
iBIMi
buildingSMART
Italy

IFC Bridge Italian Working group

Phase1 Report

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Objectives of the Workgroup

The members of the WG did not participate in the IFC Bridge project, but they have joined the working group to understand the standard, implement it, use it, and extend it where necessary.

The objectives of the WG are:

- **Analyze and understand the standard proposed by IFC Bridge**
- **Test the application of the standard to some of the bridge types that were not verified by the International Project**
- **Identify deficiencies, solutions and possible additions to the standard**
- **Report the results of these activities to the international community**

Methodology

1. Study and understanding of the standard and the new entities proposed by IFC Bridge
2. Identification of two case studies (two bridges) and related use cases to be tested

preliminary phase

3. Recognition of IFC elements for the two case studies
4. Drafting of a modelling plan to meet the use cases
5. Modelling of the two bridges with different software
6. Mapping towards the IFC standard

classification phase

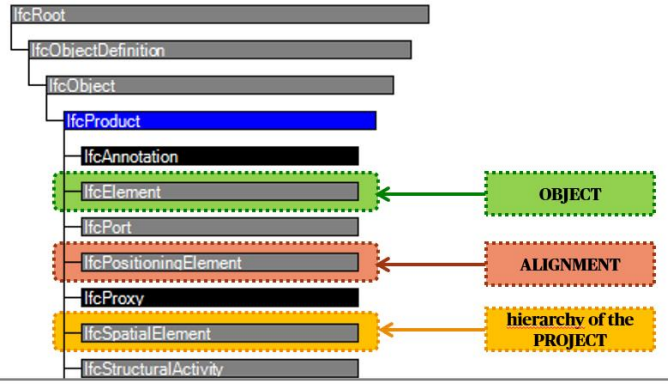
7. Production of a report that formalizes and measures the problems found and the solutions proposed

report phase

Study and understanding IFC Bridge 4.2

ifcBridge

IfcStandard - information exchange **IfcProduct**



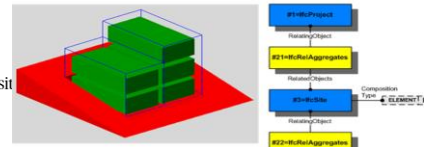
ifcBridge-Italia

IfcStandard - scambio informativo

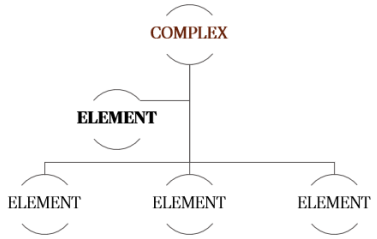
The subtypes of IfcSpatialStructureElement relate to each other by using the IfcRelAggregates relationship to build the project spatial structure.

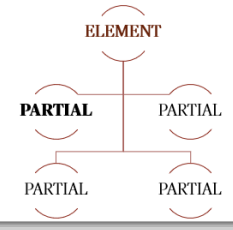
IfcElementCompositionEnum	
Constant	Description
COMPLEX	A group or aggregation of similar elements.
ELEMENT	An (undivided) element itself.
PARTIAL	A sub-element or part.

This enumeration indicates the composit of a spatial structure element or proxy.



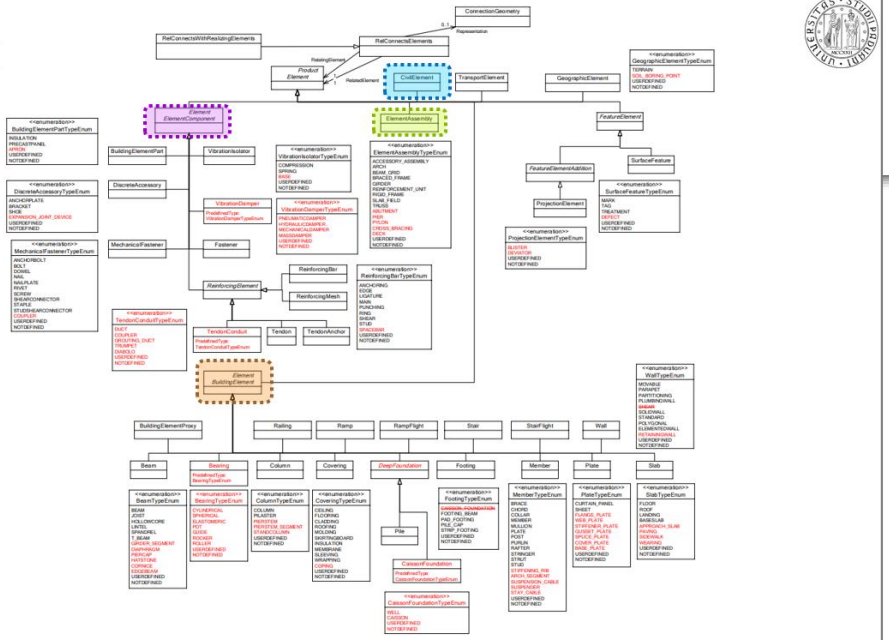
By using the inverse relationship IfcBridgePart.IsDecomposedBy it references IfcBridgePart through IfcRelAggregates.RelatedObjects.
If it refers to another instance of IfcBridgePart, the referenced IfcBridgePart needs to have a different and lower CompositionType, i.e. ELEMENT (if the other IfcBridgePart has COMPLEX), or PARTIAL (if the other IfcBridgePart has ELEMENT)





ifcBridge-Italia

IfcStandard - scambio informativo



IFC Candidate Standard 4.2

Main features:

- **Minimized** the number of new entities
- Added new **enum** to the existing classes
- Defined a new **Spatial Structure** to capture an Infrastructure project organisation

The standard development was tested basically on **girder bridges**

FEW NEW ENTITIES

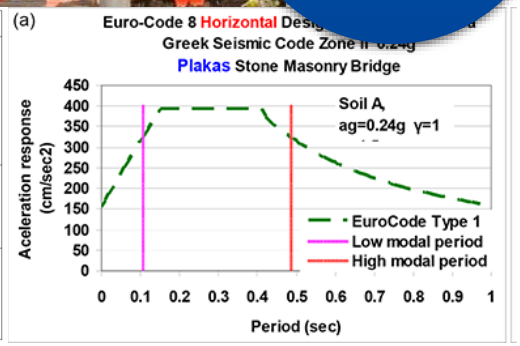
NEW ENUM

NEW SPATIAL STRUCTURE

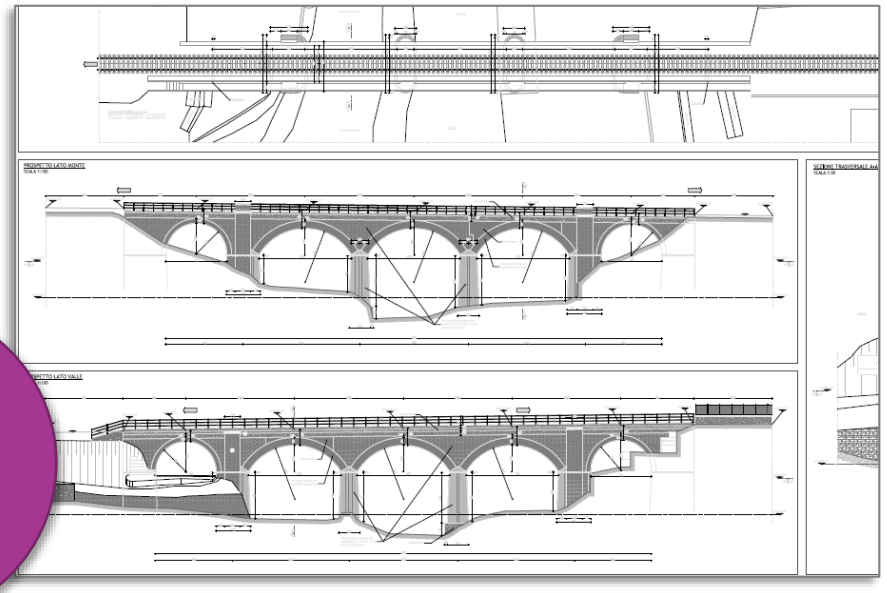
Identification of two case studies and use cases

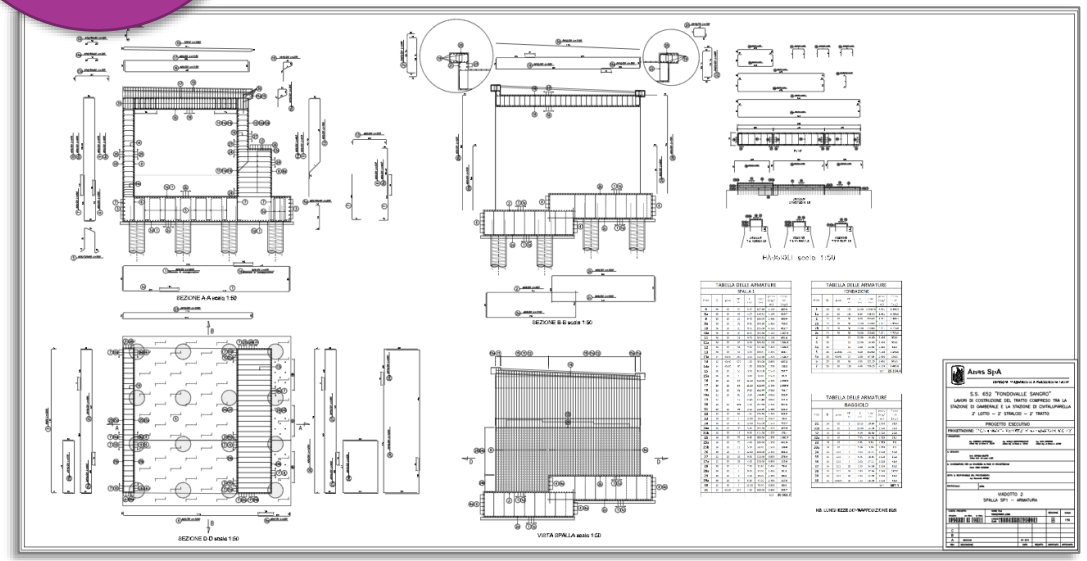
ITALIAN SCENARIO

No	Use case	Description	Purpose	IFC exchange scenario	Required geometry representation	Required semantic information	Priority	Complexity	MVD
12	Design-to-Design (full model logic)	Exchange of fully parametric description of bridge between two distinct design applications	within the same design phase, design models are exchanged between different design applications, model remains fully modifiable, all model logic is transferred	Design application to design application	Advanced BRep (NURBS), Fully parametric model information containing model logic, constraints and dependencies	All information entered in the design application	medium	high	Bridge Design Transfer View
13	Design-to-Construction	Handover from Design Phase to Construction Phase	Bridge Model is handed over from designer to Contractor for bidding and for actual construction	Design application to Tendering application and/or Review application	Faceted BRep, Sweep Geometry where suitable (Deck, Rebar, Boring Piles etc), potentially based on alignment	Material information Product information etc.	high	medium	Alignment-based Bridge Reference View
14	Structural Analysis incl. Structural Dynamics, Fluid-Structure Interaction, etc.	Structural analysis of bridges, tunnels, retaining walls	Ensure stability of the structures	Design application to structural analysis application	Procedural Description (Sweep and CSG) and/or Analytical Model	Loads, Material properties	medium	medium - high	Bridge Structural View



COMMON BRIDGES

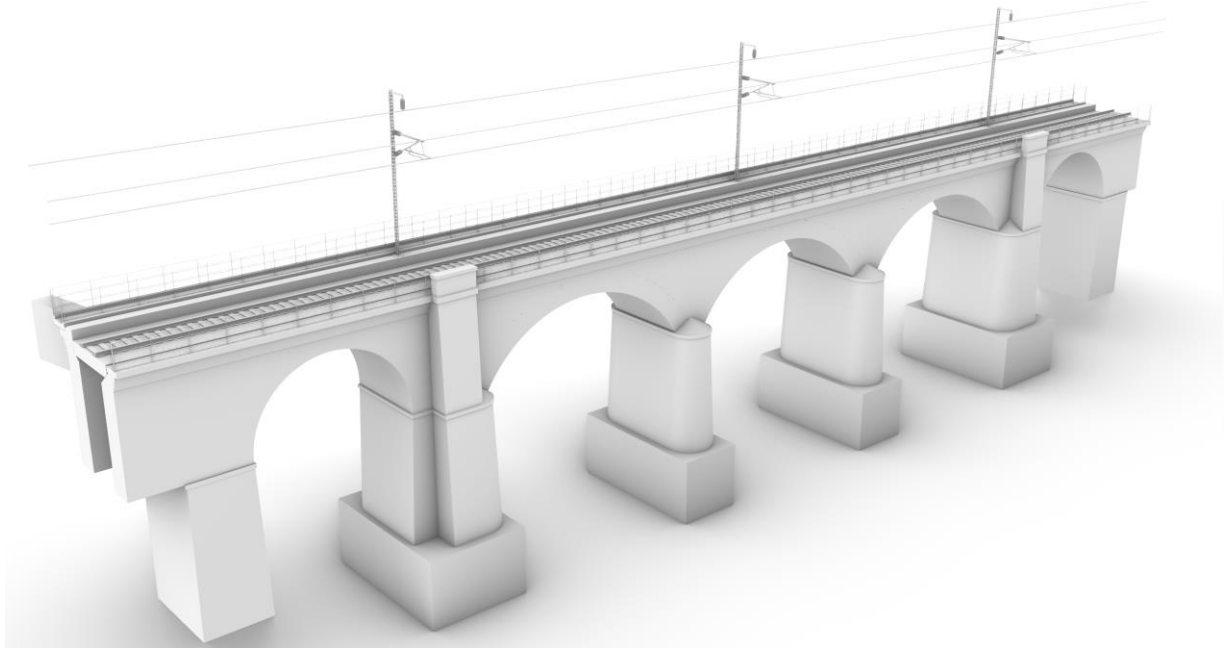




Case studies

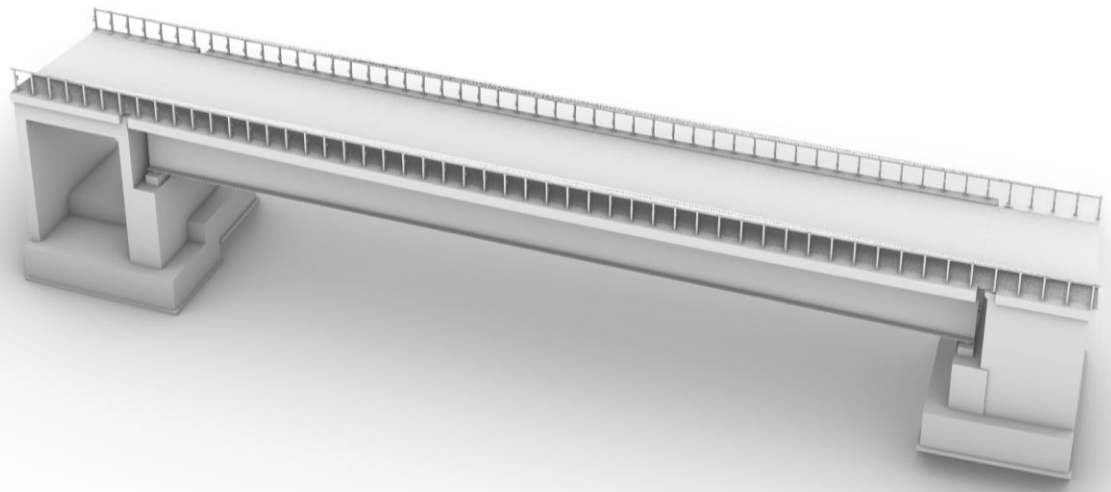
Case study A

- Existing masonry arched bridge



Case study B

- Steel-Concrete slab-girder bridge design to construction



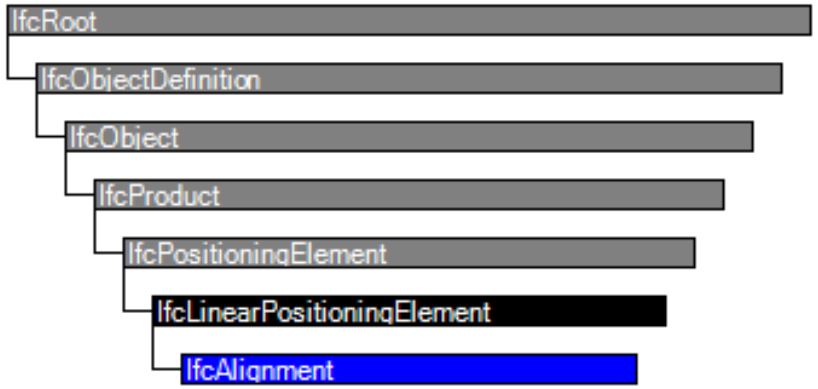
Images credits R. Bernardello | A. Basso – Dicea, UNIPD

	CASE STUDY "A"	CASE STUDY "B"
Owner	RFI Italian railway network manager	ANAS Italian government-owned company deputed to the construction and maintenance of Italian motorways and state highways
Bridge type	Arched bridge	Girder bridge
Construction type	Masonry	Slab-girder bridge
Superstructure geometry	Straight	(slightly) In curve
Materials	Masonry	Steel-Concrete
Condition	Existing	To be built
Model use cases	Degradation analysis	Design to construction
Modelling strategy	**A model used to identify the condition of the asset**	**Comparative approach between three different BIM authoring tools**
Modelling time	20 days	20 days
Software tested	1	3
Expected results	**Classes representation of complex elements (i.e., vaults). Relations between BIM-objects and condition.**	**Comparison between the IFC files exported from the different tools. Detailed model ready for tendering.**

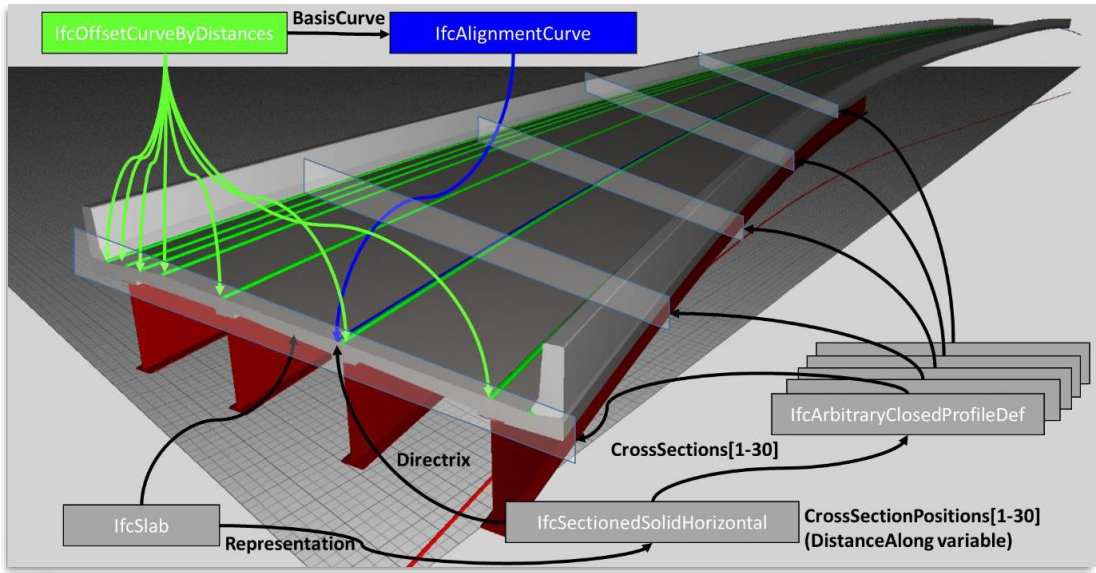
IfcAlignment

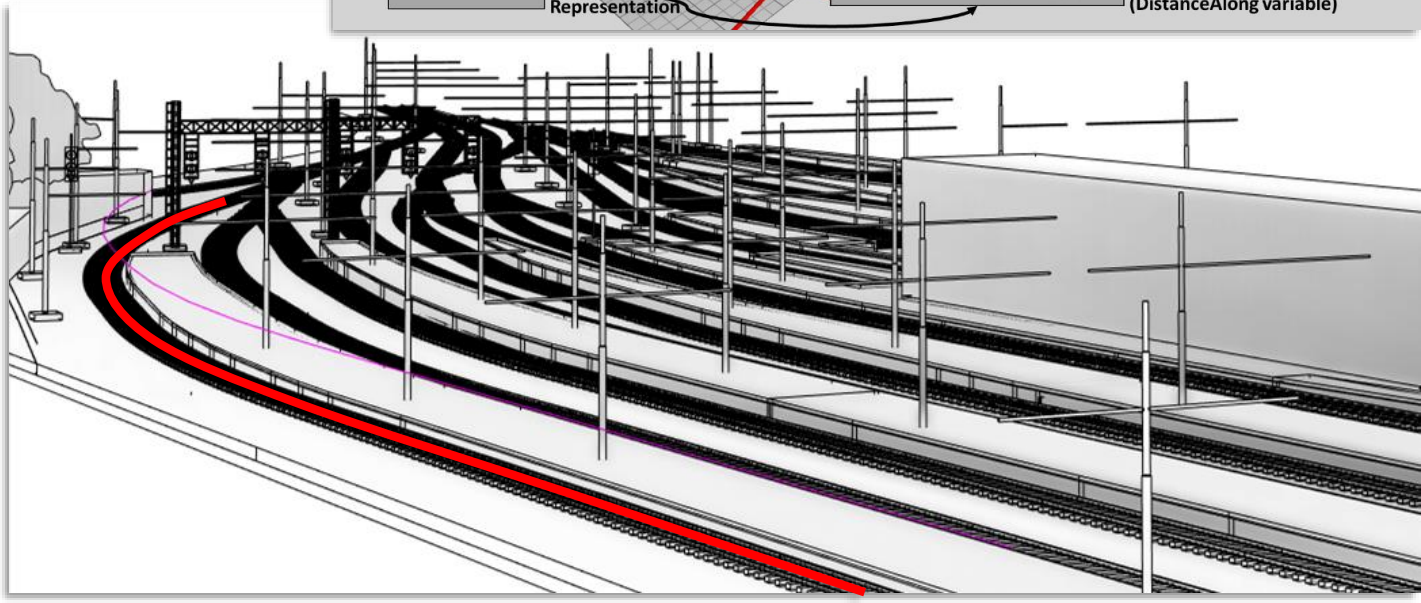
According to the client, in the first phase the Alignment placement of the bridge components is avoid.

It was more important to focus on the occurrences classification and the Spatial structure organisation



[…] Derivative alignments may be used to indicate dependent alignments, such as an alignment for a bridge that is relative to a parent alignment for a road […]





Images BuildingSMART | P. Borin- Dicea, UNIPD

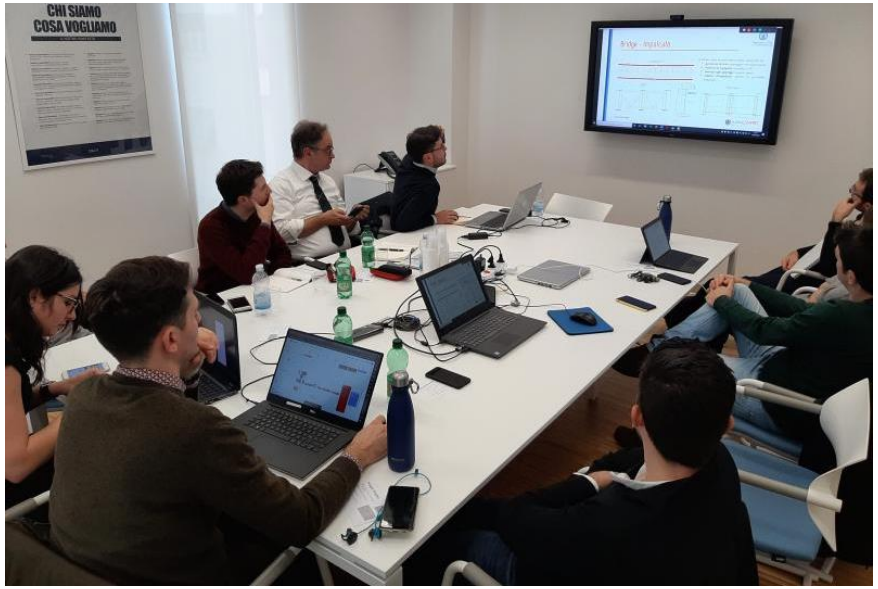
Classification phase

During each phase any encountered issues are highlighted and some solutions are proposed.

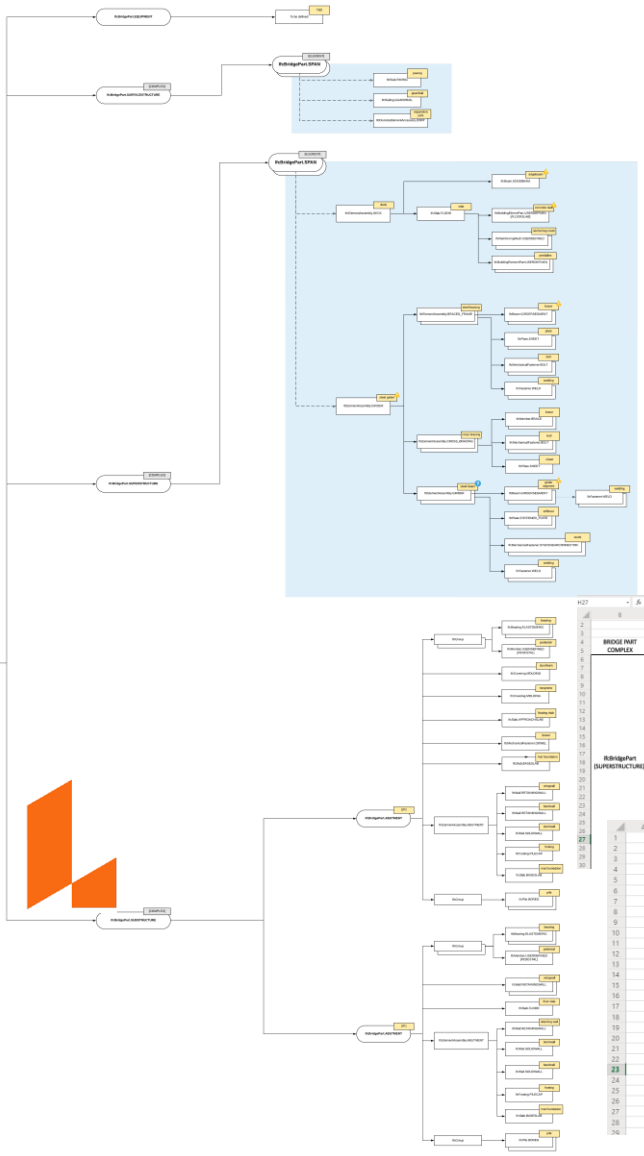
The implemented process can be divided in:

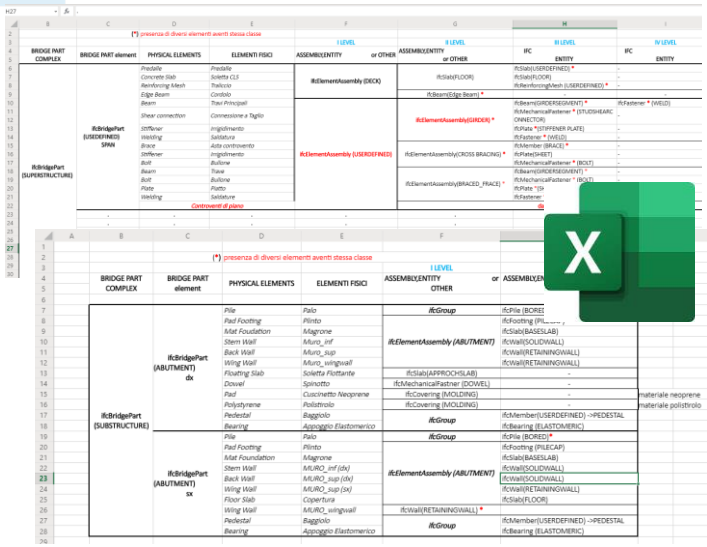
1. **IFC classification**
   - **Spatial Structure decomposition**
   - **Object IFC classification**
2. **Modelling**
3. **Export test**

To better understand the IFC classification organisation of each case study, it is represented by a diagram, which highlights both the relationship between the spatial structure and the objects and between composed objects.



Bridge and Conceptual Map – Case B





Images credits A. Basso – Dicea, UNIPD | A. Ciccone Dist, UNINA

Spatial Structure decomposition

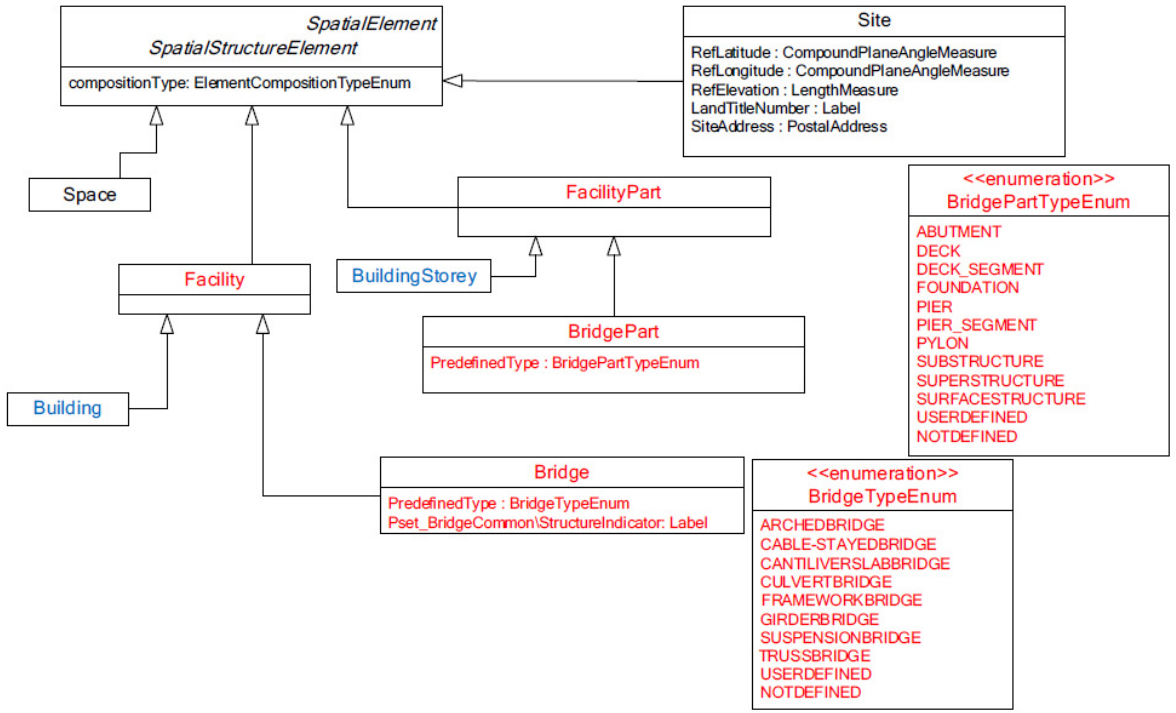
The first classification aim, related to the two projects, is the Spatial Structure organization. It is constructed on:

- Predefined types
- Element composition of the classes

The spatial schemes are based on:

- Use case of each model
- Client specifications
- Common practise of the designer

IfcElementCompositionEnum	
Constant	Description
COMPLEX	A group or aggregation of similar elements.
ELEMENT	An (undivided) element itself.
PARTIAL	A sub-element or part.



A. Borrmann et al., 2019 the IFC-Bridge project – extending the IFC standard to enable high-quality exchange of bridge information models

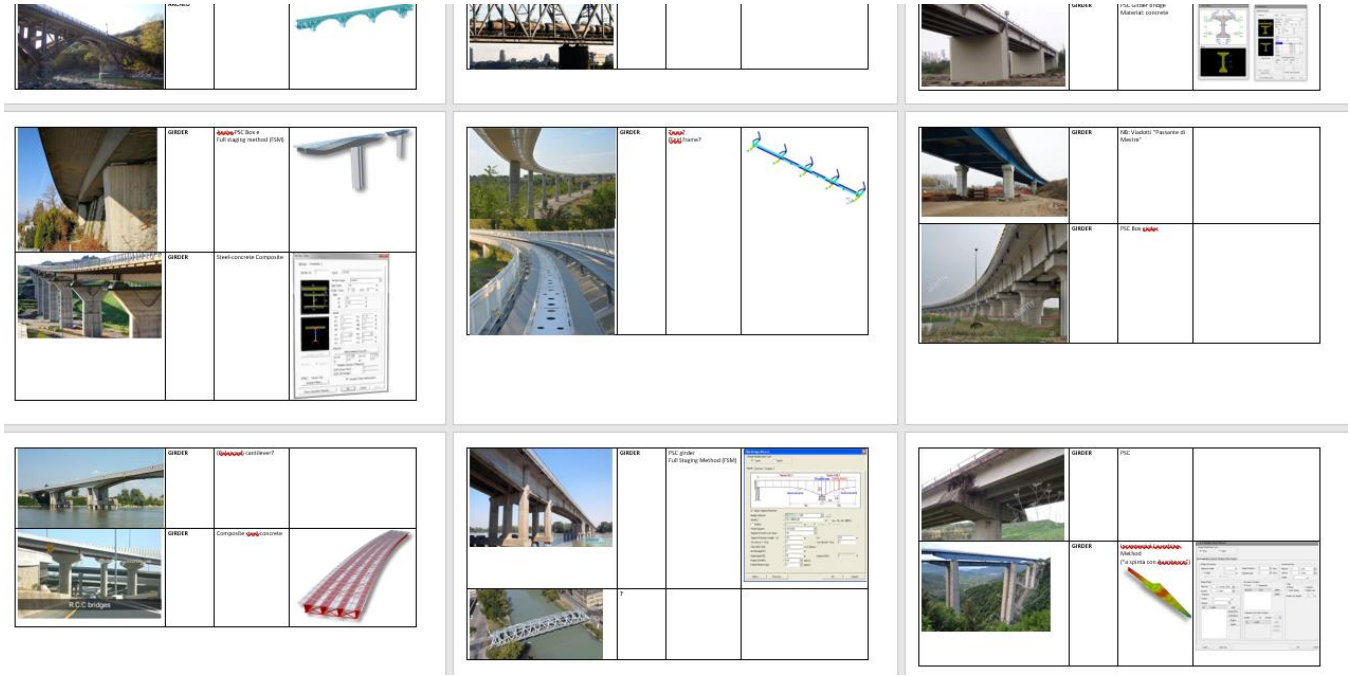
IfcBridgeTypeEnum reference

To define the IfcBridgeTypeEnum a document of different bridge examples was drawn up, which is based on:

- Italian and international bridge construction literature
- 2020 Italian guide lines for existing bridge edited by the MoT

IFC BRIDGE Candidate
ARCHED
CABLE_STAYED
CANTILEVER
CULVERT
FRAMEWORK
GIRDER
SUSPENSION
TRUSS
USERDEFINED
NOTDEFINED

Linee Guida Con.Sup.
Arco in muratura
Arco in CA
Strallato o sospeso
Travate appoggiate
Travate gerber
Travate continue
Cassone in precompresso
Soletta in CA
Sezione tubolare in acciaio
Sezione tubolare in CA
Arco in acciaio
Travate in CAP a cavi post tesi



credits P. Segala – CSPFea

IfcBridgePart – Case A

IfcBridge.ARCHED

First level COMPLEX of spatial decomposition

Deck

Superstructure

Substructure

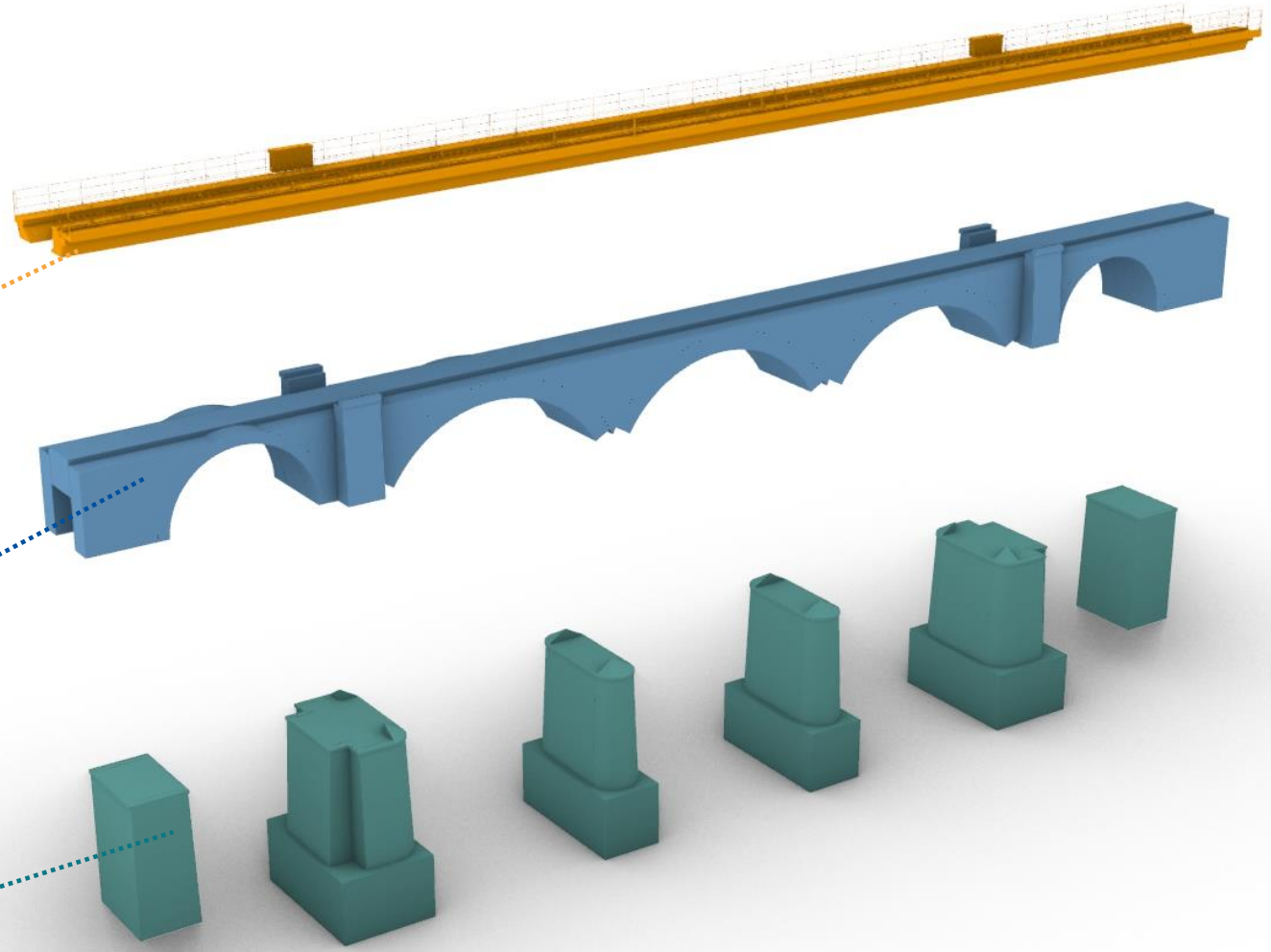
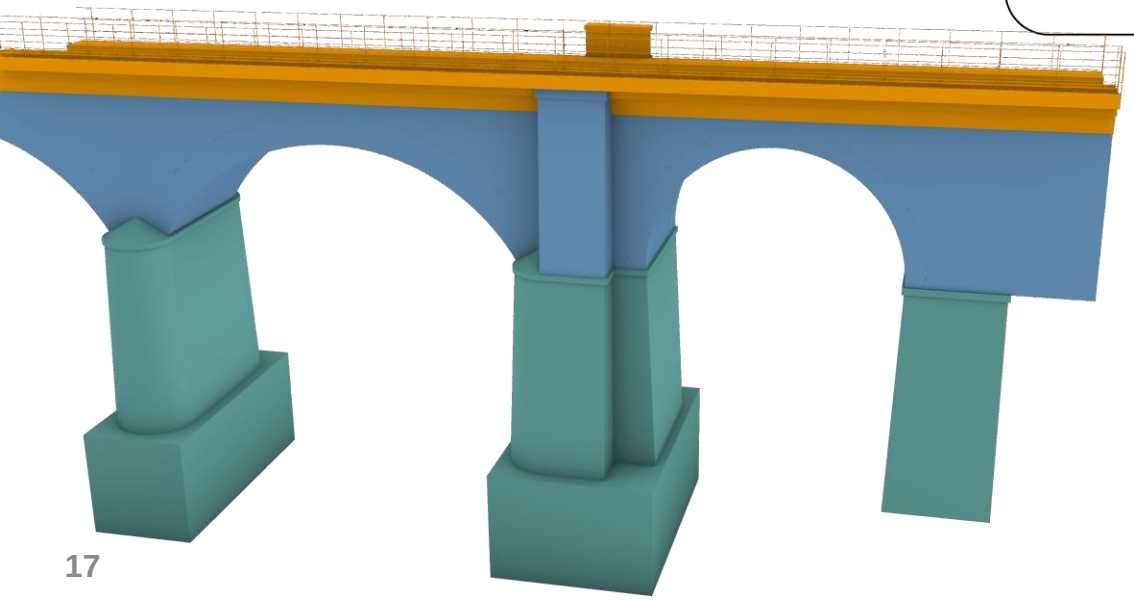
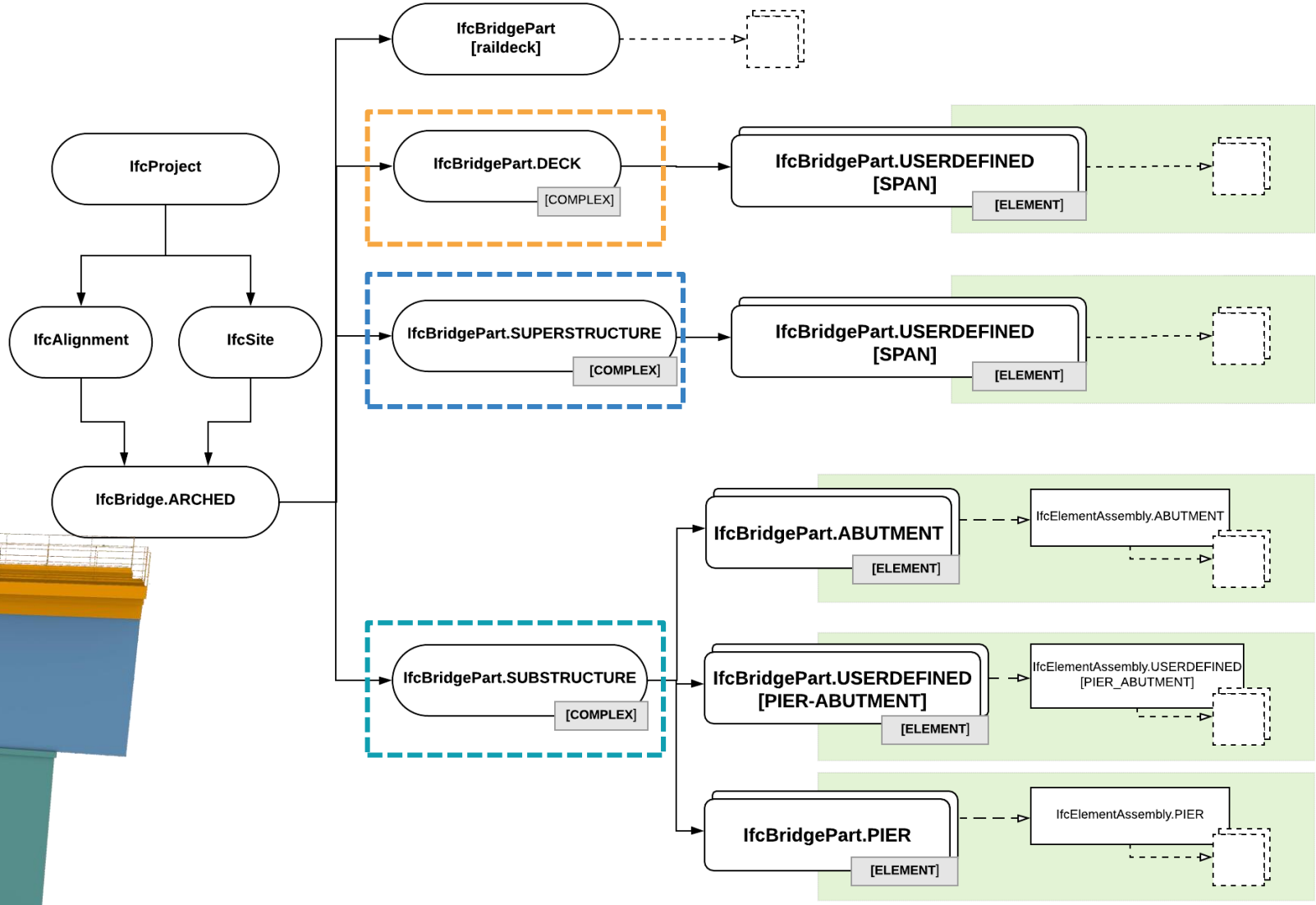


Image credit R. Bernardello – Dicea, UNIPD

Spatial structure – Case A

All levels of spatial decomposition





Images credits R. Bernardello – Dicea, UNIPD

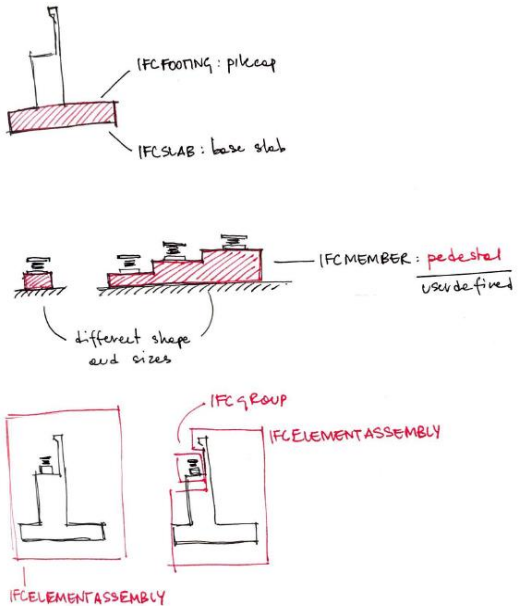
Object IFC classification

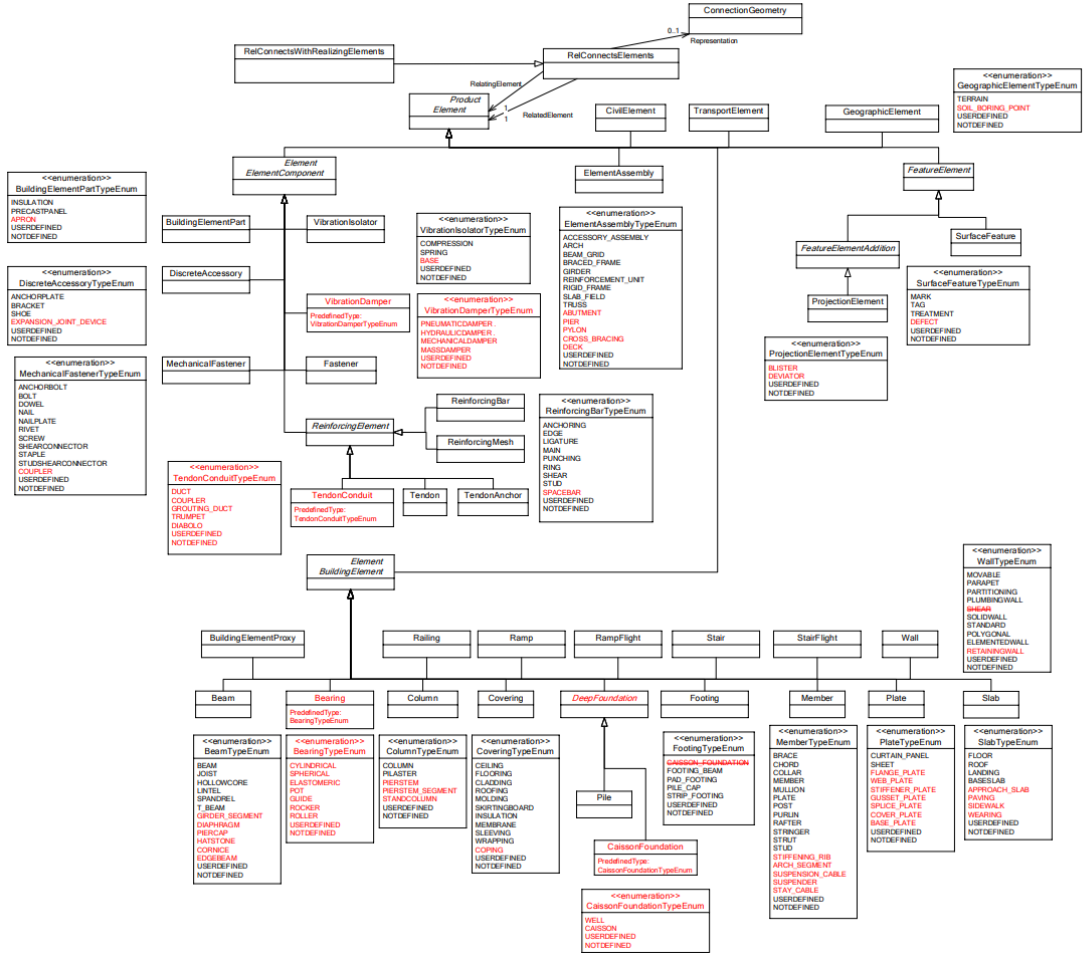
After the set up of a spatial structure schema, each component of the construction is classified focusing on:

- Classes and enum
- Relations between IfcObject

The component decompositions are based on:

- Use case of each model
- IFC logic





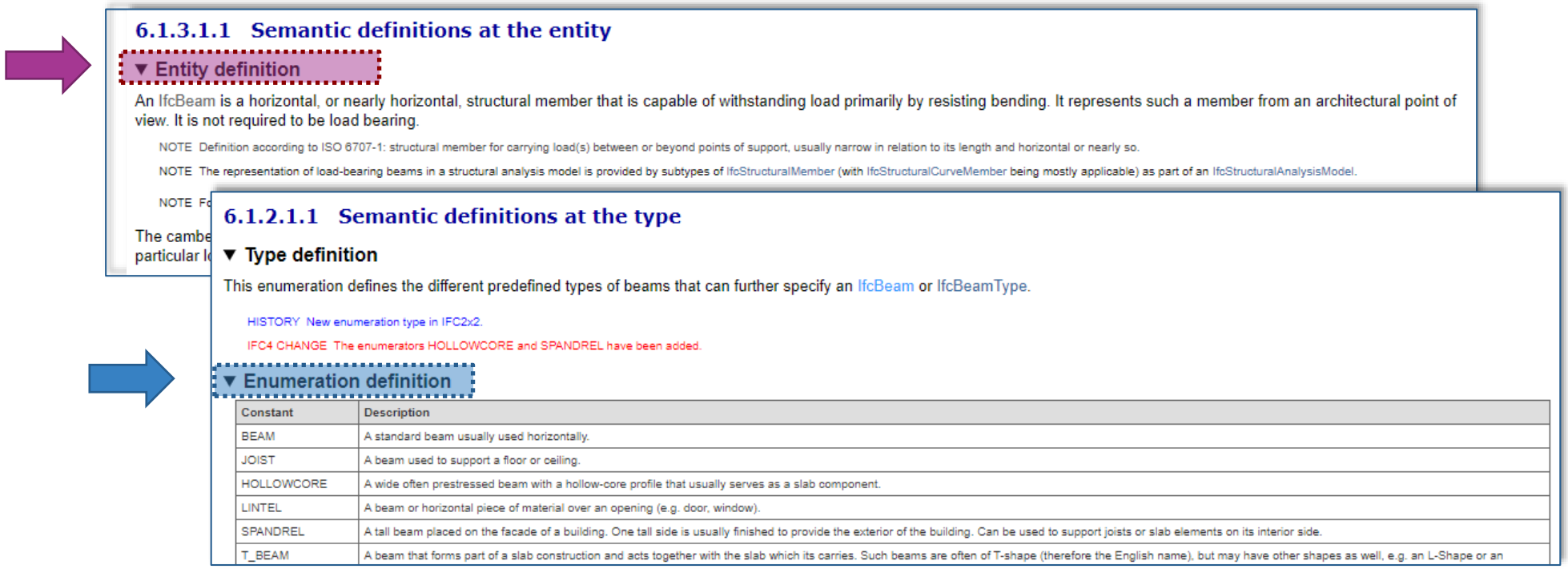
A. Borrmann et al., 2019. The IFC-Bridge project – extending the IFC standard to enable high-quality exchange of bridge information models

Images credits D. Tommasi – ETS | A. Basso – Dicea, UNIPD

IFC class mapping

For the occurrence mapping, an in-depth analysis of the classification is carried out on two distinct levels:

- a higher level based on the definition of the **classes**
- a lower level based on the definition of the **enum** of the class



6.1.3.1.1 Semantic definitions at the entity

▼ Entity definition

An IfcBeam is a horizontal, or nearly horizontal, structural member that is capable of withstanding load primarily by resisting bending. It represents such a member from an architectural point of view. It is not required to be load bearing.

NOTE Definition according to ISO 6707-1: structural member for carrying load(s) between or beyond points of support, usually narrow in relation to its length and horizontal or nearly so.

NOTE The representation of load-bearing beams in a structural analysis model is provided by subtypes of IfcStructuralMember (with IfcStructuralCurveMember being mostly applicable) as part of an IfcStructuralAnalysisModel.

NOTE Fc

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6.1.2.1.1 Semantic definitions at the type

▼ Type definition

This enumeration defines the different predefined types of beams that can further specify an IfcBeam or IfcBeamType.

HISTORY New enumeration type in IFC2x2.

IFC4 CHANGE The enumerators HOLLOWCORE and SPANDREL have been added.

▼ Enumeration definition

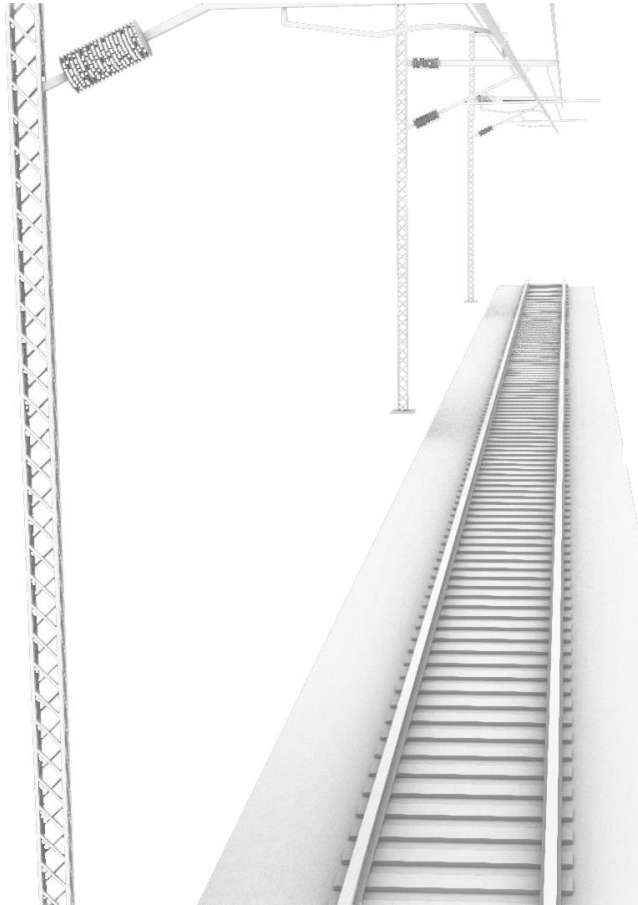
Constant	Description
BEAM	A standard beam usually used horizontally.
JOIST	A beam used to support a floor or ceiling.
HOLLOWCORE	A wide often prestressed beam with a hollow-core profile that usually serves as a slab component.
LINTEL	A beam or horizontal piece of material over an opening (e.g. door, window).
SPANDREL	A tall beam placed on the facade of a building. One tall side is usually finished to provide the exterior of the building. Can be used to support joists or slab elements on its interior side.
T_BEAM	A beam that forms part of a slab construction and acts together with the slab which its carries. Such beams are often of T-shape (therefore the English name), but may have other shapes as well, e.g. an L-Shape or an

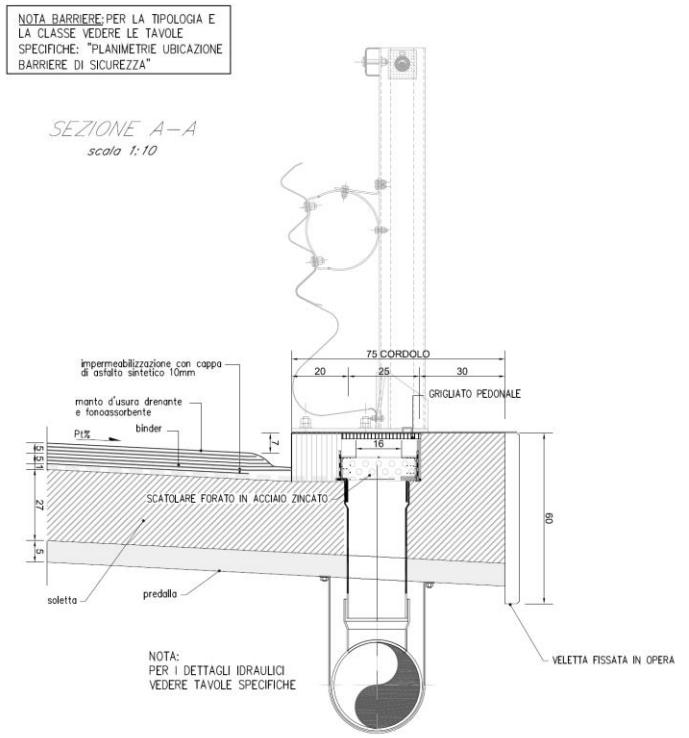
Bridge structure interface

In both projects the IWG decided not to classify some elements because they belong to:

- the interface between the bridge structure and the linear infrastructure
- the equipment of the linear infrastructures

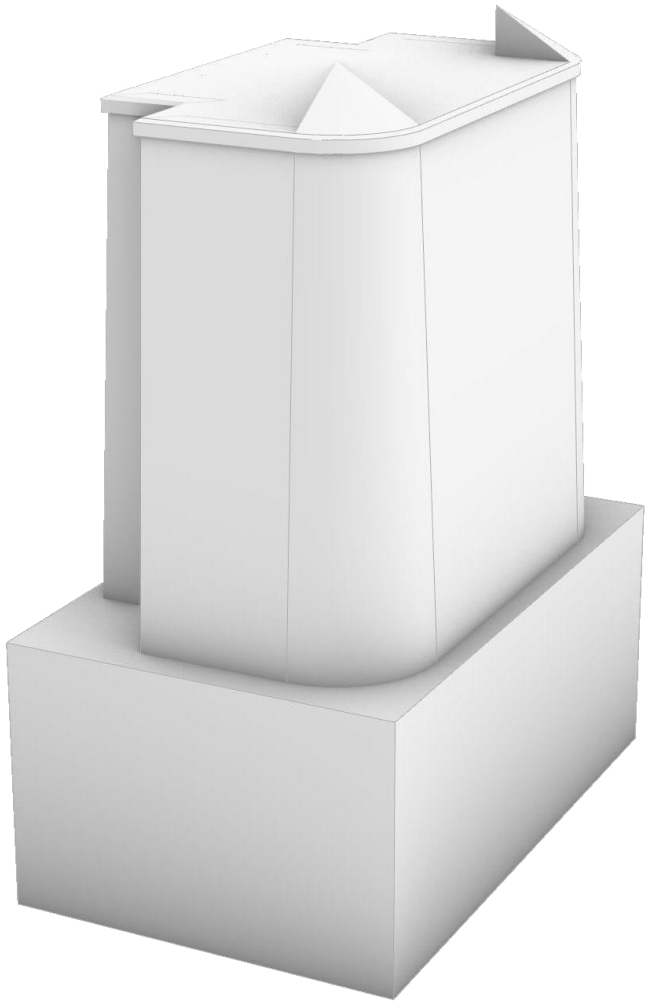
In this cases they are allocated in a specific spatial structure and the object classification is postponed to a second phase or to an integrated classification of the common schema.

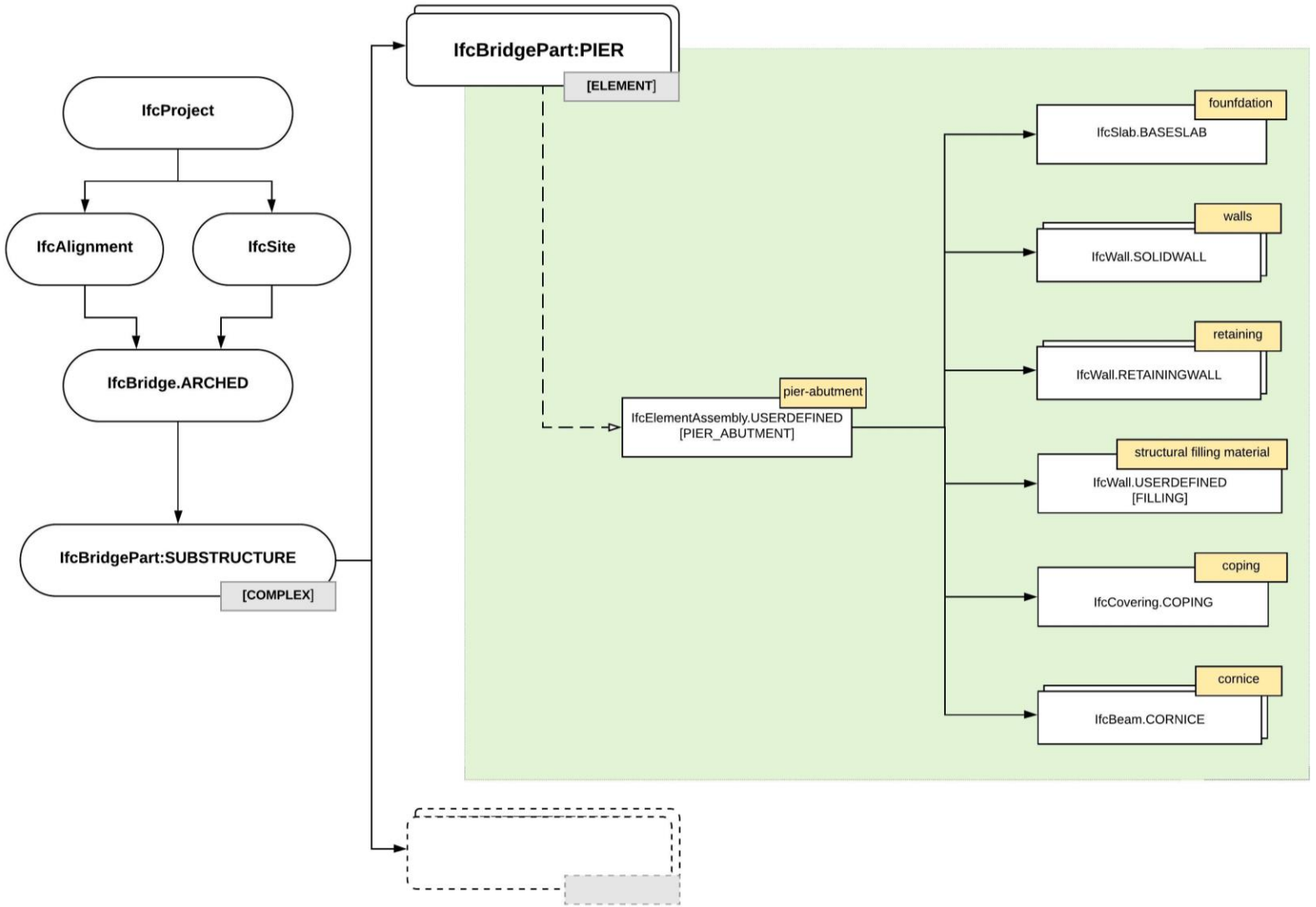




credits R. Bernardello - UNIPD | ANAS

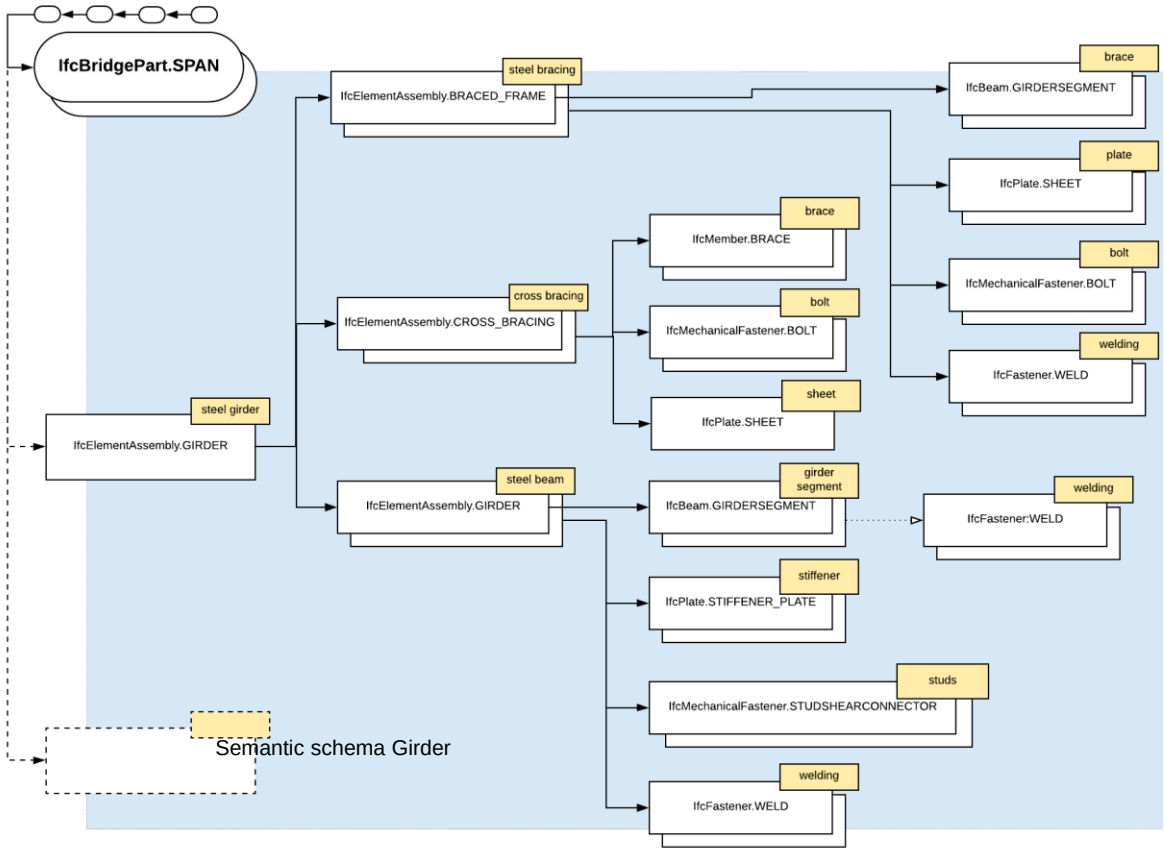
IfcBridgePart.Substructure



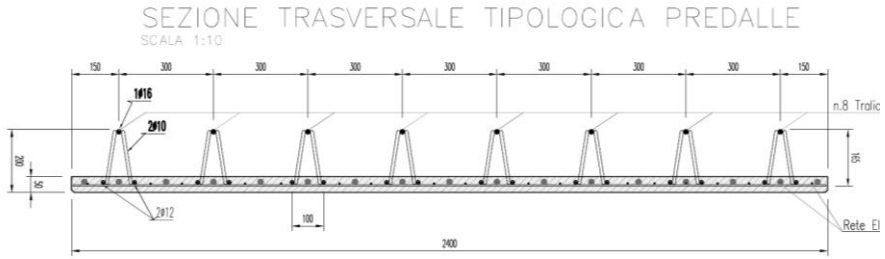


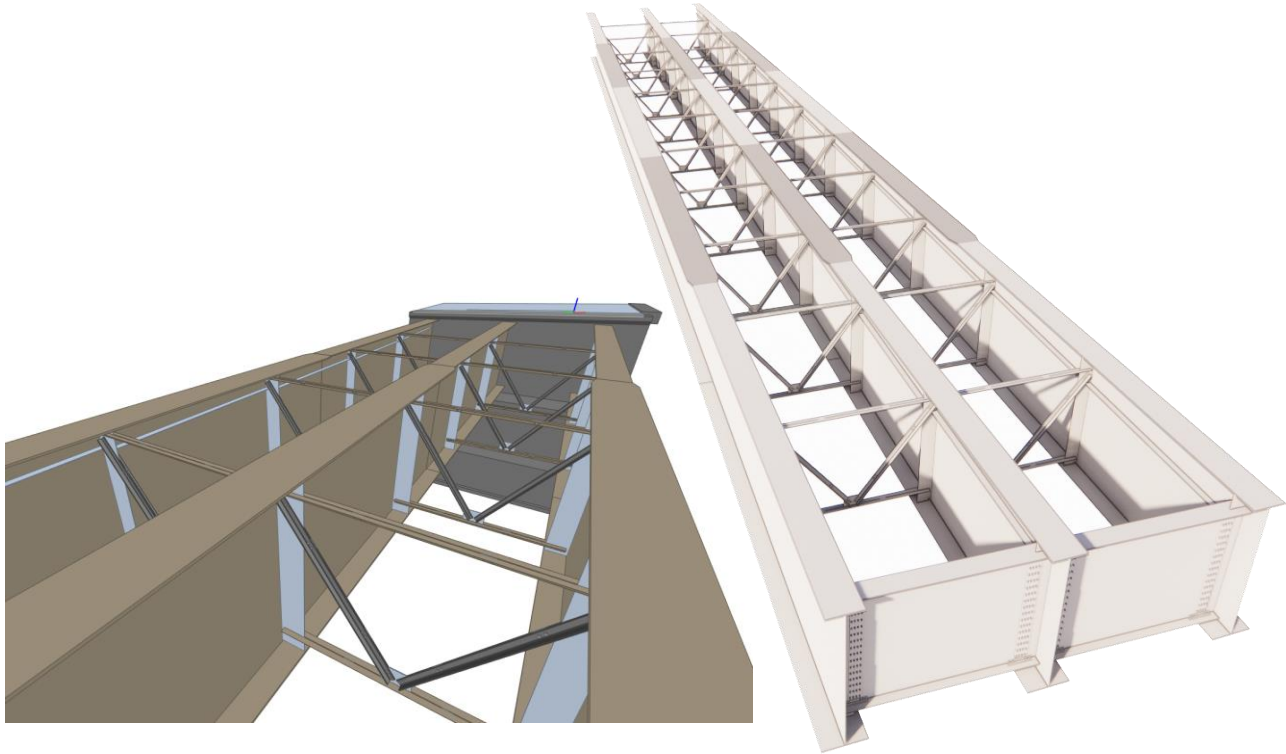
Images credits R. Bernardello – Dicea, UNIPD

Superstructure. Girder



Semantic schema Girder



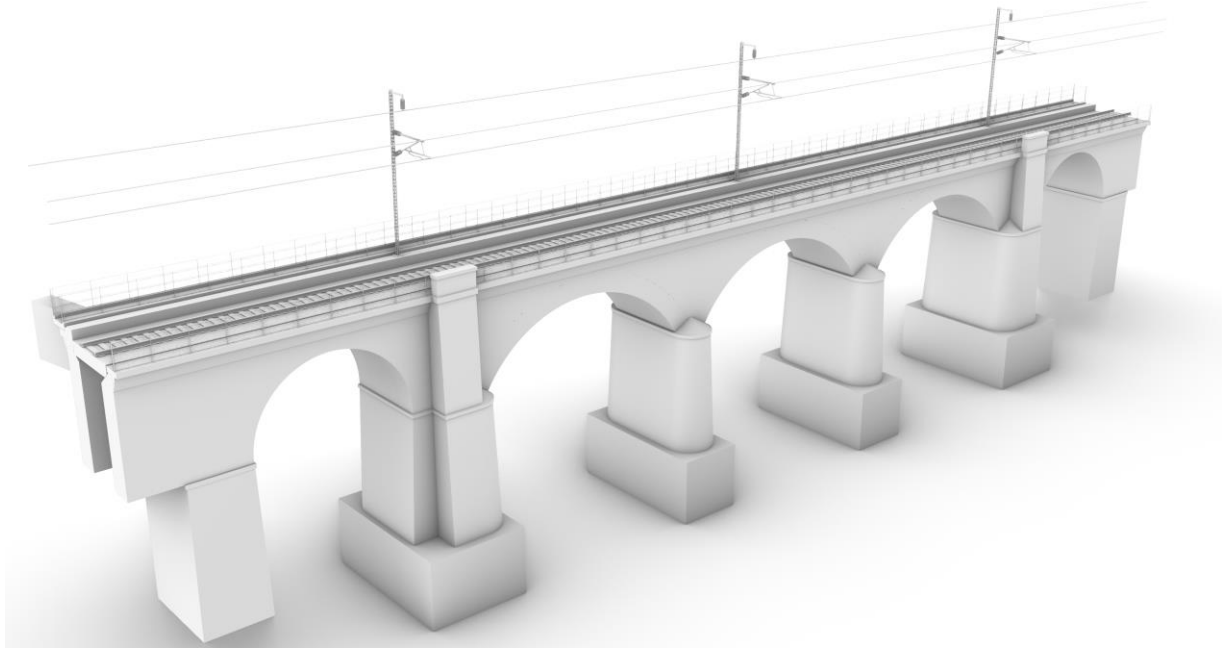


Images credits R.A. Bernardello | A. Basso – Dicea, UNIPD

Modelling

Strictly based on IFC classification, the modelling phase was conducted with an approach that forced the software towards classification.

Highlighting the inconsistency of the IFC classification or the gap in the authoring software, whether necessary.



Images credits R. Bernardello | A. Basso – Dicea, UNIPD

IFC Export

- Check the relations between components
- Analyse geometry export issues
- Drive the software towards a correct IFC mapping

Few new entities added

Customize ENUM

```
#54= IFCDERIVEDUNIT((#52,#53),.MASSDENSITYUNIT.,$);
#56= IFCSIUNIT(*,.TIMEUNIT.,$,.SECOND.);
#57= IFCSIUNIT(*,.FREQUENCYUNIT.,$,.HERTZ.);
#58= IFCSIUNIT(*,.THERMODYNAMICTEMPERATUREUNIT.,$,.KELVIN.);
#59= IFCSIUNIT(*,.THERMODYNAMICTEMPERATUREUNIT.,$,.DEGREE_CELSIUS.);
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#61= IFCDERIVEDUNITELEMENT(#58,-1);
#62= IFCDERIVEDUNITELEMENT(#56,-3);
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#68= IFCDERIVEDUNIT((#66,#67),.VOLUMETRICFLOWRATEUNIT.,$);
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#71= IFCSIUNIT(*,.ELECTRICVOLTAGEUNIT.,$,.VOLT.);
#72= IFCSIUNIT(*,.POWERUNIT.,$,.WATT.);
#73= IFCSIUNIT(*,.FORCEUNIT.,.KILO.,.NEWTON.);
#74= IFCSIUNIT(*,.ILLUMINANCEUNIT.,$,.LUX.);
#75= IFCSIUNIT(*,.LUMINOUSFLUXUNIT.,$,.LUMEN.);
#76= IFCSIUNIT(*,.LUMINOUSINTENSITYUNIT.,$,.CANDELA.);
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#87= IFCSIUNIT(*,.PRESSUREUNIT.,$,.PASCAL.);
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#100= IFCDERIVEDUNITELEMENT(#43,1);
#101= IFCDERIVEDUNITELEMENT(#56,-2);
#102= IFCDERIVEDUNITELEMENT(#43,-2);
#103= IFCDERIVEDUNIT((#99,#100,#101,#102),.PLANARFORCEUNIT.,$);
#105= IFCUNITASSIGNMENT((#43,#44,#45,#49,#51,#54,#56,#57,#59,#63,#68,#70,#71,#72,#73,#74,#75,#76,#81,#85,#87,#91,#97,#103));
#107= IFCAXIS2PLACEMENT3D(#6,$,$);
#108= IFCDIRECTION((6.12303176911189E-17,1.));
#110= IFCGEOMETRICREPRESENTATIONCONTEXT($,'Model',3,1.00000000000000E-5,#107,#108);
#114= IFCGEOMETRICREPRESENTATIONSUBCONTEXT('Axis','Model',*,*,*,*,#110,$,.GRAPH_VIEW.,$);
#116= IFCGEOMETRICREPRESENTATIONSUBCONTEXT('Body','Model',*,*,*,*,#110,$,.MODEL_VIEW.,$);
#117= IFCGEOMETRICREPRESENTATIONSUBCONTEXT('Box','Model',*,*,*,*,#110,$,.MODEL_VIEW.,$);
#118= IFCGEOMETRICREPRESENTATIONSUBCONTEXT('FootPrint','Model',*,*,*,*,#110,$,.MODEL_VIEW.,$);
#119= IFCPROJECT('03OKcG64H6ShxQndAFnApx',#42,'0001',$,$,'Nome','Stato',(#110),#105);
#130= IFCPOSTALADDRESS($,$,$,$,(),$,'','38.085262298584','','15.7232837677002');
#134= IFCBUILDING('03OKcG64H6ShxQndAFnApw',#42,'',$,$,#33,$,'',.ELEMENT.,$,$,$);
#144= IFCAXIS2PLACEMENT3D(#6,$,$);
#145= IFCLOCALPLACEMENT(#33,#144);
#147= IFCBUILDINGSTOREY('03OKcG64H6ShxQnd9mEr2k',#42,'0 - FONDAZIONI_PILE',$,'Level:Livello',#145,$,'0 - FONDAZIONI_PILE',.ELEMENT.,0
```

Pset_Condition

Template	Value	PropertyName	Description
Single Value	IfcDate	AssessmentDate	Date on which the overall condition is assessed
Single Value	IfcLabel	AssessmentCondition	The overall condition of a product based on an assessment of the contributions to the overall condition made by the various criteria considered. The meanings given to the values of assessed condition should be agreed and documented by local agreements. For instance, is overall condition measured on a scale of 1 - 10 or by assigning names such as Good, OK, Poor.
Single Value	IfcText	AssessmentDescription	Qualitative description of the condition.

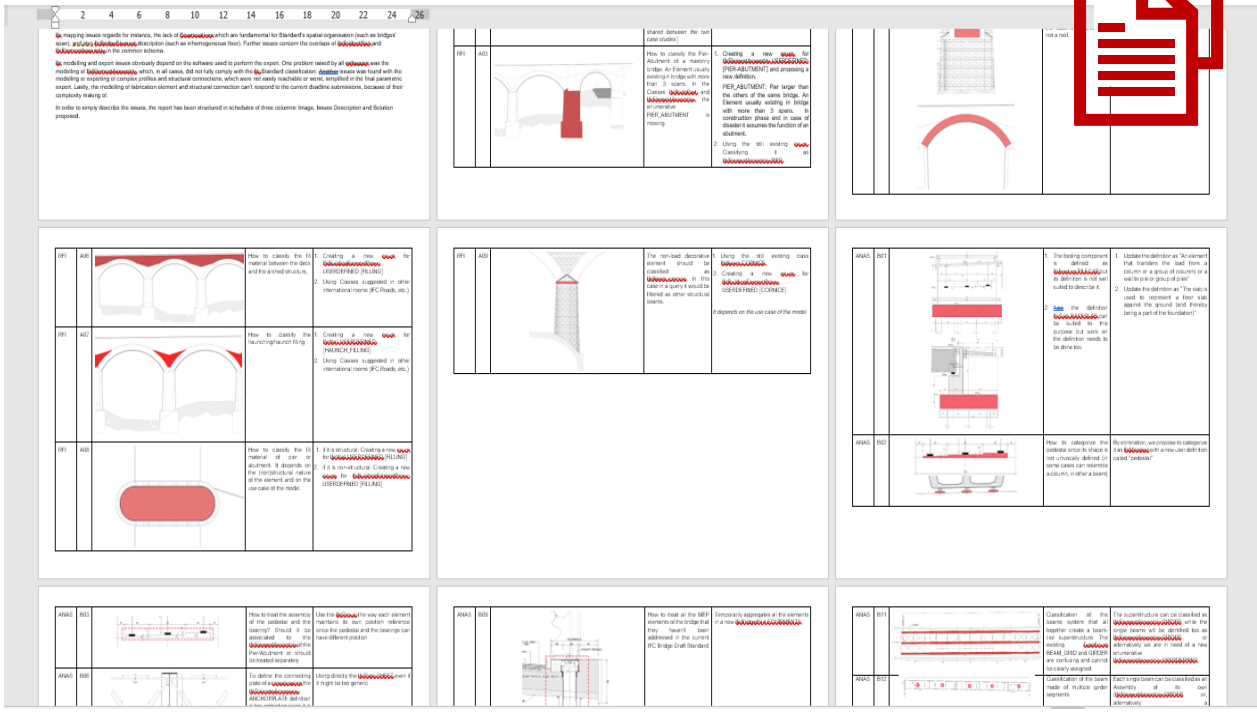
Issues

Due to the intrinsic differences between the marked problems, they are organised in three main parts

1. **Ifc classification issues**
2. **Modelling issues**
3. **Others ifc related (like geometry export, etc.)**

Some of the issues are in common between the two case studies, some others are linked to the bridge type.

The key issues are following proposed, and the others are deeply exposed in the attached document.



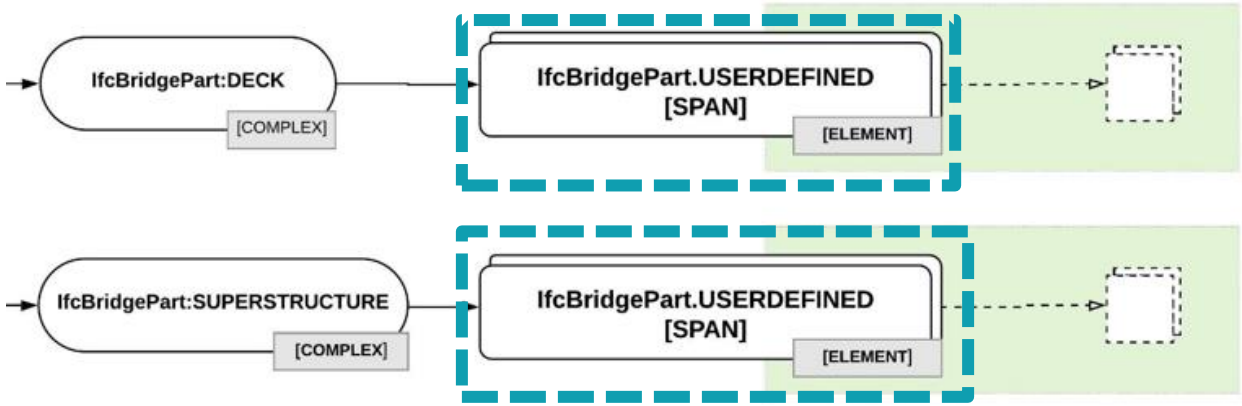
1. IfcBridgePart.SPAN

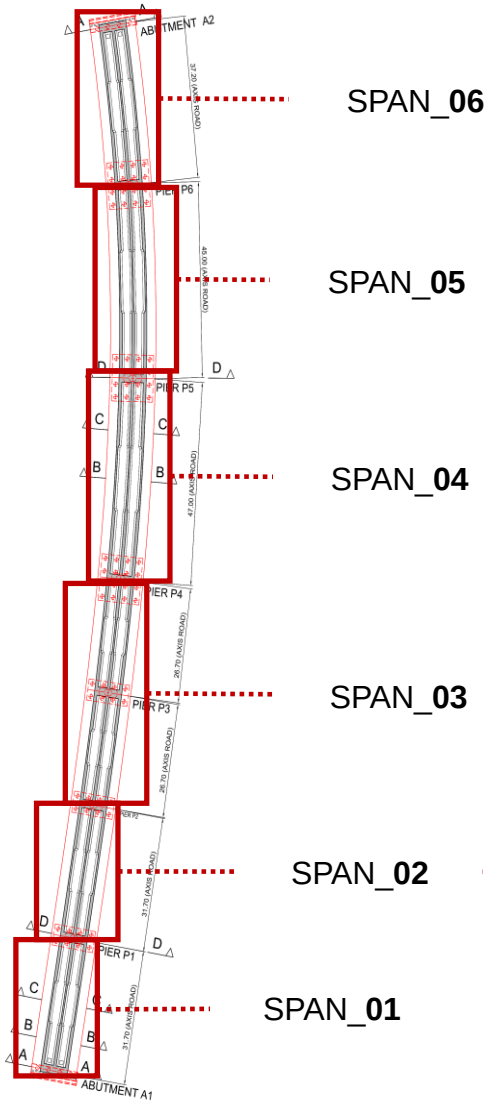
Problem

Span organization

Solution

Creating a new enum for IfcBridgePart.[SPAN]





Images credits A. Basso – Dicea, UNIPD

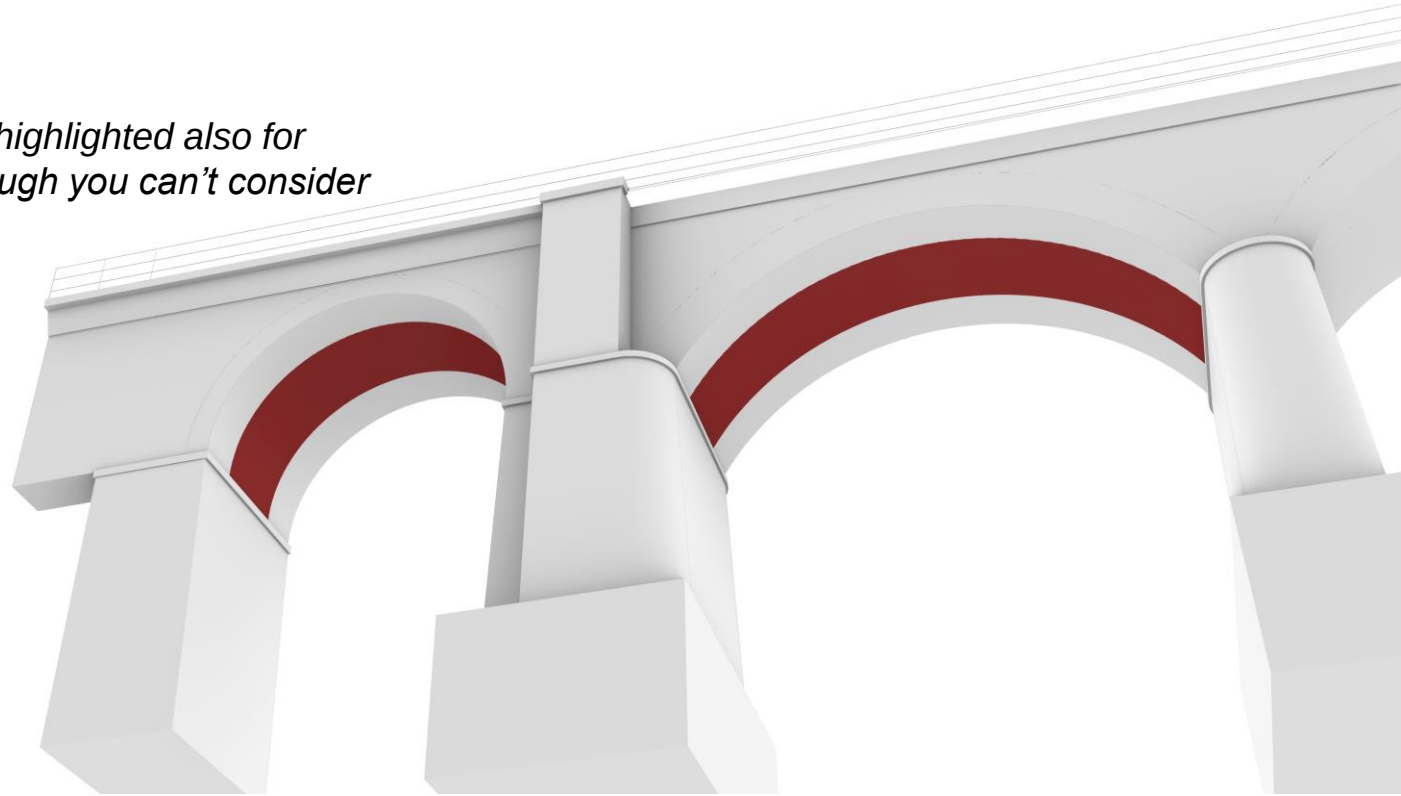
1. Vault

Problem

How to classify the vault of a masonry bridge.
The class for non-planar structure is missed. The problem, highlighted also for buildings, is when the vault is a partitioning not a roof, although you can't consider it as slab.

Solution

1. **IfcSlab_ enum userdefined VAULT (/DOMED)**
2. IfcRoof.BARREL_ROOF (/RAINBOW_ROOF)
3. IfcElementAssembly enum VAULT (/DOMED)



Images credits R. Bernardello – Dicea, UNIPD

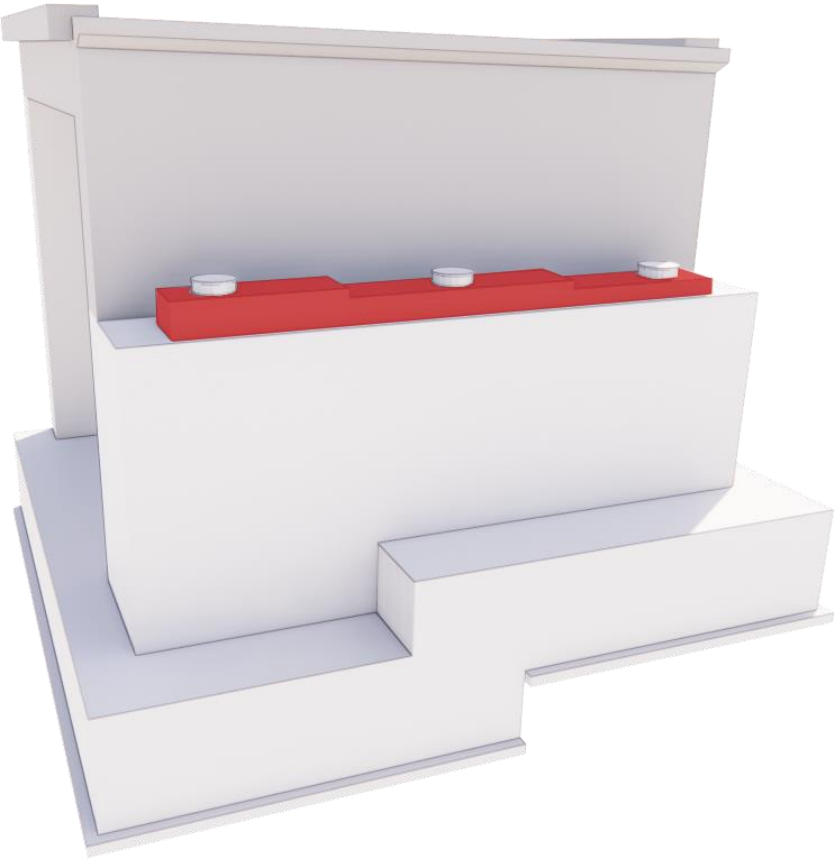
1. Pedestal

Problem

How to categorize the pedestal since its shape is not univocally defined (in some cases can resemble a column, in other a beam)

Solution

By elimination, we propose to categorize it as **IfcMember** with a new userdefined TypeEnum called "*pedestal*"



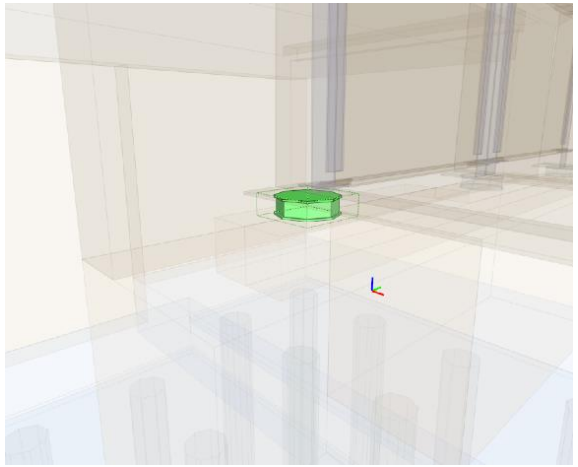
Images credits A. Basso – Dicea, UNIPD

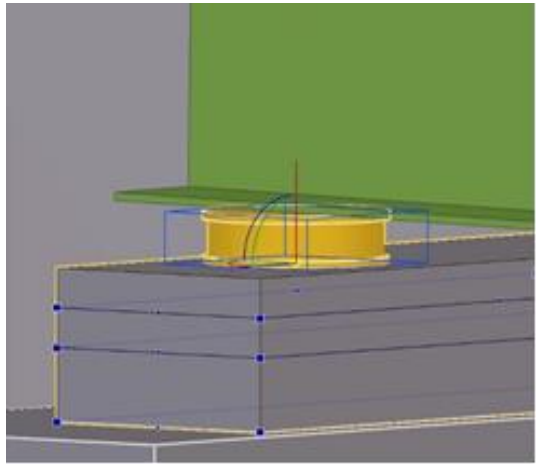
2. Modelling Issues

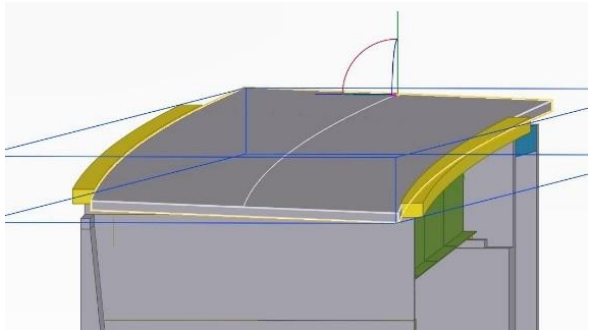
Ifc modelling and export issues obviously depend on the software used to perform the export.

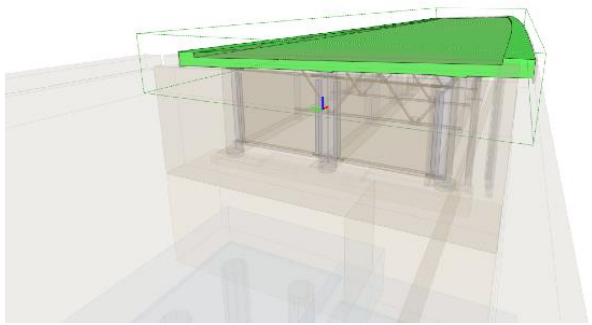
However some problems are in common between the software, specially those related to the relations between IfcObjects defined in the primary IFCmapping and the geometry export of some complex components

Example: Issues was found with the modelling or exporting of complex profiles and structural connections, which were not easily reachable or worst, simplified in the final parametric export.



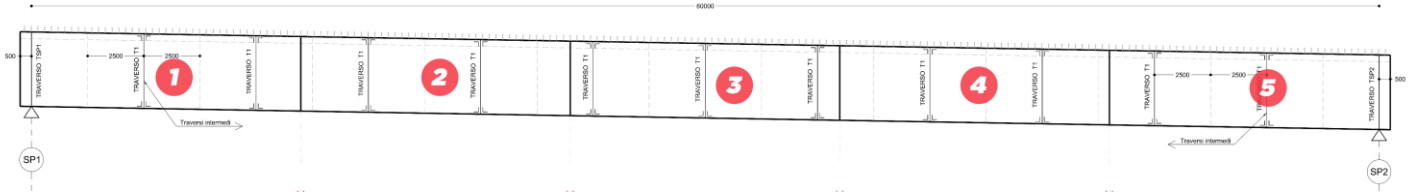


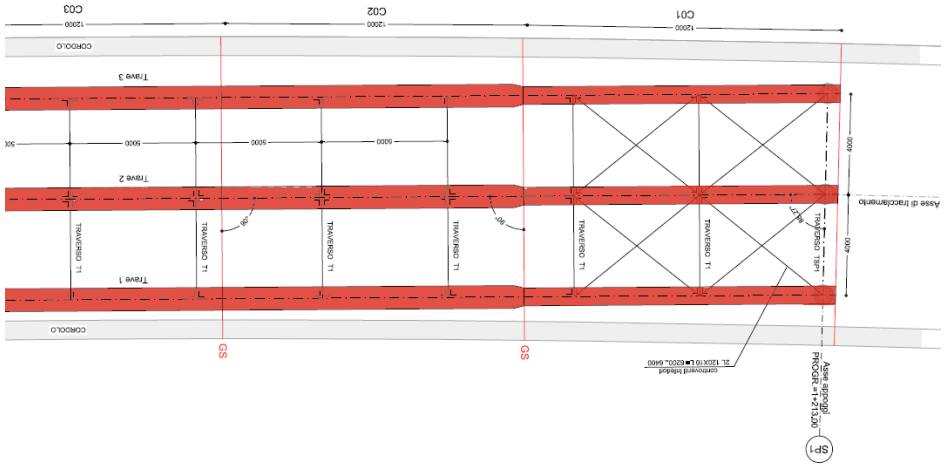


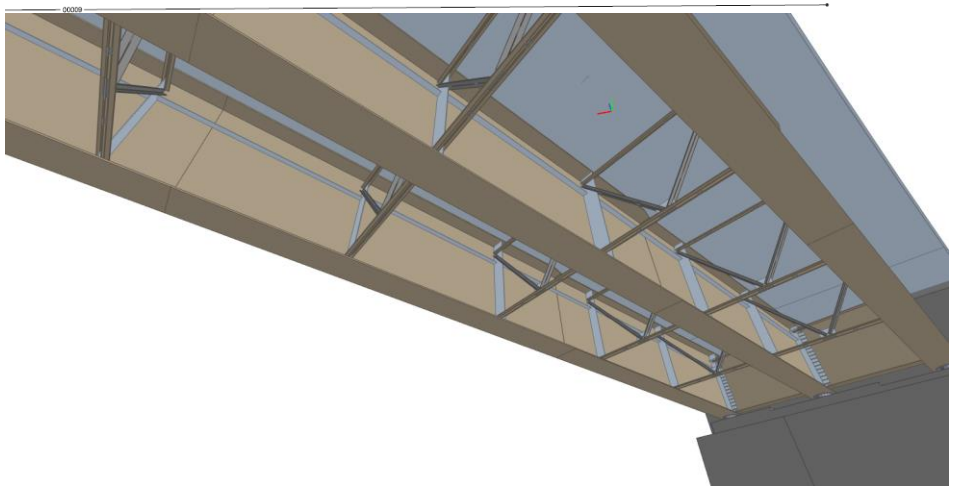


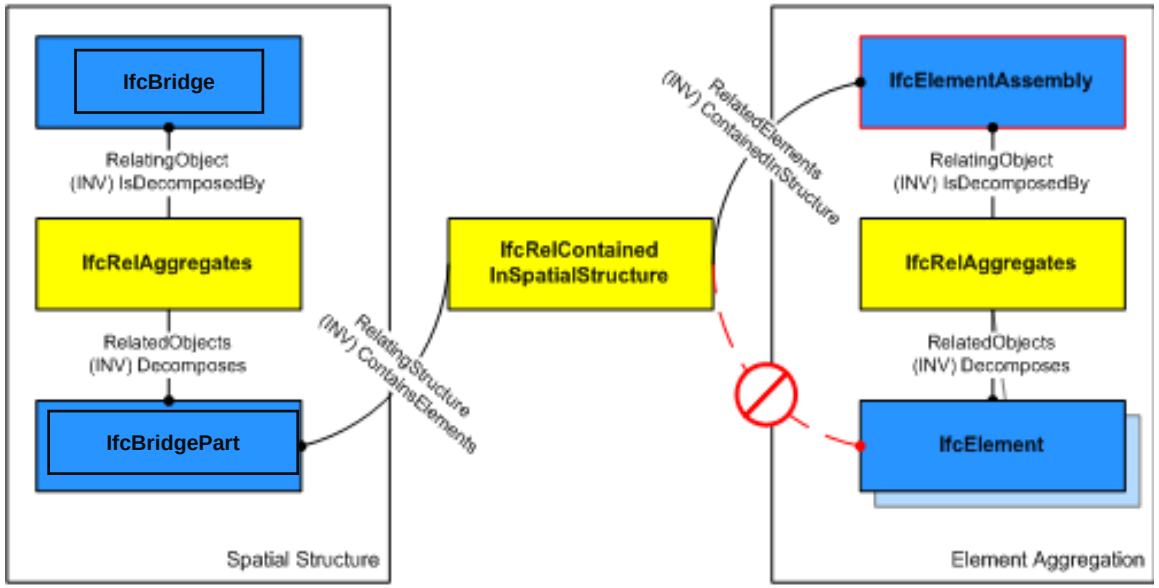
Images credits MinnucciAssociati | Dicea, UNIPD

3. IfcElementAssembly

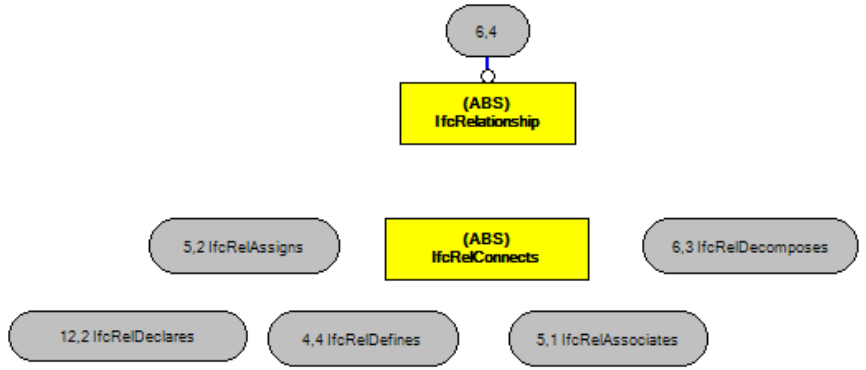






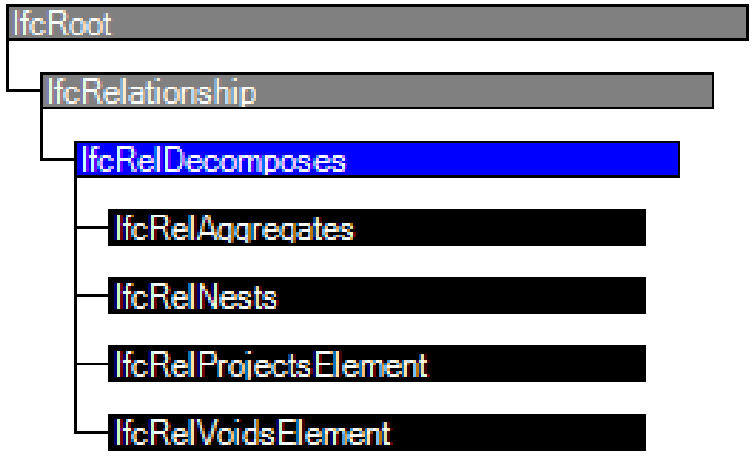


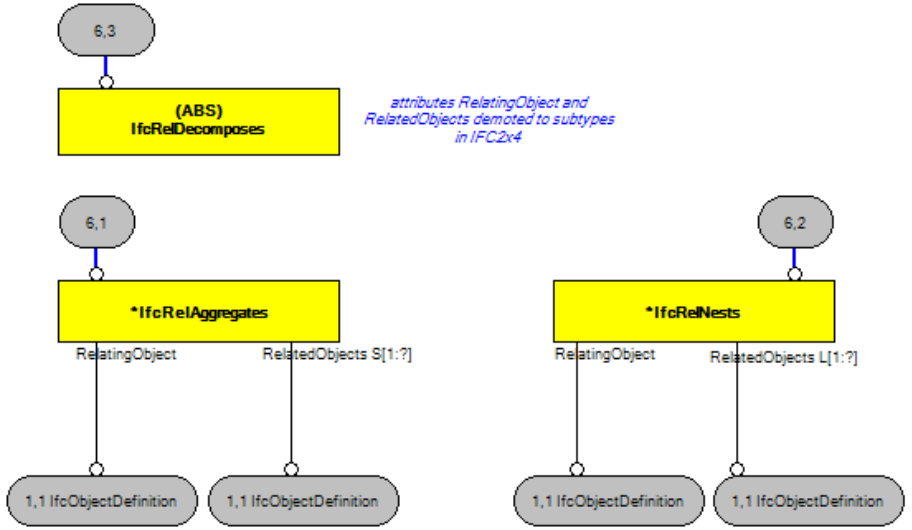
3. Element Aggregation



Problem

Element aggregation. Possibility inside the software of representing this type of relations between the IfcElement (more than IfcRoof and IfcCurtainWall)





Next steps

Infrastructures extensions representation

Mapping of the classes to the Candidate Standard 4.3 RC1.

- Spatial Structure
- Alignment
- Linear placement

existing masonry bridge – Case A

- **Reinforcement standardization on an existing bridge**

IFC mapping and classification within the restoration interventions model. Explore and describe the relationships between the intervention element and the model instance.

- **DOMUS and IFC**

Associating the IFC classes used in the model with the existing elements of the DOMUS system

slab-girder bridge to be built – Case B

- **Structural analysis use case**

Design application to structural analysis application

- **Material**

Test of material properties and performances according to Italian regulations

- **Pset**

Control the Pset associated to each IfcObject

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