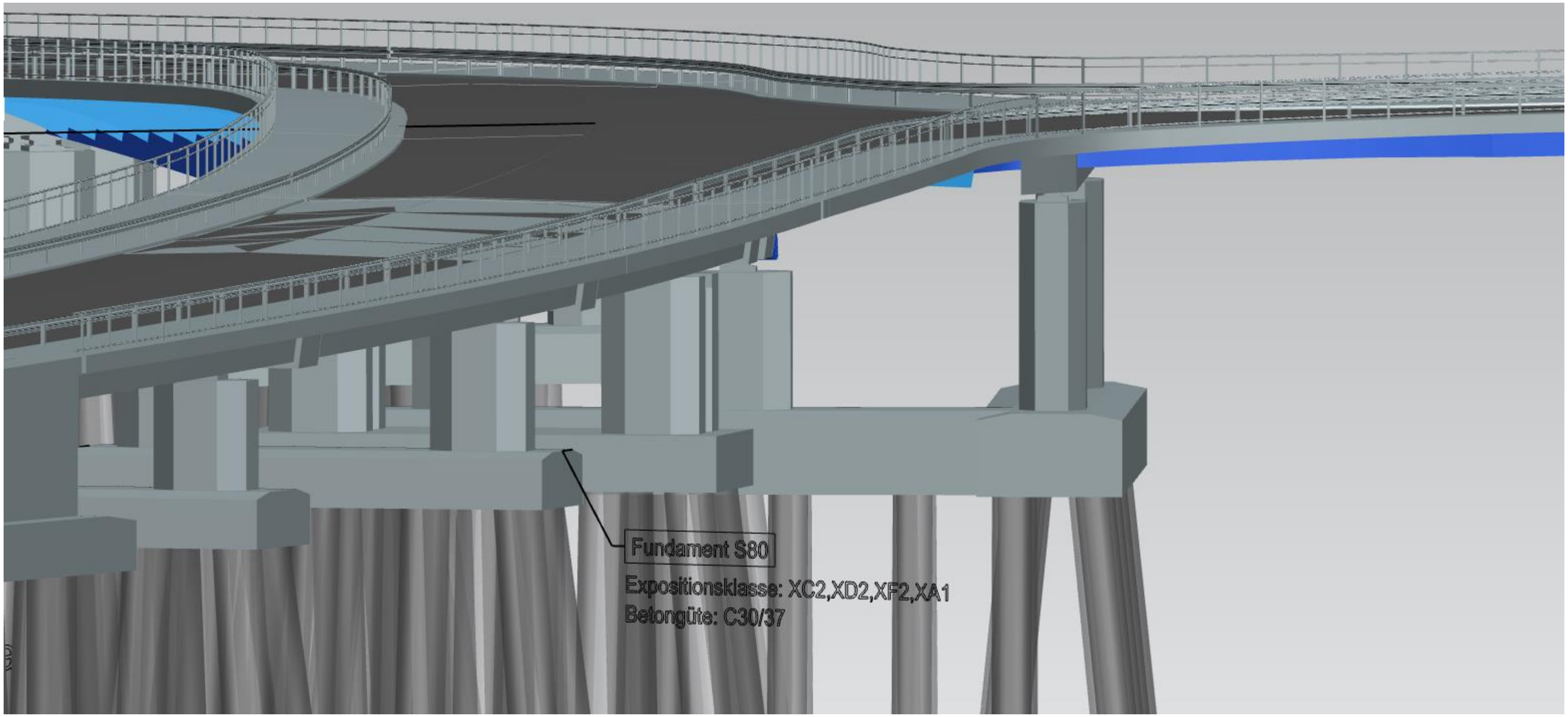
Important measurements are associatively calculated and visualised



Measurements are associciatively calculated, stored and integrated as PMI within construction modell (PMI: Product Manufacturing Information)

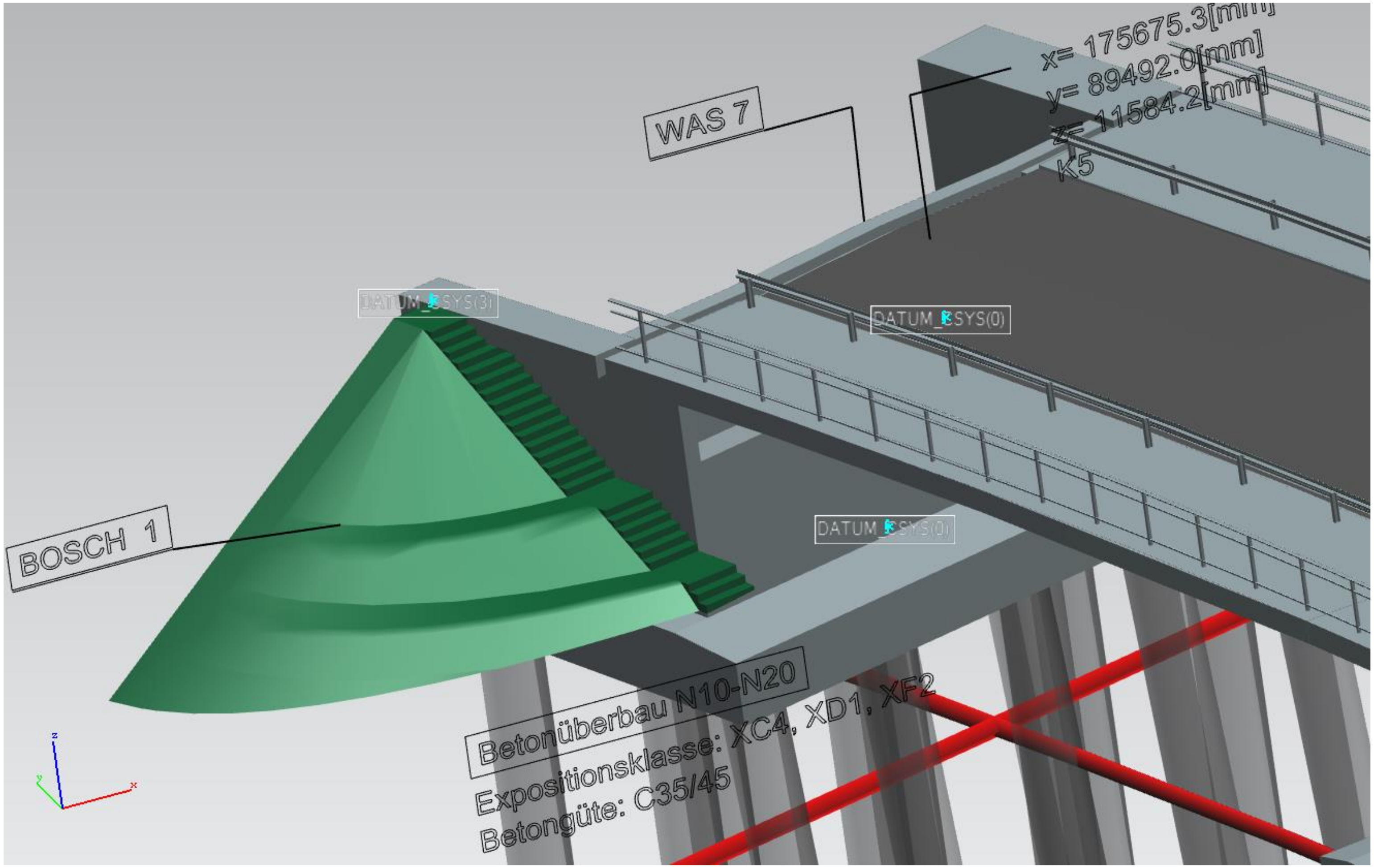
Important attributes are associated and visualized



Informations (attributes) of construction modell are saved as PMI and visualised.

Here exemplaric as foundation in axis S80.

Important attributes are associated and visualized



Standardised description, coordinates of important bridge points, attributes

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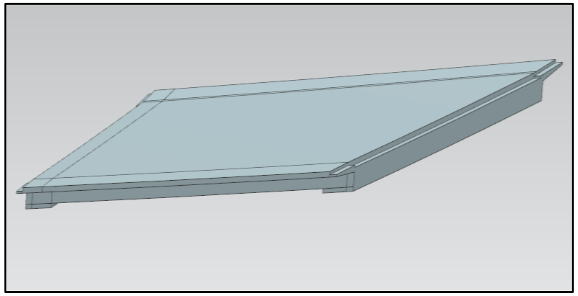
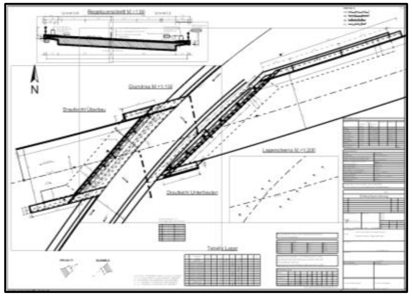
Master-Model-Concept

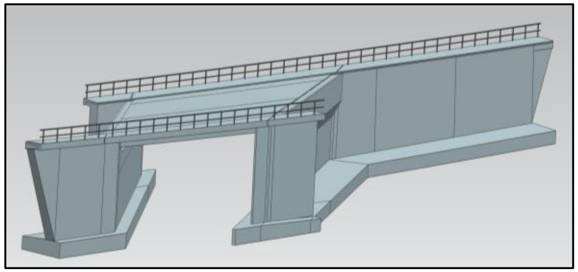
Master-Model



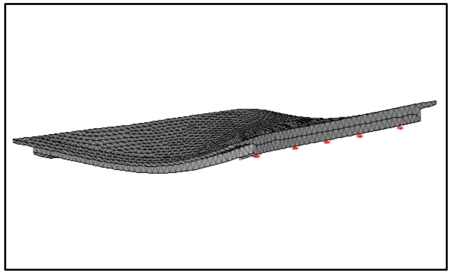
Drawing



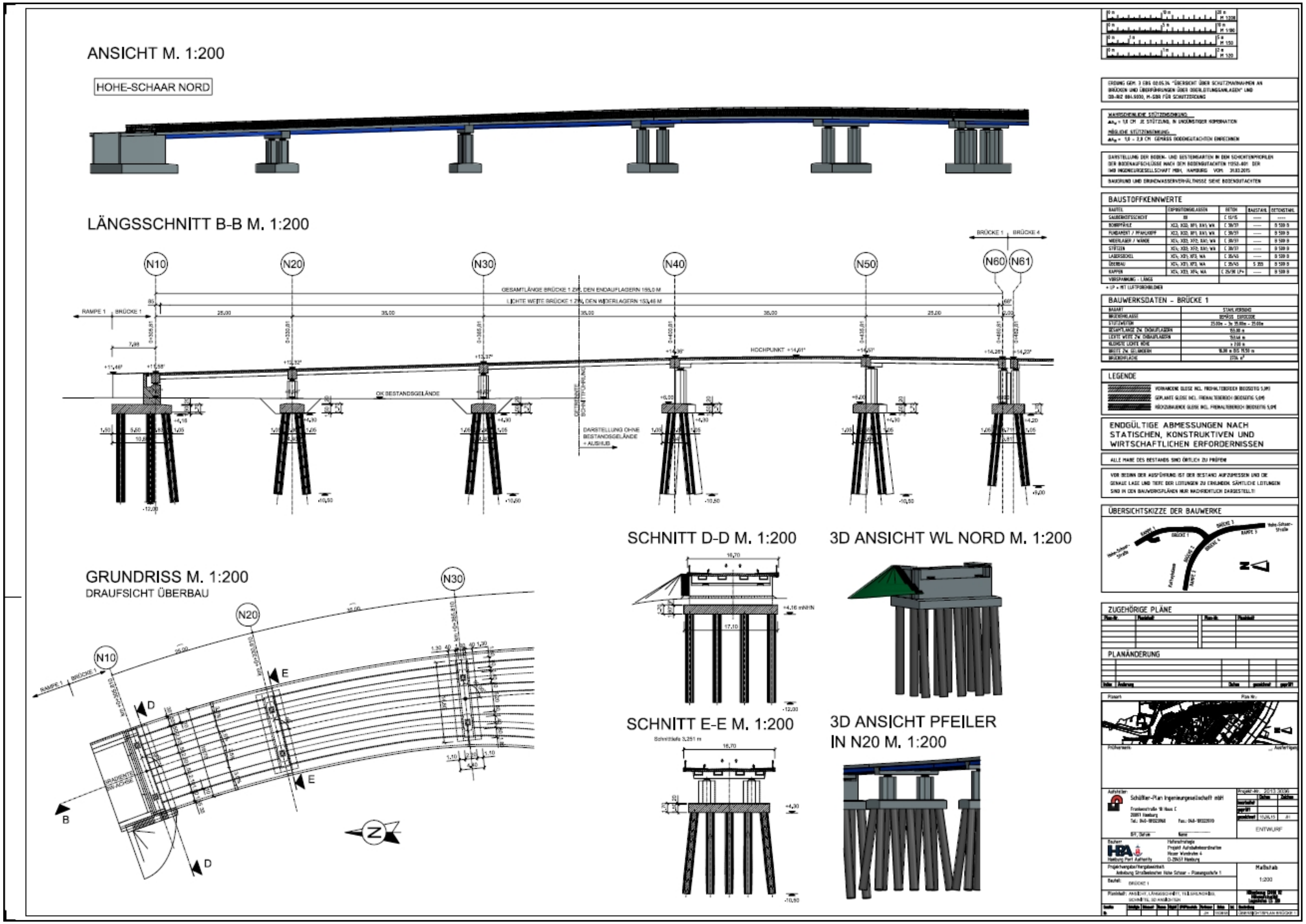
Assembly



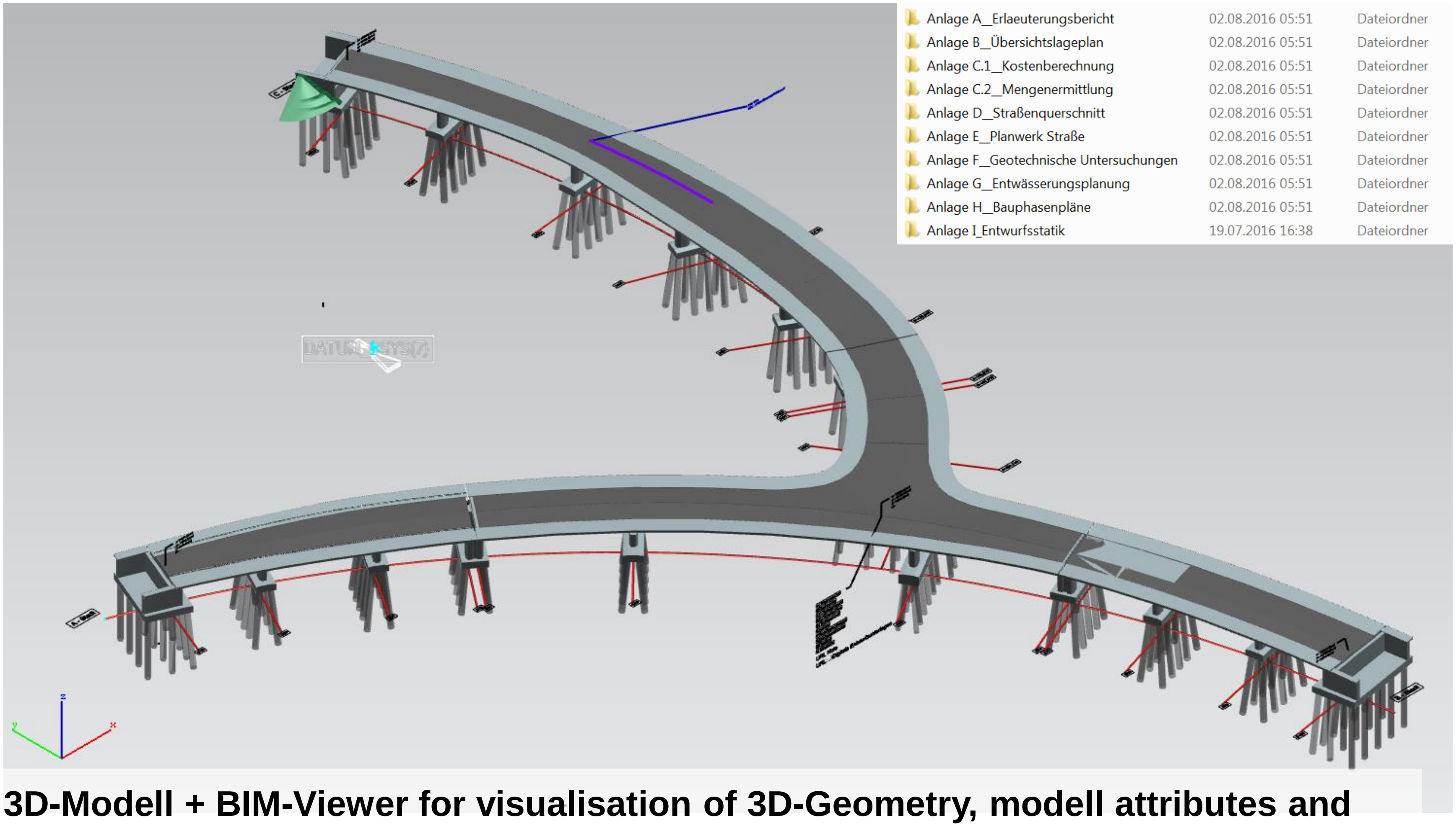
FE-Analysis



Drawings derived from 3D-Model



Digital Draft Design – BIM- Construction Modell 2017



3D-Modell + BIM-Viewer for visualisation of 3D-Geometry, modell attributes and access of linked database for additional informations (documents, drawings …)

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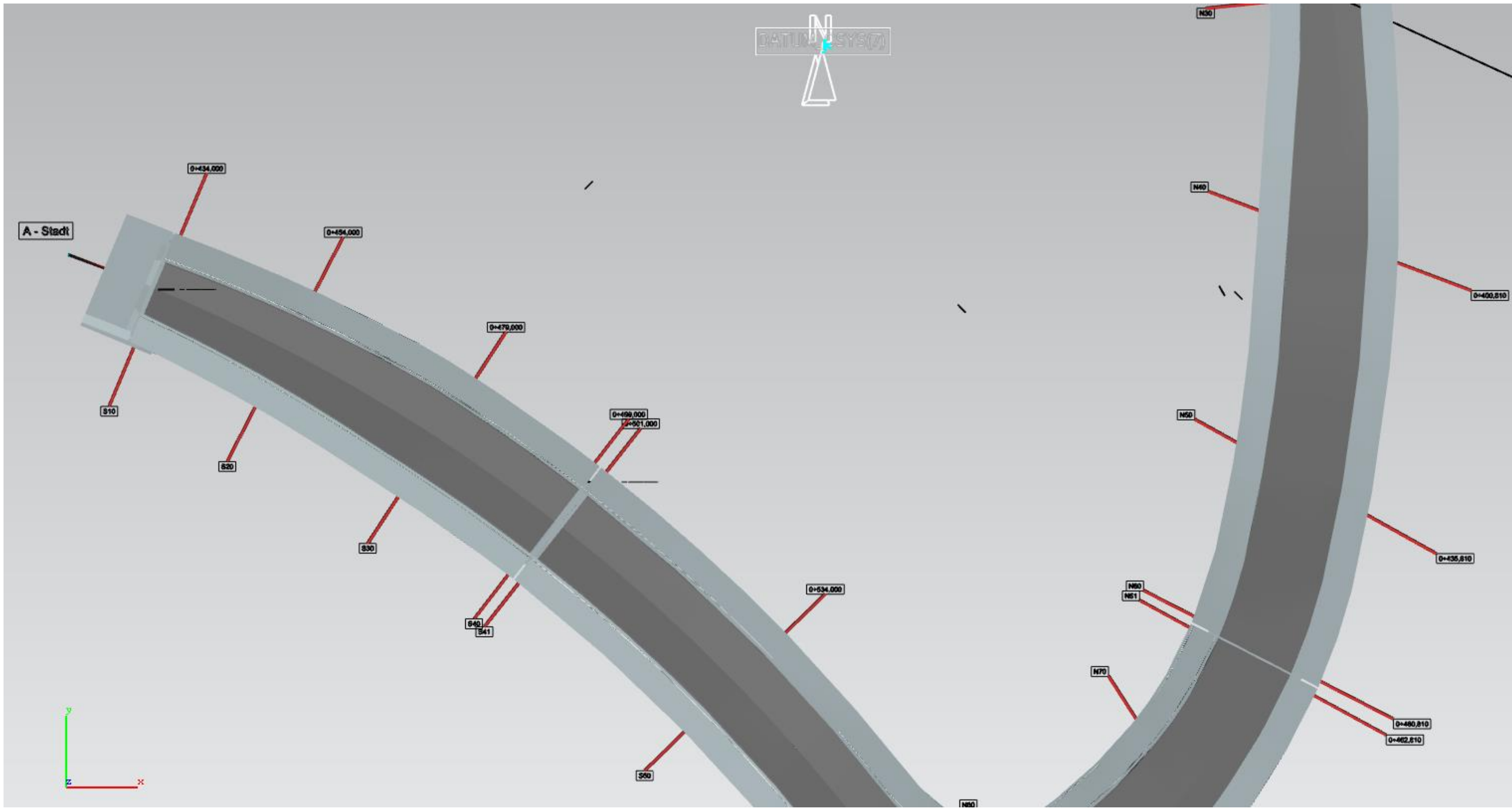
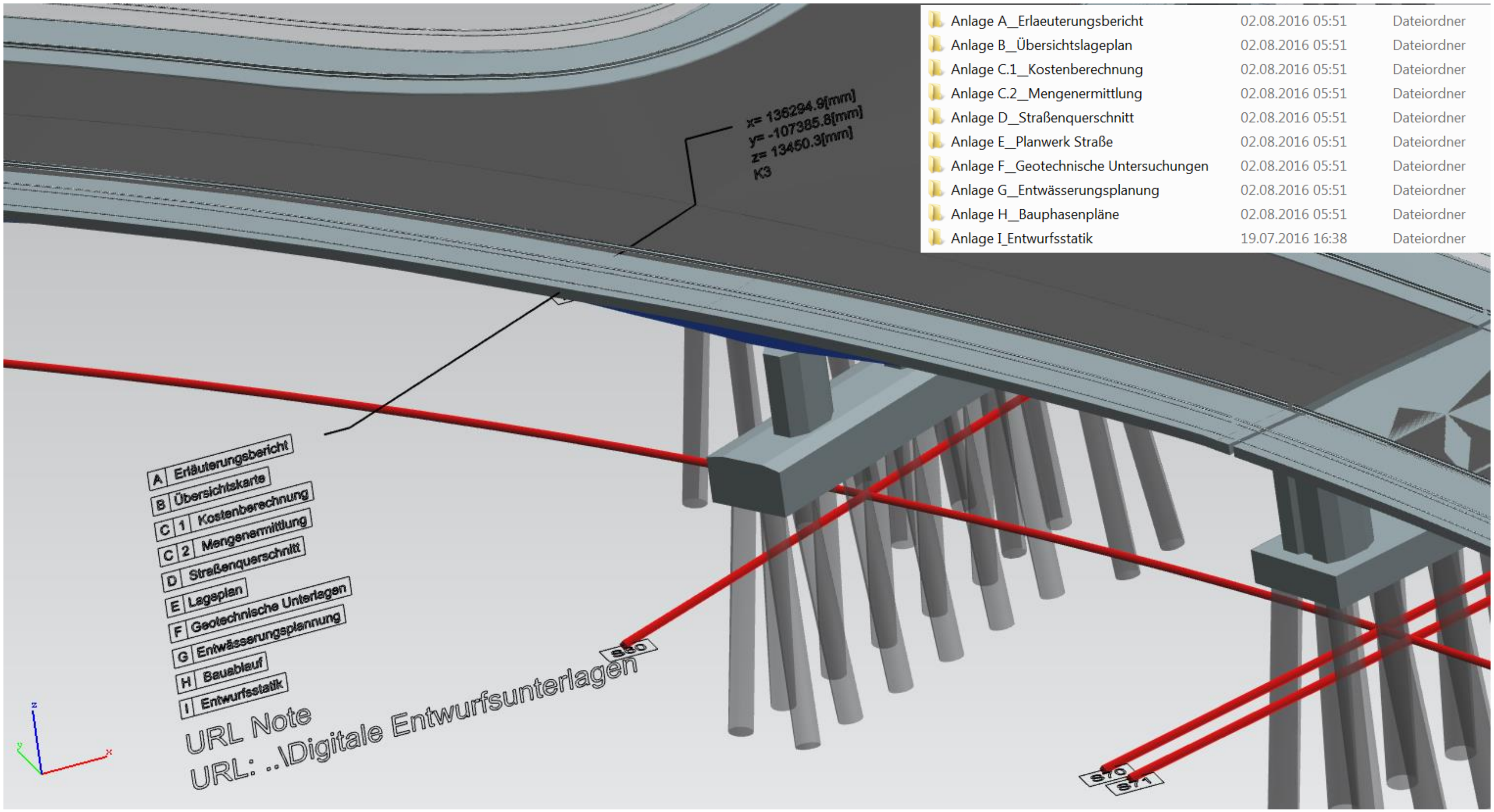
Modellinformation for Overview and Patterning



3D-Modell includes and visualizes:

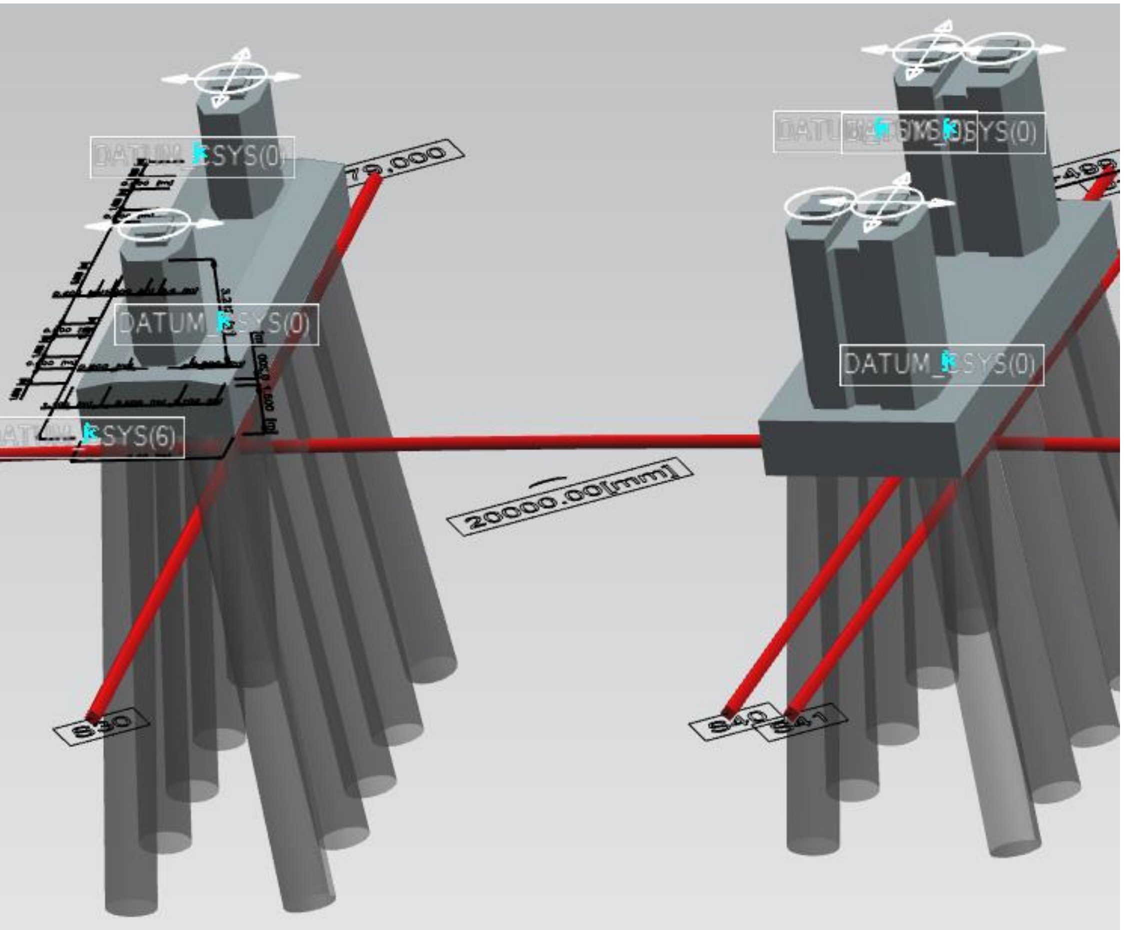
Street routing , main axes, north arrow, Reference point

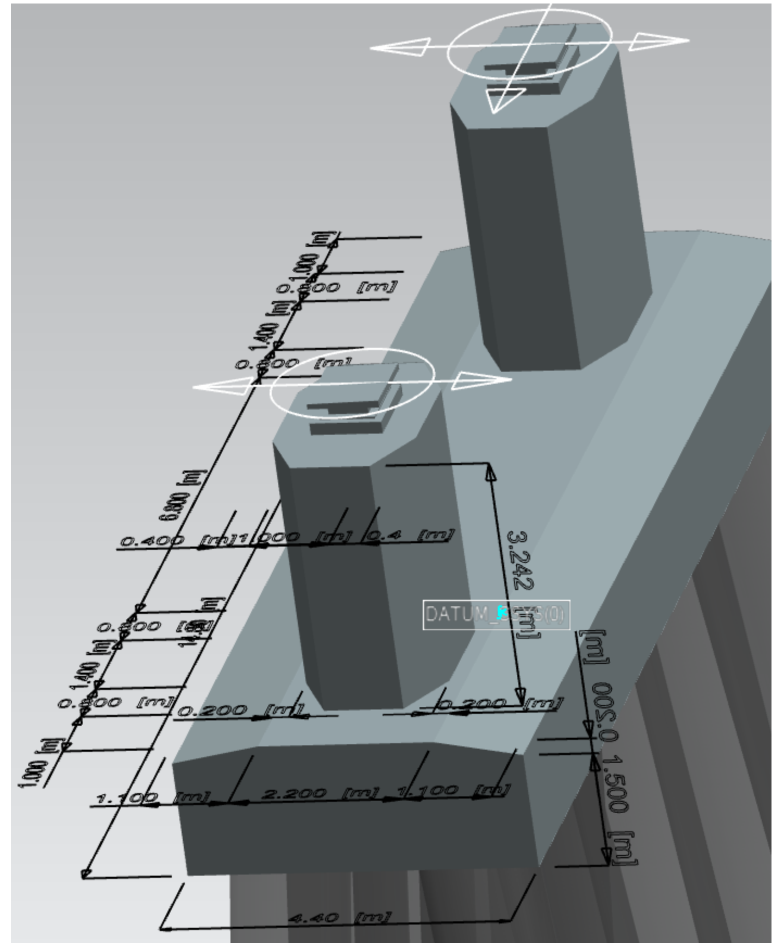
Link of Data Base using URLs



Structure of final draft design is integrated within modell and linked to database using URLs

Important callouts are integrated and visualized

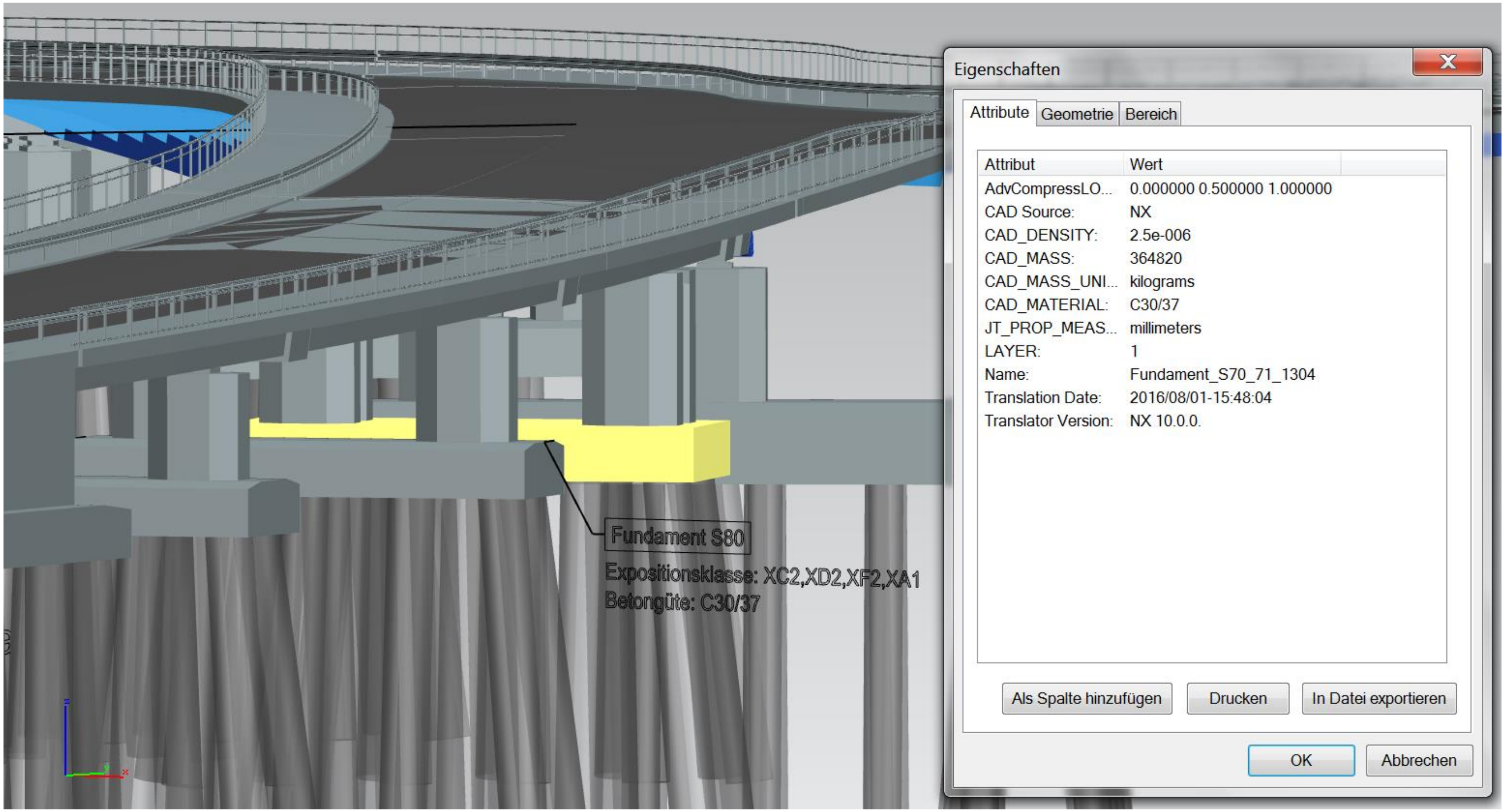




Left: Bearing Symbols, Span length

Right: Dimensions, i.E. Pier

How Interactive is the modell?



Informations (Attributes) can be directly derived from context menu an be exported, measurements within .jt-Modell are possible

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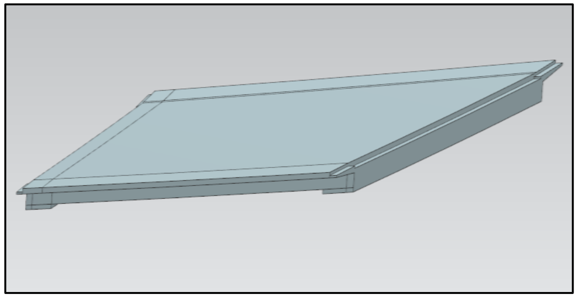
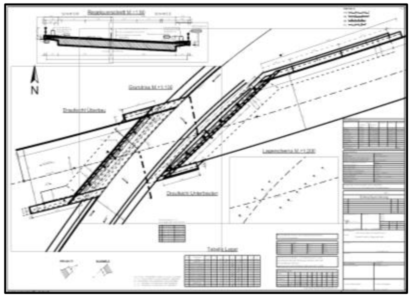
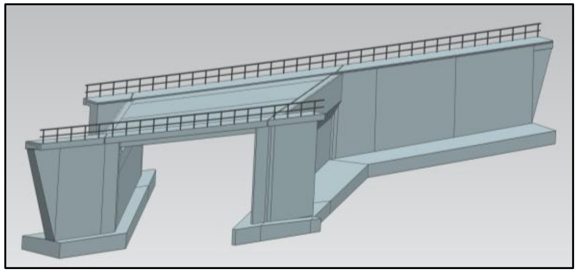
Master-Model



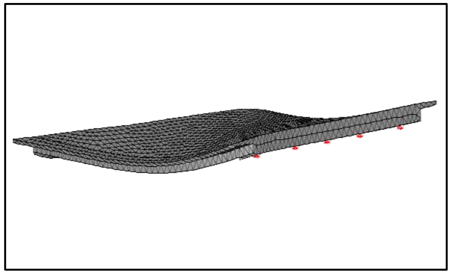
Drawing



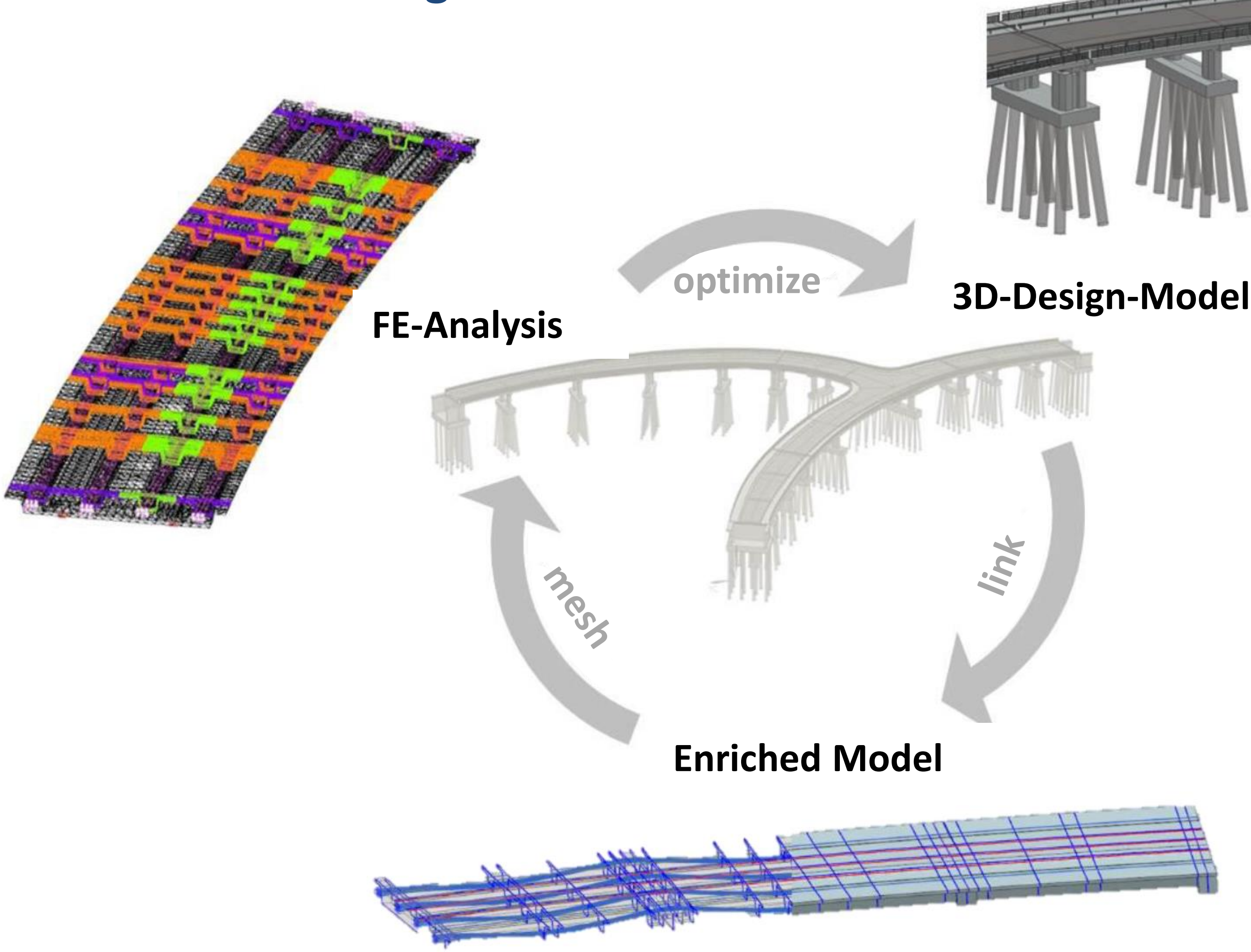
Assembly



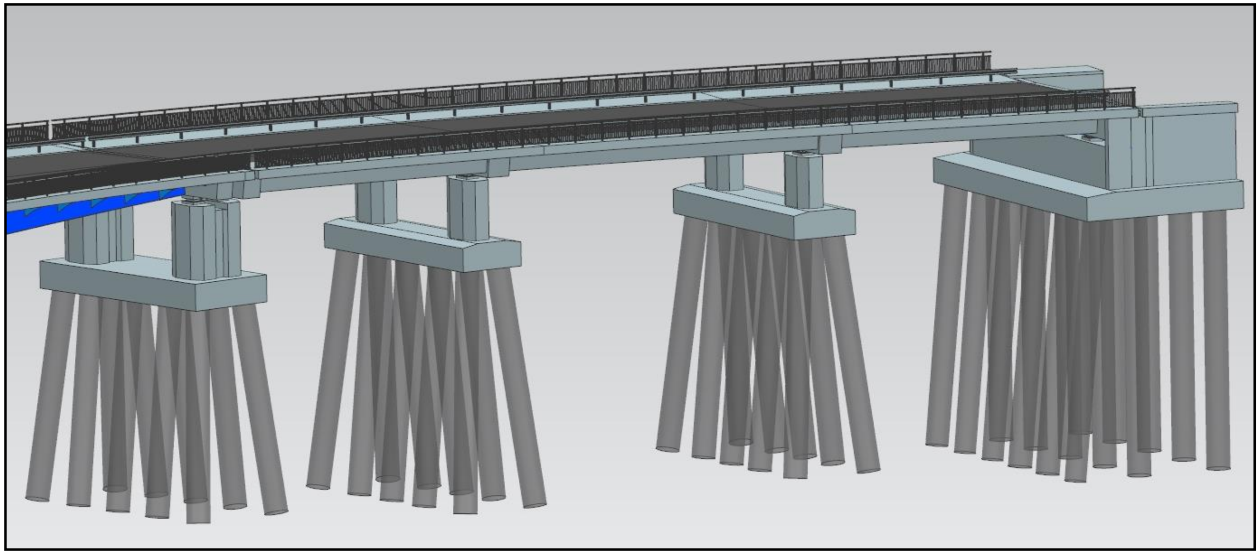
FE-Analysis



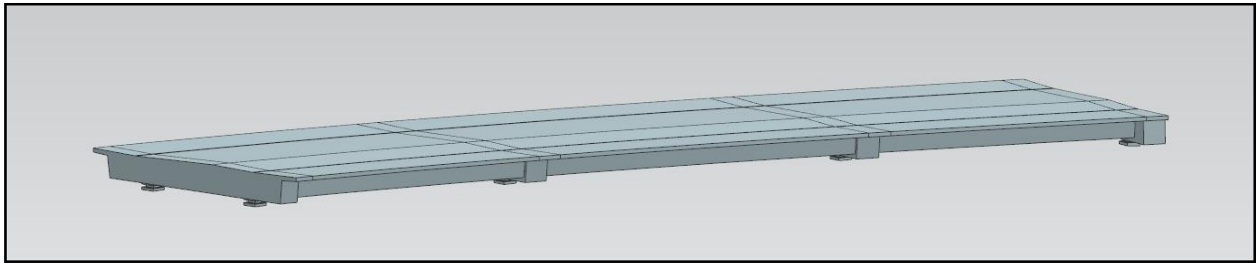
BIM2FEM – Design Embedded Simulation



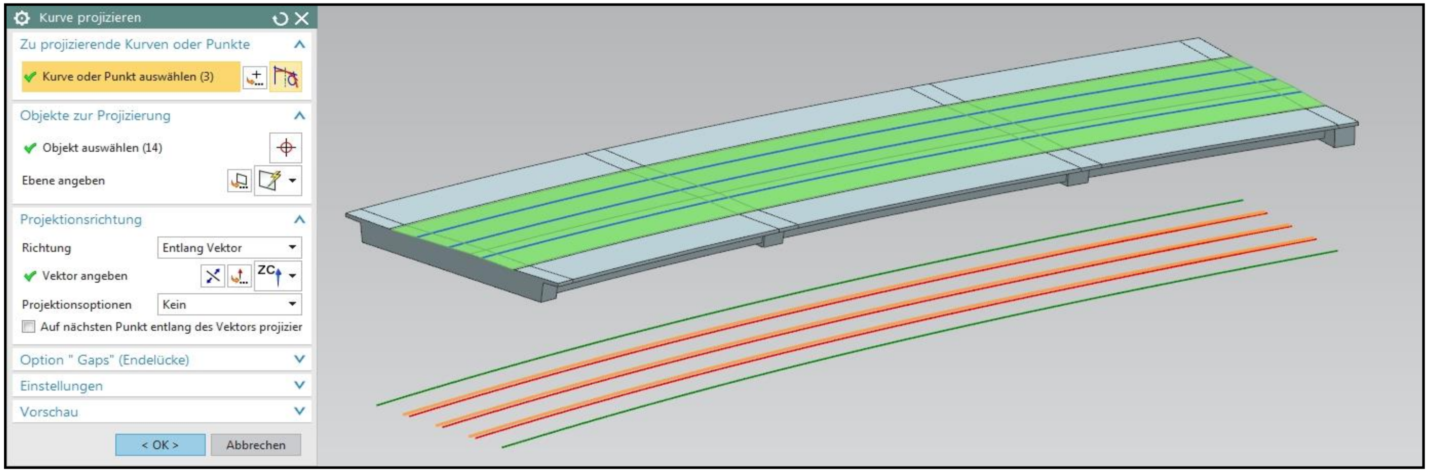
Design of a three-span prestressed bridge



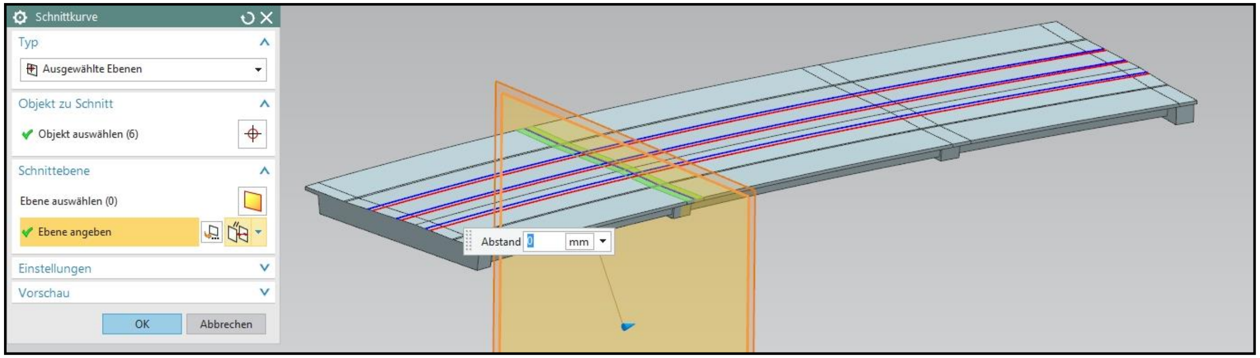
Calculation Model of the superstructure: geometrical constraints



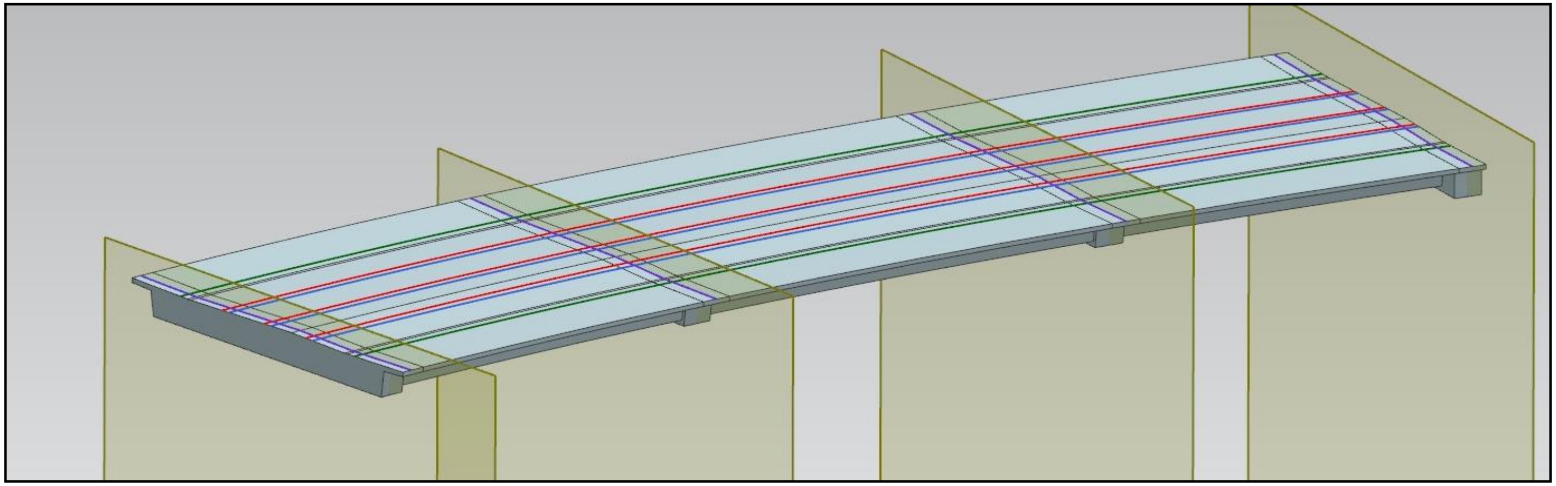
Traffic lanes in projection on the bridge deck, cut in surface



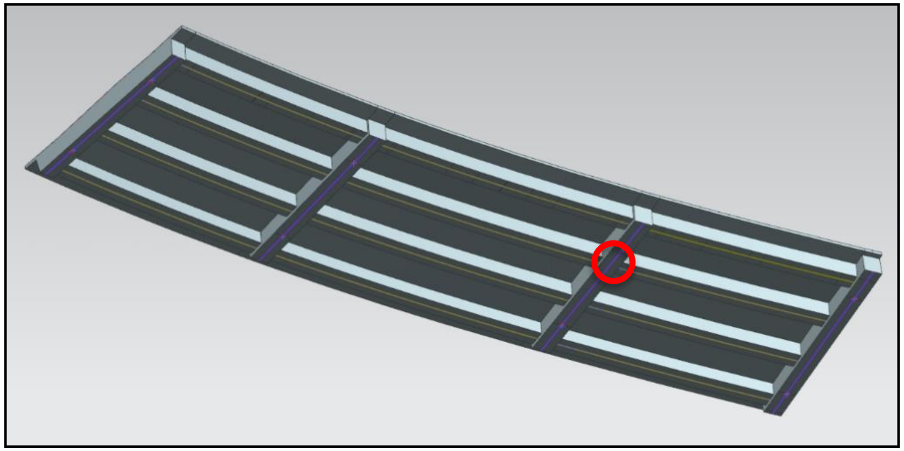
Cross section girder axis cut in surface



Main axis cut in surface to define fieldwise loaded areas

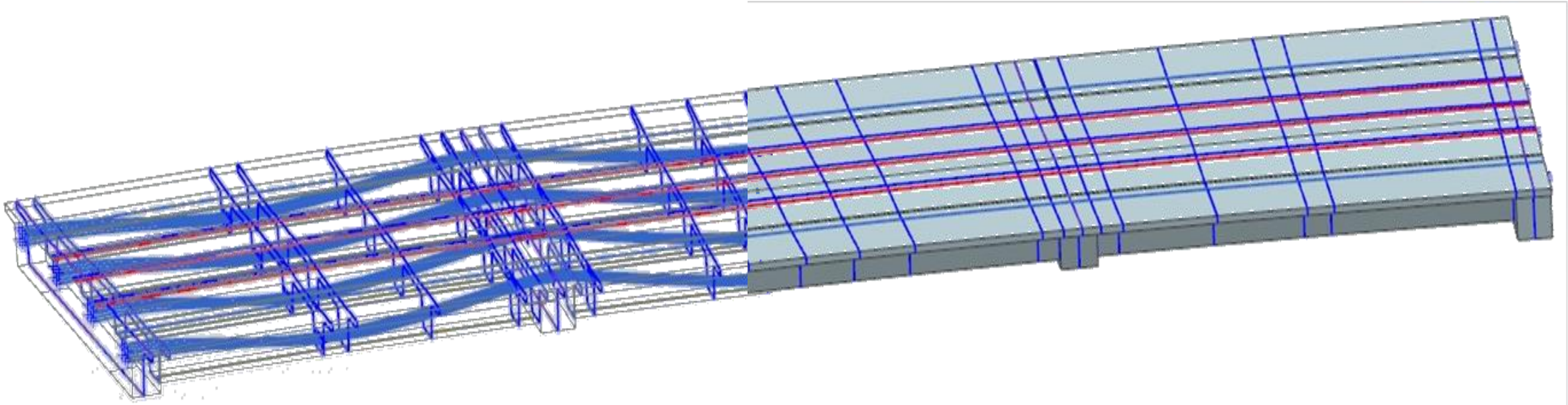


Positioning of points for support reactions



Calculation model: geometric and static constraints

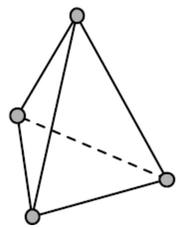
Summary:



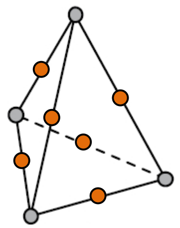
Finite-Element-Discretization:

4-Node versus 10-Node Tetrahedron-Elements

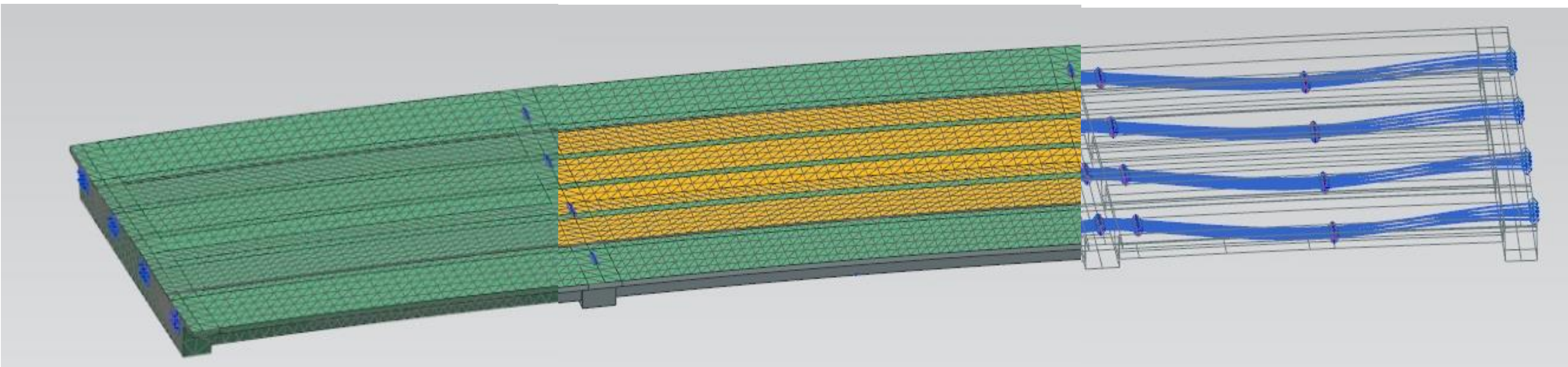
Linear form function



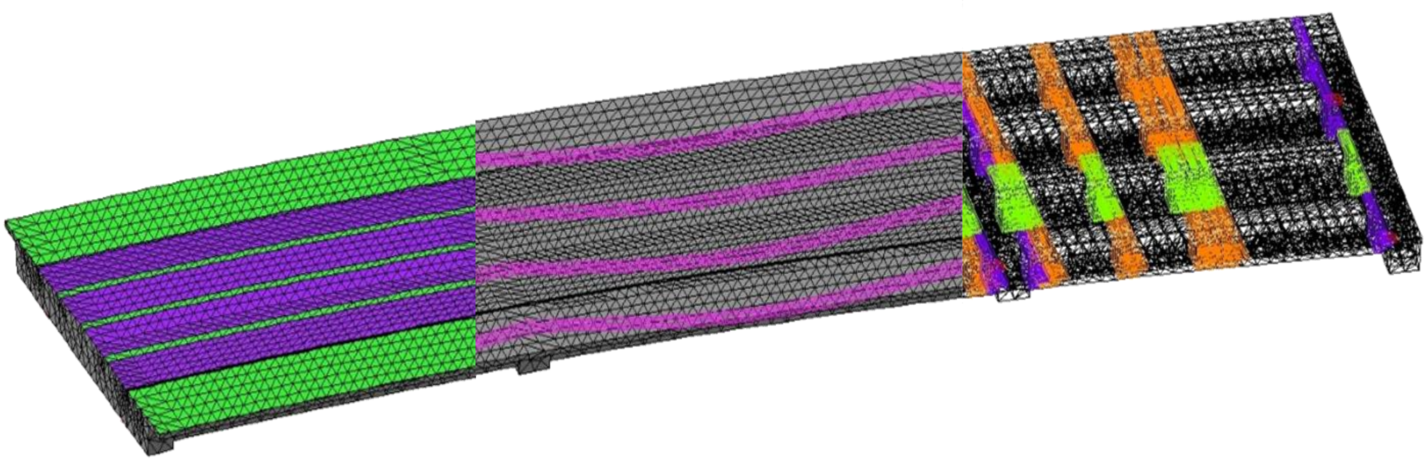
Quadratic form function



Solid – Tetrahedron | **Surface Bridge Deck – Shell** | **Tendons - Splines**



Load Surfaces | **Spline in Element** | **Integration objects**



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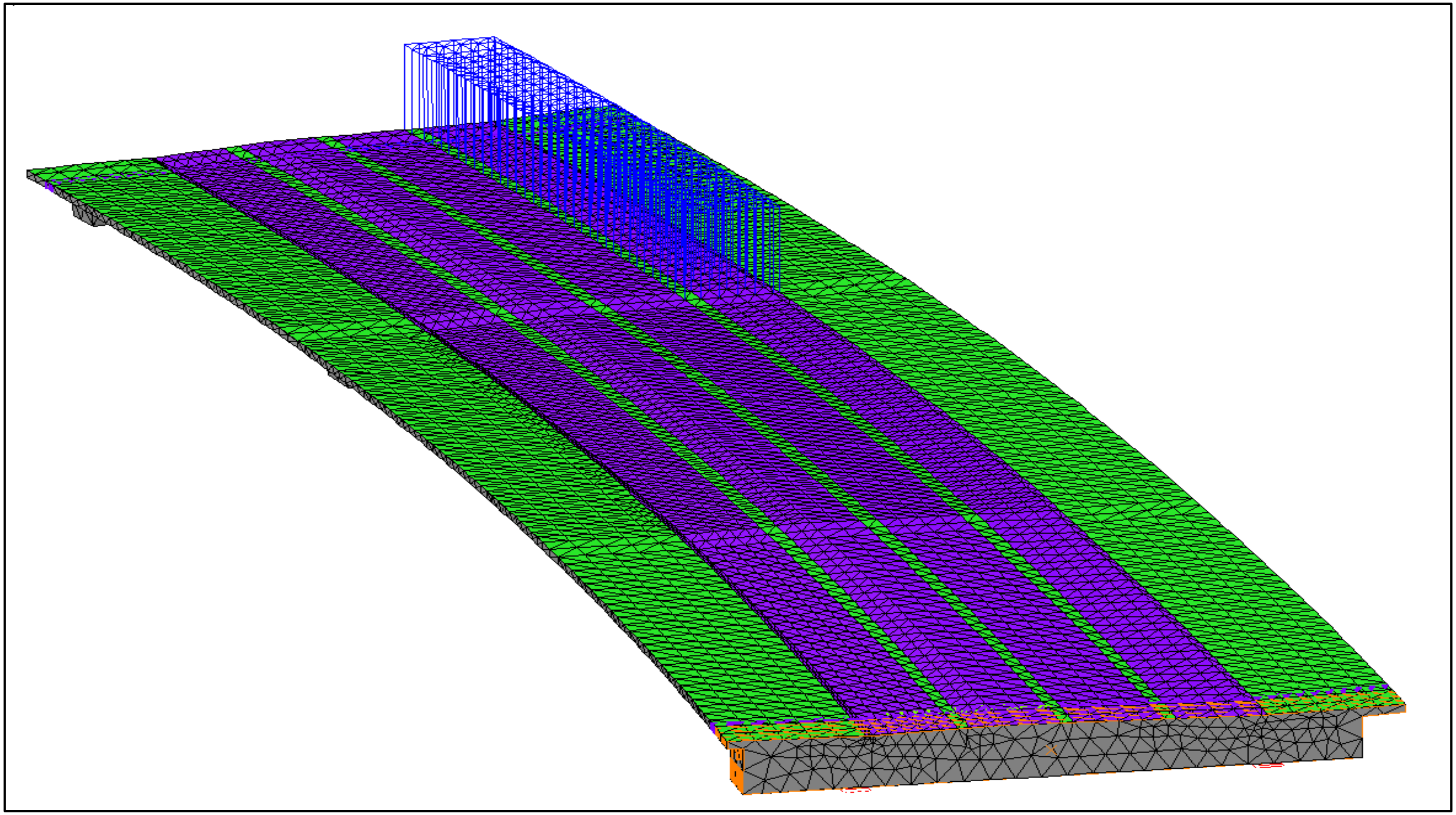
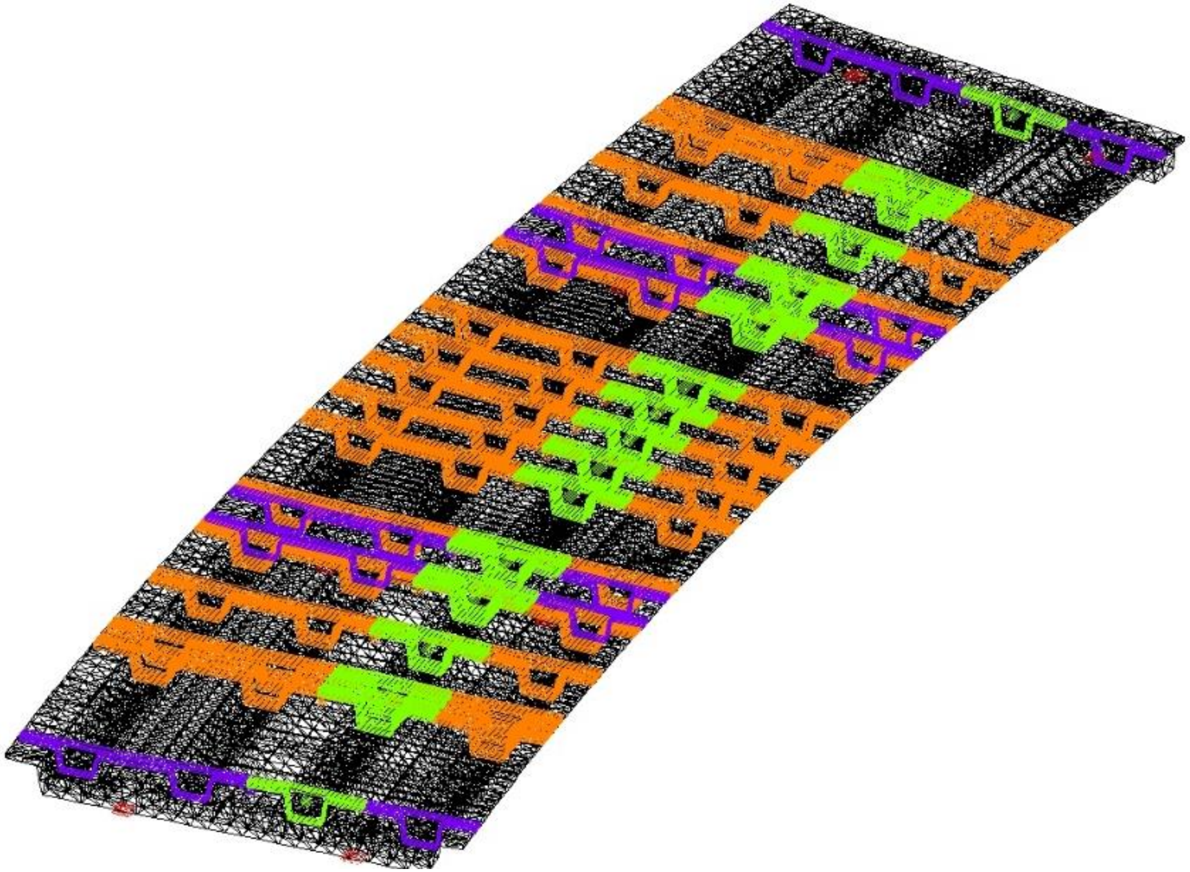
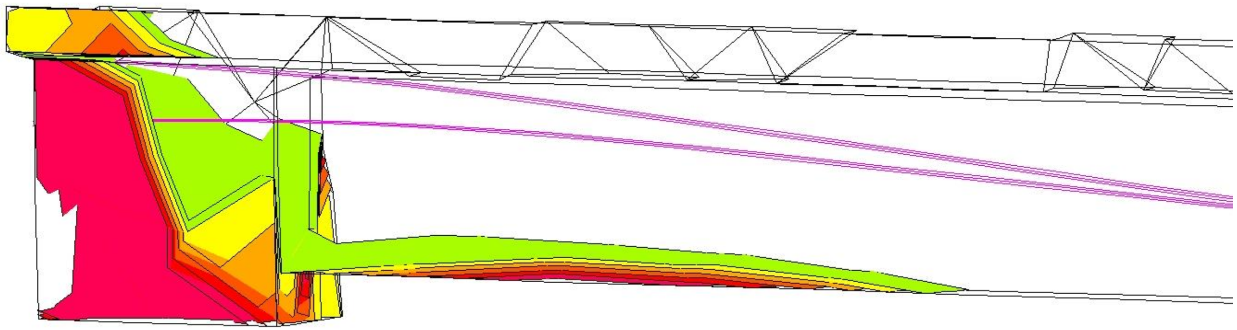
Fieldwise loading onto double-curved bridge deck



Integration objects, controlling girder, whole cross section



Local tensile stresses in longitudinal direction - Decompression



Agenda

Conclusions

- **More work in the beginning**
- **Quality improvements (3D avoids gaps, failures, allows for measurements, semantic data integration…)**
- **More Flexibility and Automated Work (e.g. alignment change)**
- **Referenced and Automated Drawings; Augmented Reality with PMI, Attributes, Measurements**
- **Referenced FEA as Design Embedded Simulation**

  - **Coincidence of 3D-Model, Drawings and FEA**
  - **Coherent set of data, updating and optimization**