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Integration of BIM-related bridge information in an ontological knowledgebase

LDAC 2020
17th June 2020

Introduction
Relevant Research projects

wiSIB

A simulation- and knowledge-based system identification method for bridges

http://www.wisib.de/

Research Partners:

Leonhardt, Andrä und Partner
Leonhardt, Andrä und Partner
Beratende Ingenieure VBI AG
Dresden

TECHNISCHE UNIVERSITÄT DRESDEN
Technische Universität Dresden
Institut für Bauinformatik
Dresden

FIDES DV-PARTNER
Fides DV-Partner Beratungs- und
Vertriebs- GmbH
München

Introduction
Relevant Research projects

cyberBridge

Cyber-physical bridge assessment system

http://www.cyberbridge.eu/

Research Partners:

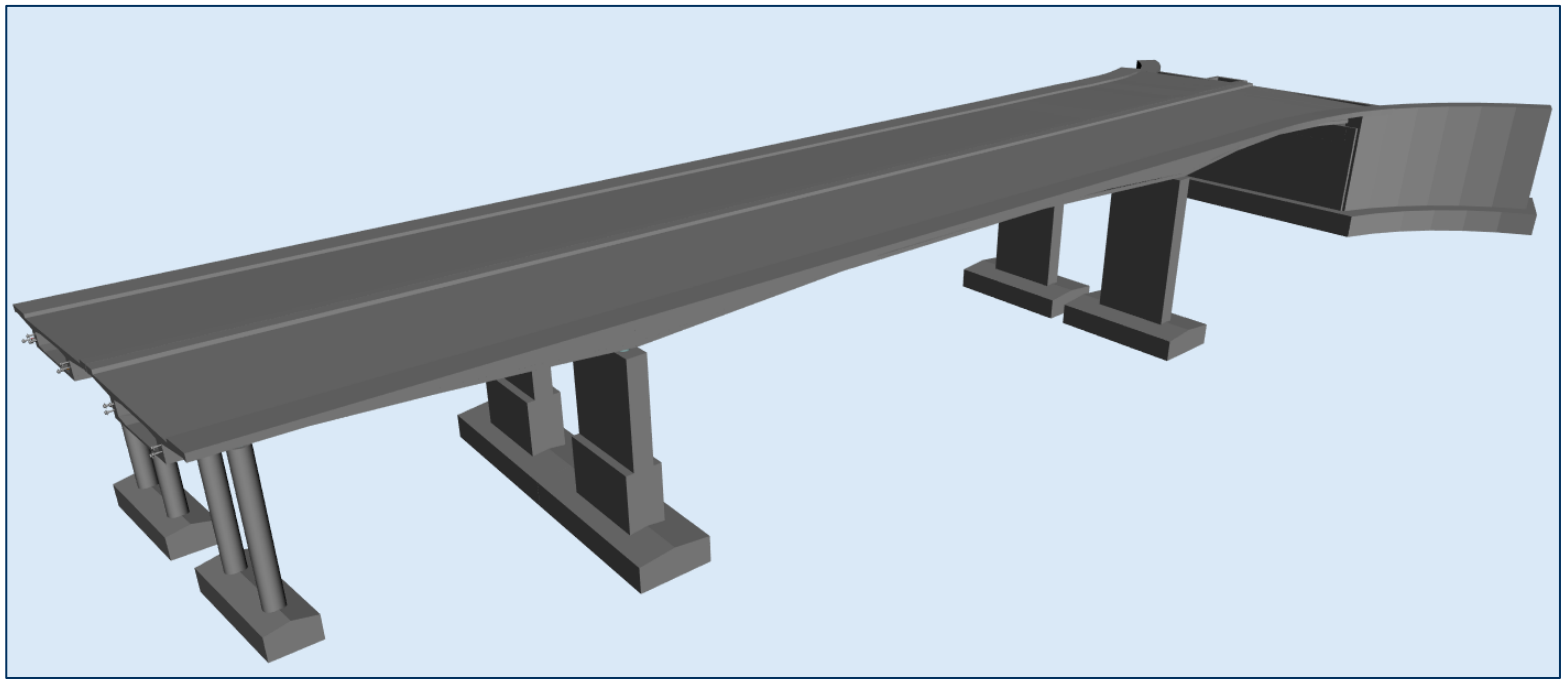
Cervenka Consulting s.r.o.

Petschacher Software und Projektentwicklungs GmbH

Leonhardt, Andrä und Partner, Beratende Ing. VBI AG

Institut für Bauinformatik, TU Dresden Partner

Introduction
Digital Bridge Modeling



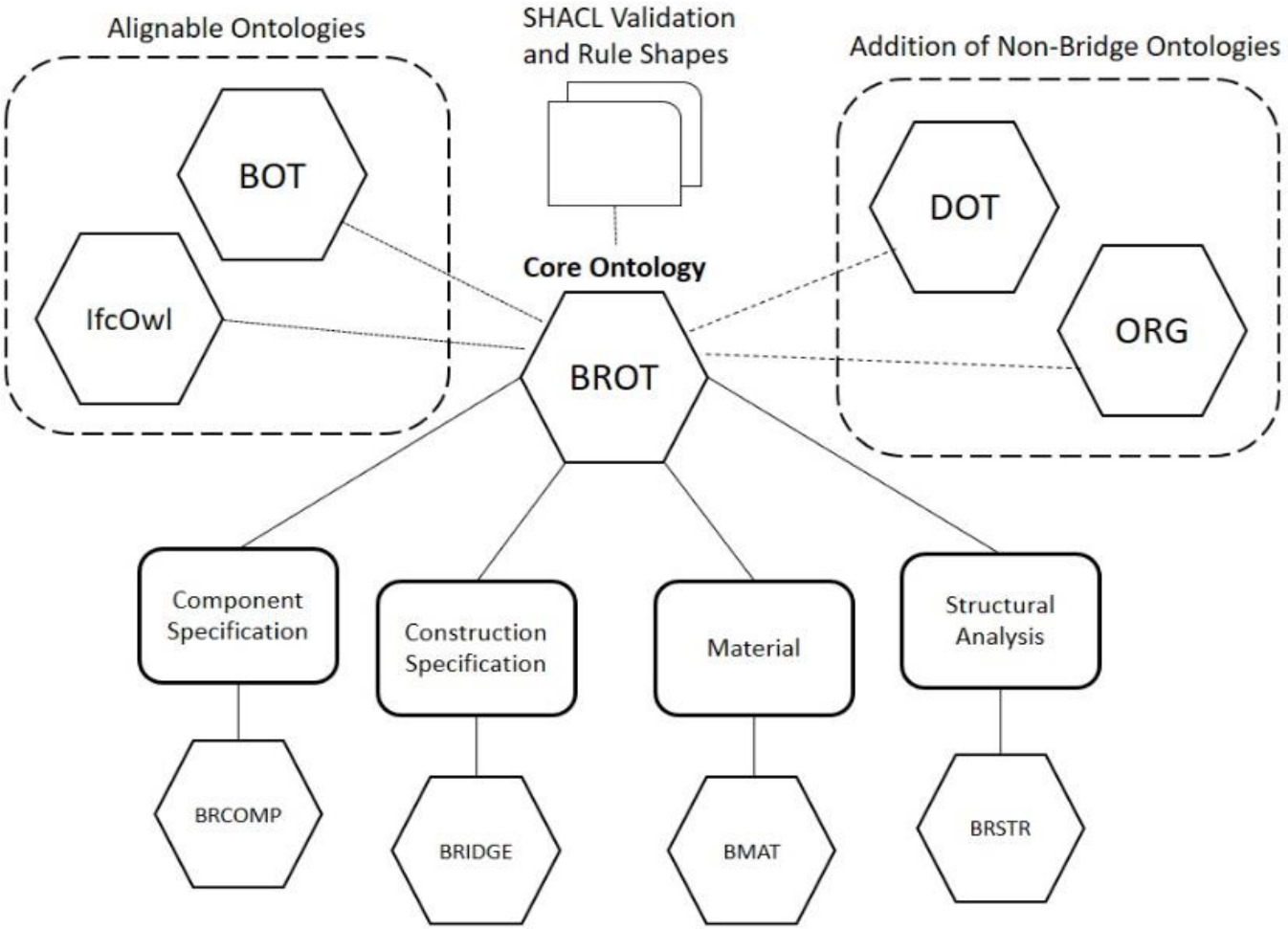
- 3D Bridge Models consist mainly of geometric data
- IFC-Bridge as IFC4 extension adds semantic data to bridge models
  - -> However benefits of Semantic Web Technology are not used for bridges

Introduction
Features of a bridge ontology

- Definition of topological relations between bridge components
- Detailed Classification of bridge components.
- Definition of various bridge-related information (dependent on the supported information domain)

- Specific requirements for the application of the bridge ontology in our research:
  - Supporting the definition of standard-related information (based on German standards (DIN 1076 / D-ASB-ING)
  - Description of the structural behaviour of the bridge
  - Definition of specific material information and key-parameters

Structure of the Bridge Ontology Framework
Overview



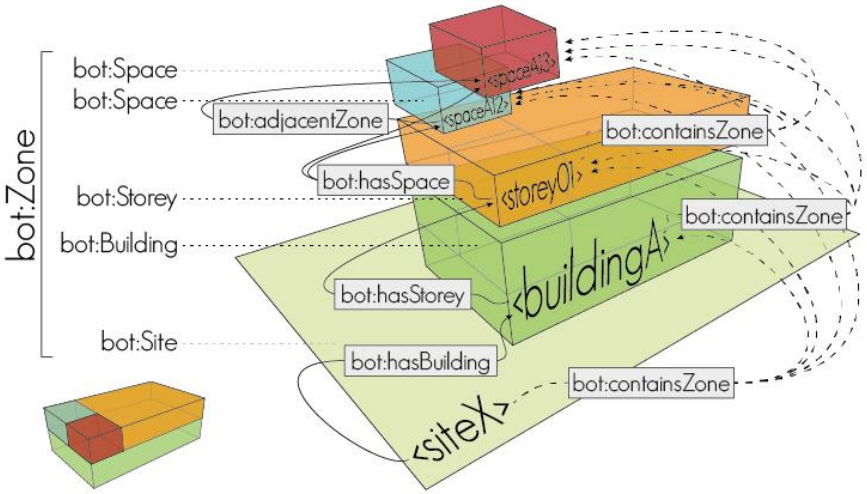
Structure of the Bridge Ontology Framework
Namespaces

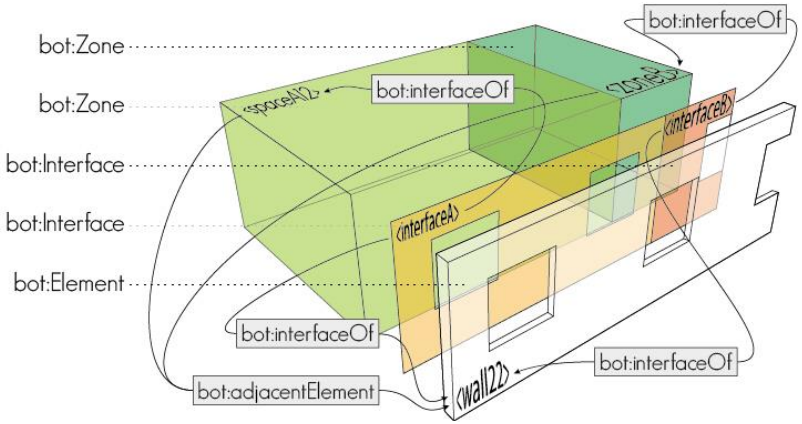
- Bridge Topology Ontology (BROT): https://w3id.org/brot
- Bridge Component Ontology (BRCOMP): https://w3id.org/brcomp
- Bridge Ontology (BRIDGE): https://w3id.org/bridge
- Building Material Ontology (BMAT): https://w3id.org/bmat
- Bridge Structure Ontology (BSTR): https://w3id.org/brstr

- Github: https://github.com/Alhakam/bridgeOntology

Structure of the Bridge Ontology Framework
Bridge Topology Ontology (BROT)

Based on the concepts of the Building Topology Ontology (BOT):

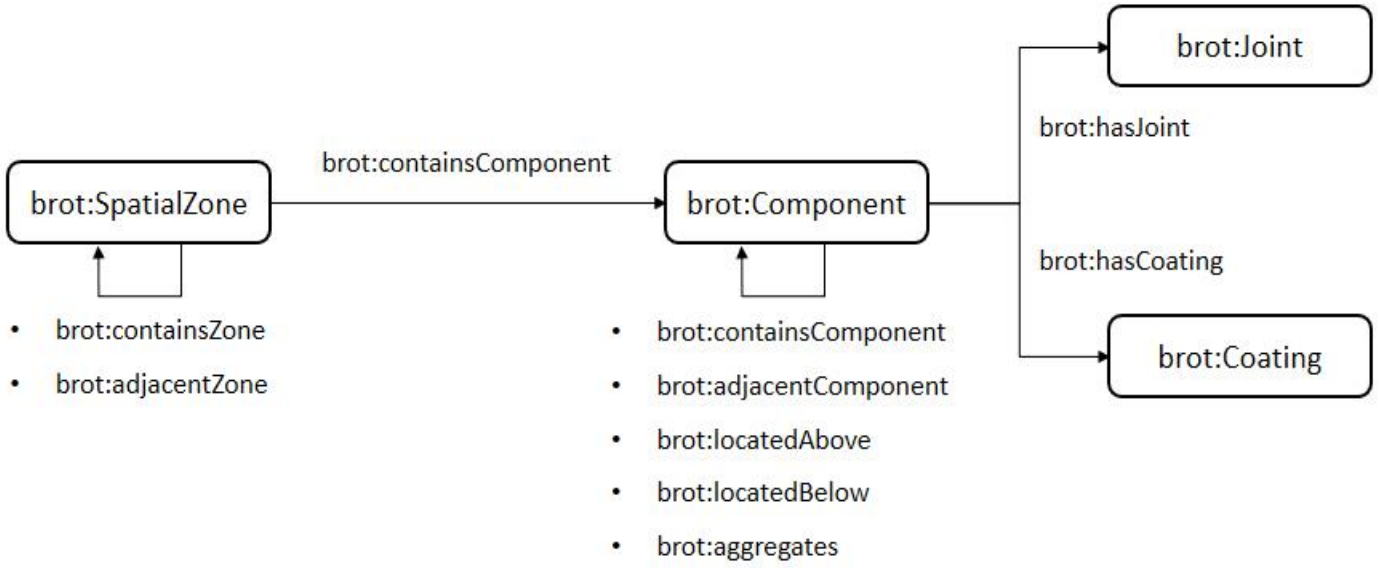




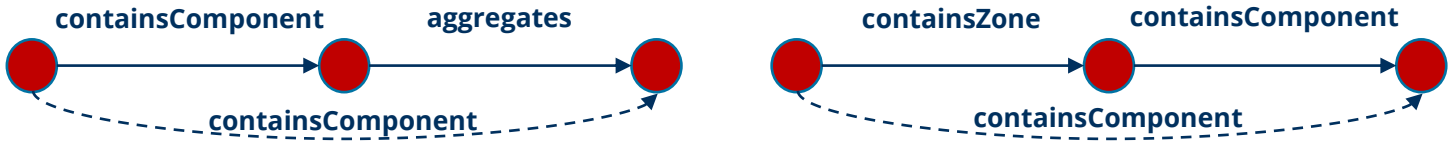
https://w3c-lbd-cg.github.io/bot/

Structure of the Bridge Ontology Framework
Bridge Topology Ontology (BROT)

General classes and object properties of BROT:

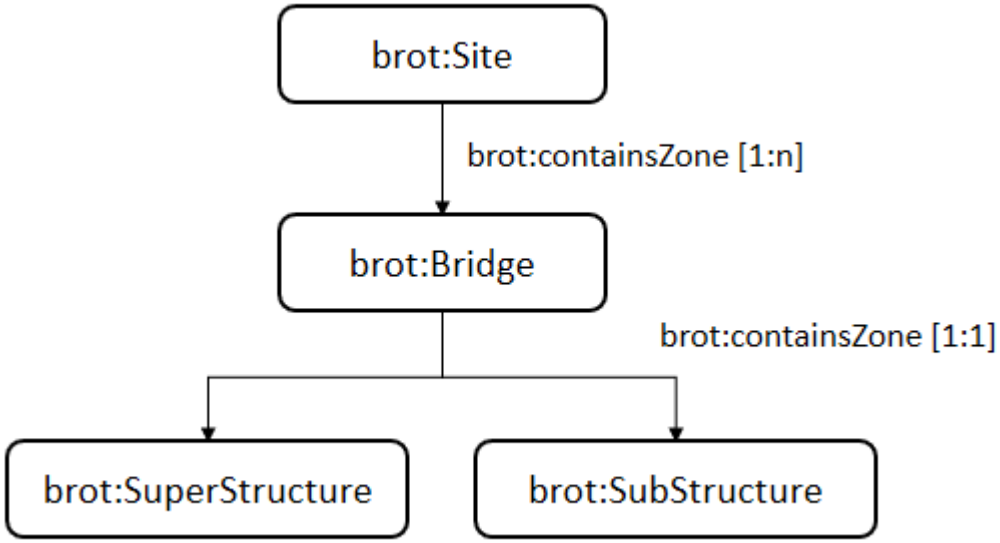


Property Chain Axioms:



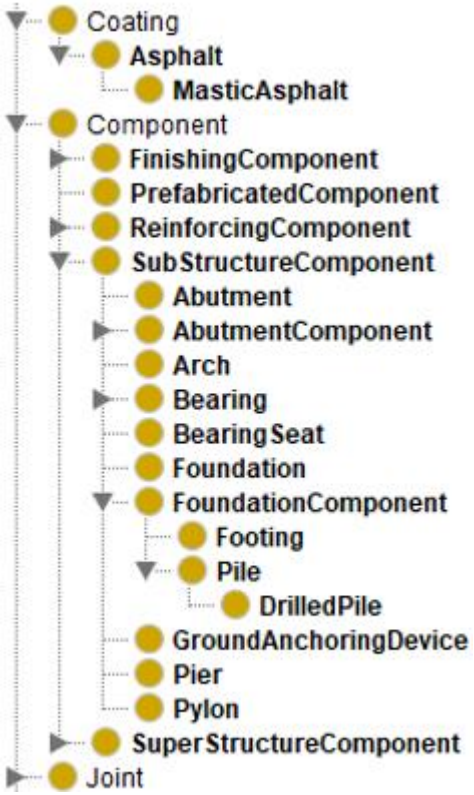
Structure of the Bridge Ontology Framework
Bridge Topology Ontology (BROT)

General classes and object properties of BROT:



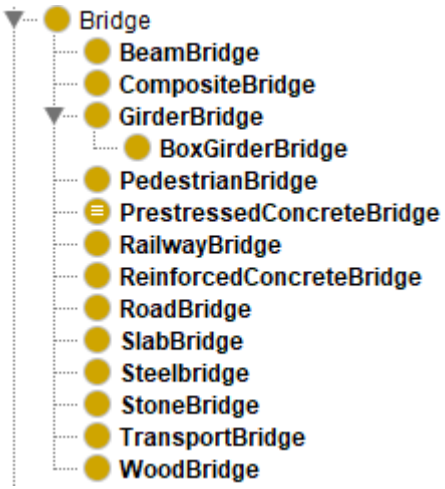
Structure of the Bridge Ontology Framework
Bridge Components Ontology

- Extends BROT with subclasses of brot:Component, brot:Coating and brot:Joint for further classification
- Adds data properties for characterizing bridge components



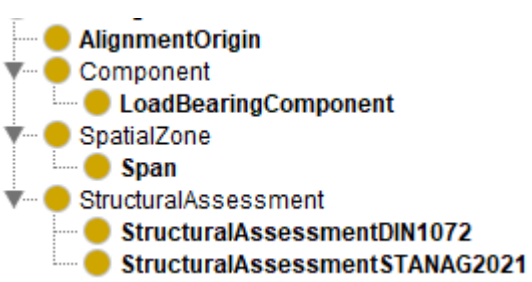
Structure of the Bridge Ontology Framework
Bridge Ontology

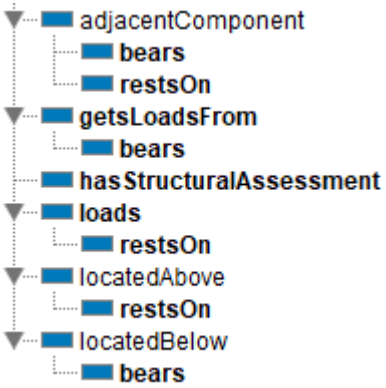
- Extends BROT with subclasses of brot:bridge for further classification
- Adds properties for characterizing the bridge structure

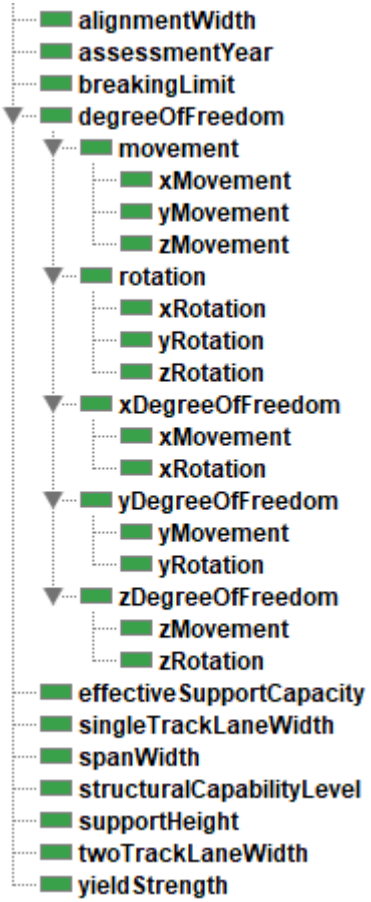


Structure of the Bridge Ontology Framework
Bridge Structure Ontology

- Adds classes and properties for describing the structural behaviour of the bridge structure and its components
- brstr:LoadBearingComponent (subclass of brot:Component) for defining load bearing components

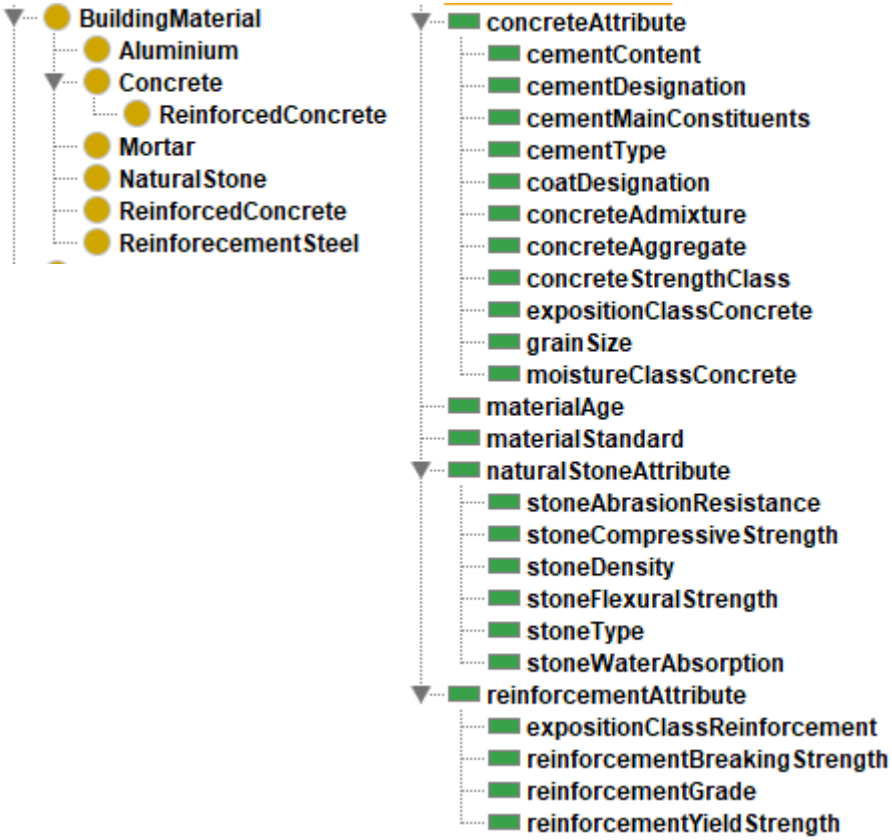






Structure of the Bridge Ontology Framework
Building Material Ontology

- Provides classes for defining building materials
- Instance of bmat:BuildingMaterial can be assigned to brot:Component via bmat:hasBuildingMaterial
- Provides data properties for characterization of building materials (mainly concrete and natural stones at the current version)



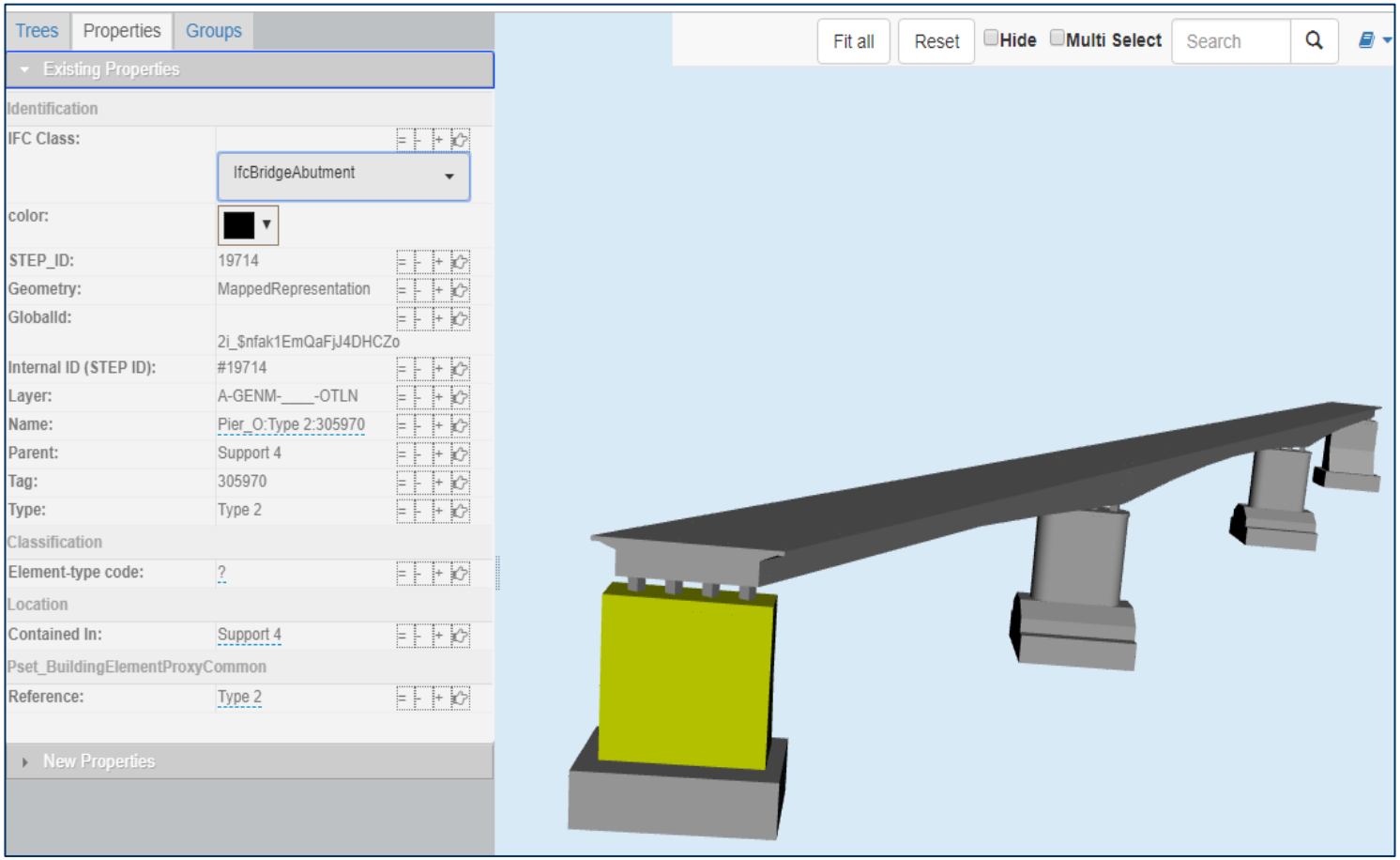
Alignment between BROT and AEC ontologies
BROT-BOT Alignment

Subject	Predicate	Object
bot:Element	owl:equivalentClass	brot:Component
bot:Zone	owl:equivalentClass	brot:SpatialZone
bot:containsZone	owl:equivalentProperty	brot:containsZone
bot:adjacentZone	owl:equivalentProperty	brot:containsZone
bot:containsElement	owl:equivalentProperty	brot:containsElement
bot:hasSubElement	owl:equivalentProperty	brot:aggregates

Alignment between BROT and AEC ontologies
BROT-IfcOWL Alignment

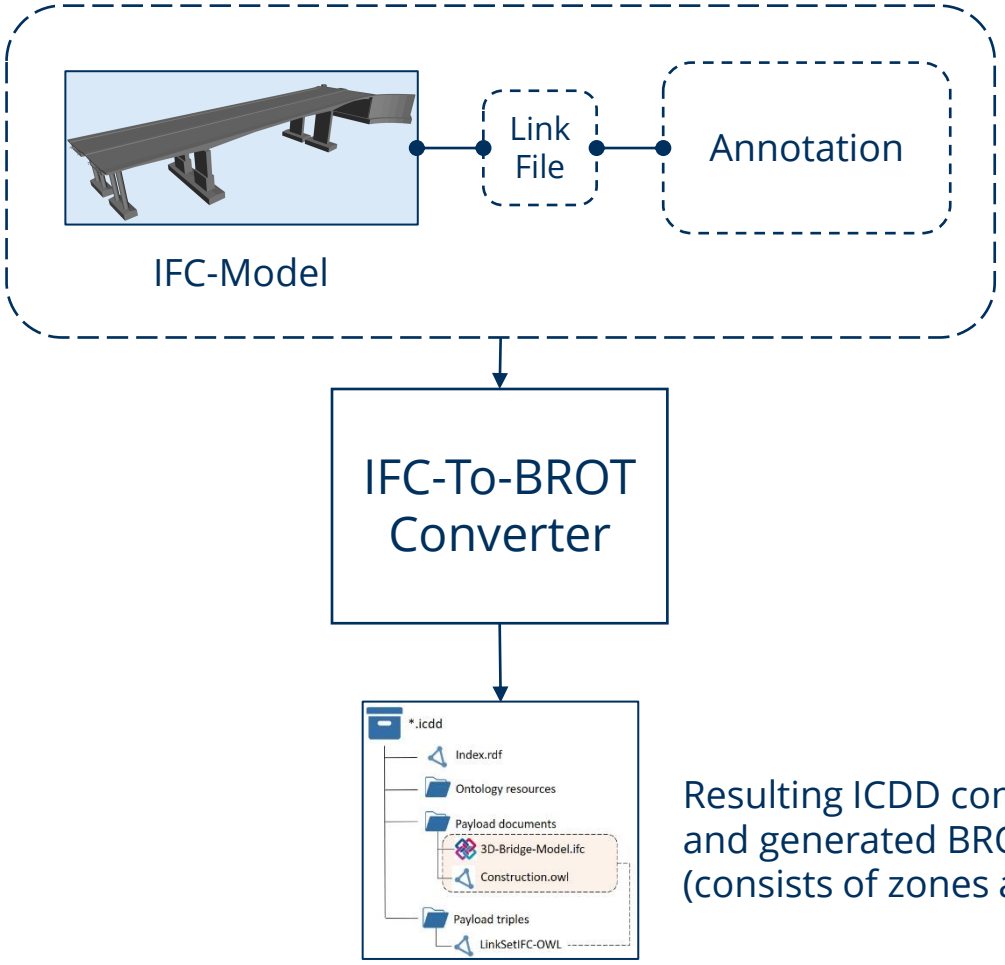
Subject	Predicate	Object
ifc:IfcSite	owl:equivalentClass	brot:Site
ifc:IfcBuilding	owl:equivalentClass	brot:Bridge
ifc:IfcBuildingElement	owl:equivalentClass	brot:Component
ifc:IfcSpatialStructureElement	owl:equivalentClass	brot:SpatialZone

Application of the Bridge Ontology Framework
IFC-Annotation



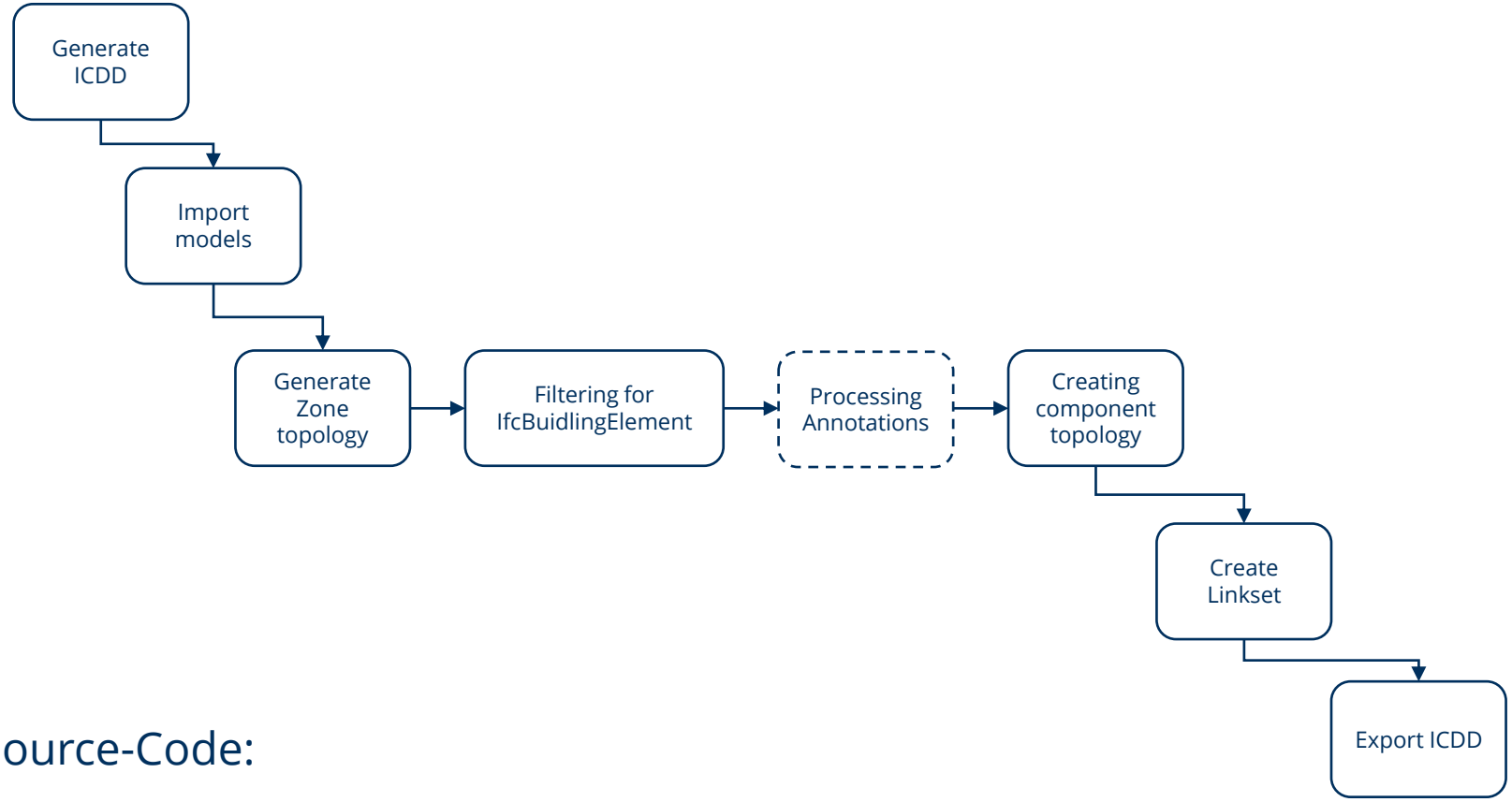
https://ifcwebserver.org/

Application of the Bridge Ontology Framework
Ontology Generation from IFC



Resulting ICDD containing the IFC-Model and generated BROT ontology (consists of zones and components)

Application of the Bridge Ontology Framework
Ontology Generation from IFC - Workflow

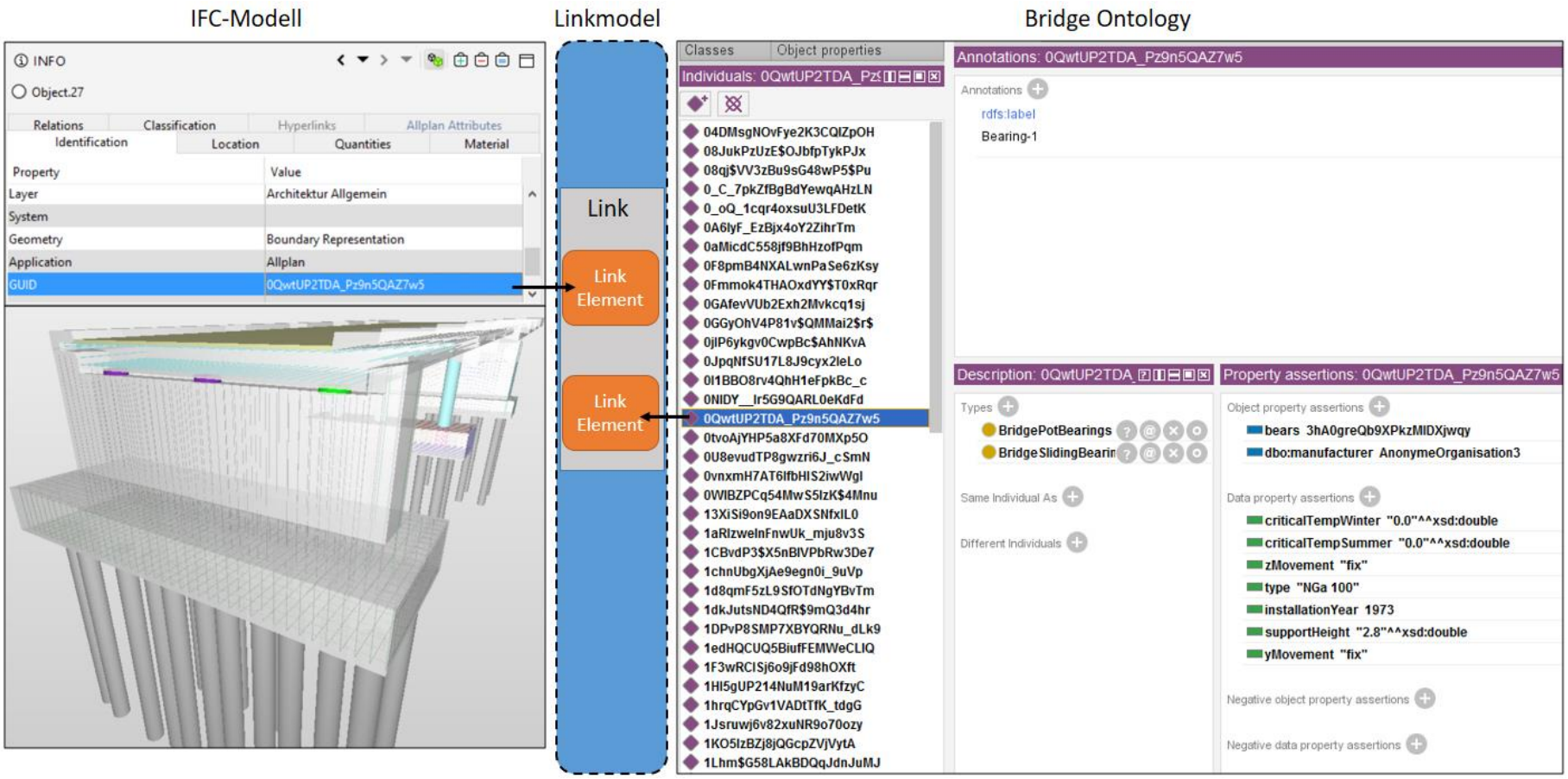


Source-Code:

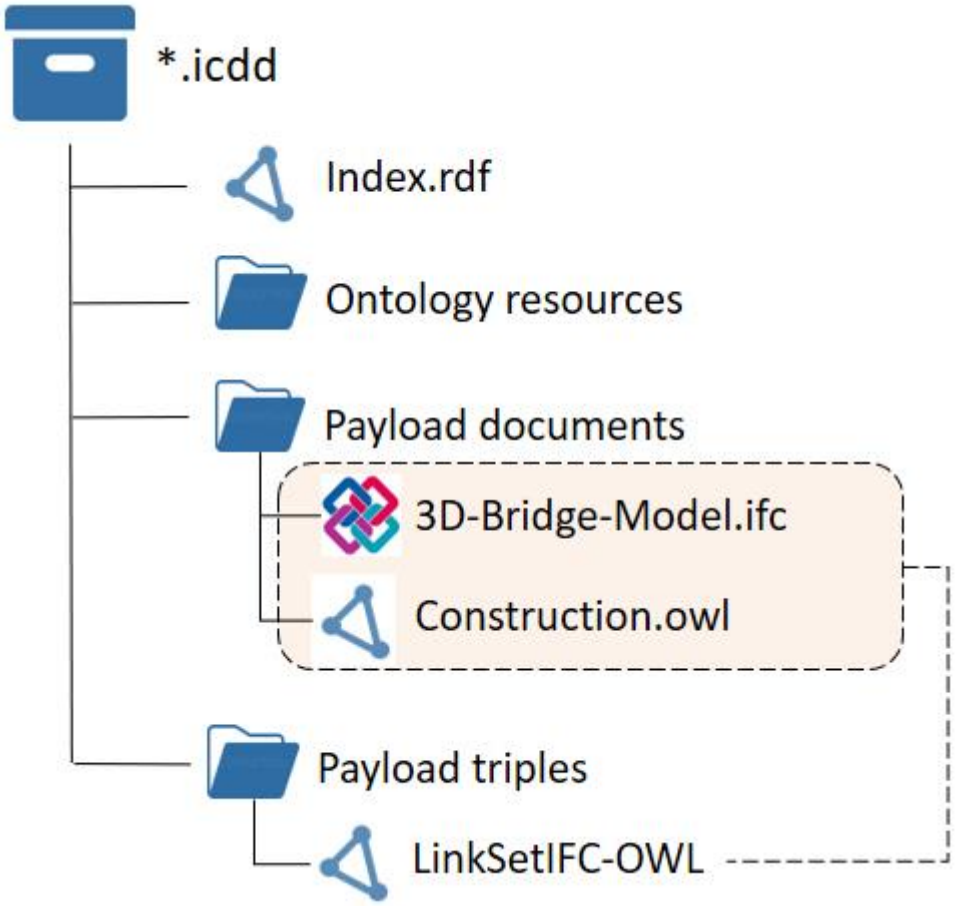
https://github.com/Alhakam/bridgeOntology/tree/master/IFCtoBROTConverter

Application of the Bridge Ontology Framework

Linking the ontology with other data / documents

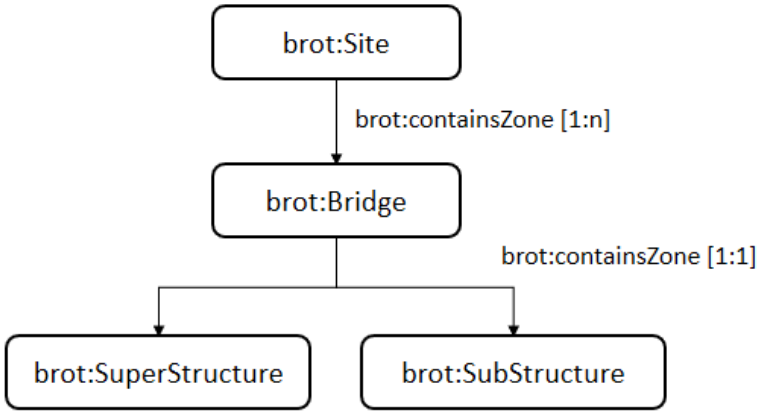


Application of the Bridge Ontology Framework
Linking the ontology with other data / documents



Application of SHACL
SHACL Validation

```
brot:Bridge
        a rdfs:Class , sh:NodeShape ;
        sh:property [
                rdf:type sh:PropertyShape ;
                sh:path brot:containsZone ;
                sh:class brot:SubStructure ;
                sh:minCount 1 ;
                sh:maxCount 1 ;
                sh:nodeKind sh:IRI ;
        ] ;
        sh:property [
                rdf:type sh:PropertyShape ;
                sh:path brot:containsZone ;
                sh:class brot:SuperStructure ;
                sh:minCount 1 ;
                sh:maxCount 1 ;
                sh:nodeKind sh:IRI ;
        ] ;
        sh:not [
                sh:property [
                rdf:type sh:PropertyShape ;
                sh:path brot:containsZone ;
                sh:class brot:Bridge ;
                sh:minCount 1 ;
                ]
        ]
.
```



Conclusion

- The presented ontologies are used for representing bridge constructions and their components
- The following information domains are covered by the ontology framework:
  - Bridge Topology (BROT)
  - Characterization of bridge components (BRCOMP)
  - Characterization of bridge structures (BRIDGE)
  - Classification of building materials and definition of material specific parameters (BMAT)
  - Description of information that are relevant for the structural analysis of a bridge (BRSTR)
- BROT functions as core ontology and is extended by the other bridge ontologies.
- Geometric data are defined in a separate geometry model (e.g. IFC) and linked with the ontology via ICDD
- The recommended topological structure and containment of mandatory parameters can be validated through SHACL shapes.

Many thanks for your attention!