



IFC as a data exchange format

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Learning outcomes

- At the end of this lecture, the learner is expected to be able to
 - Explain the role of IFC in the building and construction industry
 - Explain basic concepts used in IFC
 - Objects and entities, inheritance and properties
 - Basic IFC entities such as IfcWall
 - Describe the basic structure of an IFC file in STEP format
 - Analyze the content of an IFC file and relate its STEP entities to the IFC standard

Resources to download / view

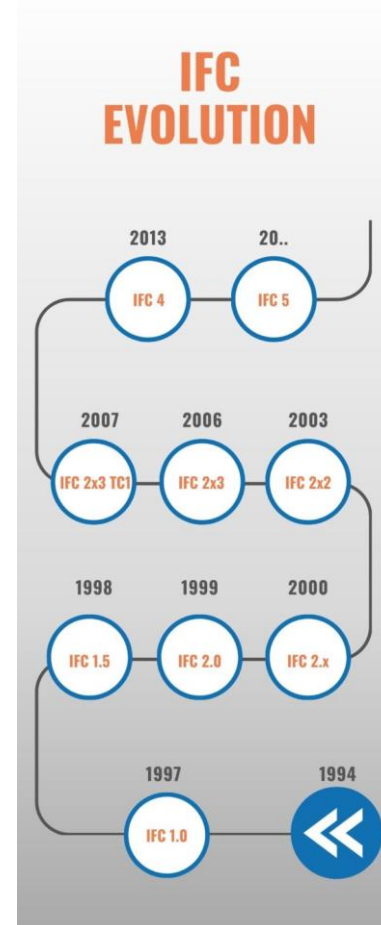
- usBIM.viewer+ (free viewer, <https://www.accasoftware.com/en/freeware/usbim.viewer+>)
- An IFC file (<https://www.ifcwiki.org/index.php?title=File:AC20-FZK-Haus.ifc>)
- Technical documentation of IFC version 4.0.2.1 (https://standards.buildingsmart.org/IFC/RELEASE/IFC4/ADD2_TC1/HTML/).
- FreeCAD software (optional) <https://www.freecad.org/downloads.php>
- Additional reading
 - <https://biblus.accasoftware.com/en/ifc-file-structure-the-ifcobjectdefinition/>

The IFC standard



- IFC (Industrial Foundation Classes) is a standard dealing with processes, data, terms and change management.
- Aims to reduce costs by enabling better collaboration and digital workflows
- Developed by buildingSMART International, <https://www.buildingsmart.org/>
- Open ISO standard ([ISO 16739-1:2018](#))
- Often used for transferring BIM data
- Is meant to be a reference copy of the design
 - "The BIM version of PDF's"
 - <https://youtu.be/9YgXXbdohOQ>

IFC Evolution

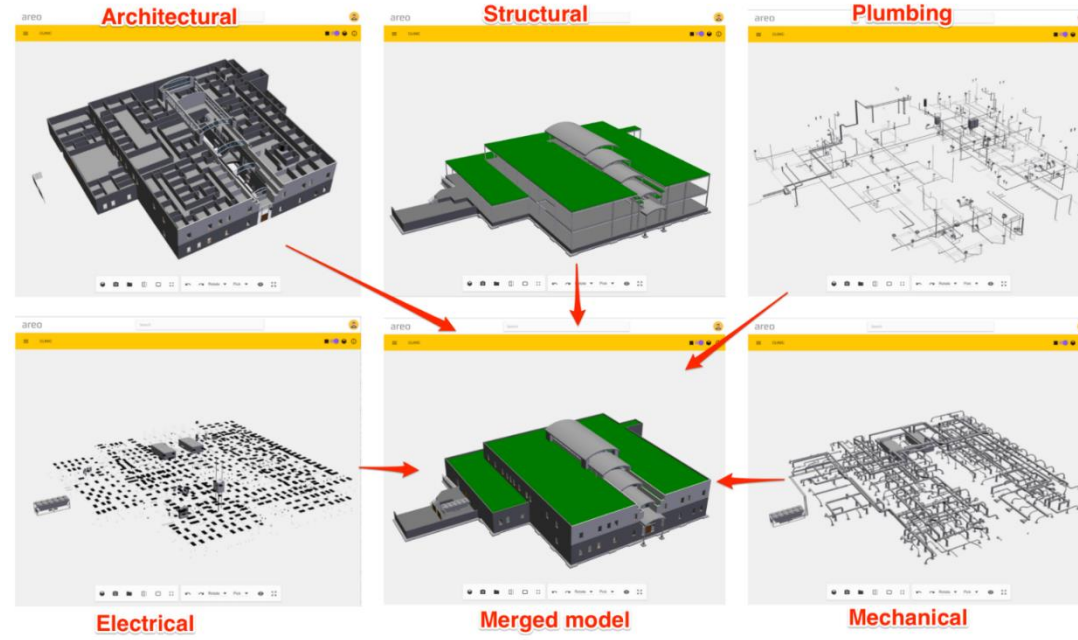


Source: <https://www.buildingsmart.org/>

Historical background

- In object-oriented programming, a class is a specification of a set of objects. A class consists of code (procedures or methods) and data (attributes or properties)
- In 1992, Microsoft introduced Microsoft Foundation Classes (MFC). This is an object-oriented library for developing C/C++ applications for Windows. By using Windows application calls, external software could be made looking like Windows applications. The most popular classes dealt with menus, controllers and all windows-like gadgets.
- In 1994, BuildingSMART started to develop Industrial Foundation Classes, which is an object-oriented library for reusing BIM data objects. The goal was to use IFC-based application calls, when reusing data from other BIM models
- Also in 1994, the Open Geospatial Consortium (OGC) was formed, aiming to improve interoperability in the GI sector. The first OGC standards specified standardised application calls to be used by various GIS software vendors
- A few years earlier, in 1989, the World Wide Web was invented. It was made public in 1991. The usage of WWW was quite limited in 1994, when the development of IFC and OGC standards started. As web technologies became more mature, the interest of data sharing increased and the API calls using internet protocols (HTTP) was more in focus of the developments

The role of IFC in BIM collaboration



From <https://blog.areo.io/what-is-ifc/> During design and construction each discipline typically have their own model. The models are merged or referenced for design and production coordination tasks

BIM collaboration – some benefits

- Improved communication and coordination
 - A common language for exchanging information
- Increased efficiency
 - Streamlining workflows
- Reduced costs
 - Eliminating the need to convert BIM data between different software applications
- Supported by a wide range of BIM software applications.
 - This makes it easy for project stakeholders to exchange BIM data regardless of the software they are using.

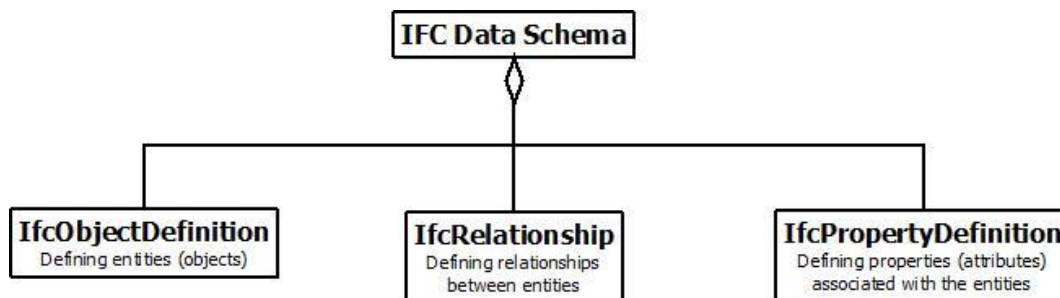
Interoperability levels

- **Interoperability** is a characteristic of a product or system to work with other products or systems.
- Syntactic interoperability: Common **data formats**. Examples: XML, SQL, STEP
- Semantic interoperability: The systems have a shared understanding of the **meaning** of the concepts
- Organisational interoperability: The output of a process in one organisation can directly **be used in another process** in another organisation

Dataset schema

- The **schema of a dataset** is describing the structure of the dataset, often by using a formal language.
- The term "schema" refers to the organization of data as a blueprint of how the dataset is constructed
- A relational database consists of table, where each table has a name and a set of columns. The schema specify, among other things, the names of the tables and the names, data type and other characteristics of the columns of each table. In many relational database systems, the schema is also stored as tables, but having reserved names and columns and cannot be modified by ordinary users. In such cases, the specification of the schema is made by using SQL statements.
- An XML file consist of elements, sub-elements and attributes. An XML schema (.xsd file) specify the names of the elements and attributes as well as other properties (cardinality etc). The formal language for specifying an XML schema is also XML.

IFC data schema

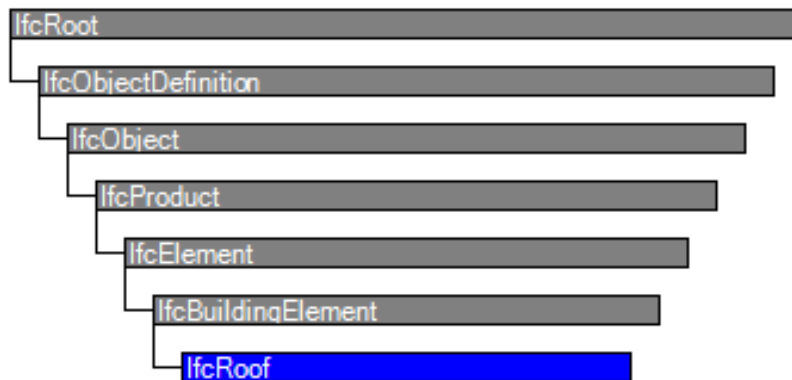


- The IFC classes have no code, only data
- Three types of classes
 - IfcObjectDefinition
 - IfcRelationship
 - IfcPropertyDefinition
- IFC data may be encoded using
 - STEP (ISO 10303-21), first release in 1994
 - XML (first W3C recommendation in 1998)

Object inheritance in IFC

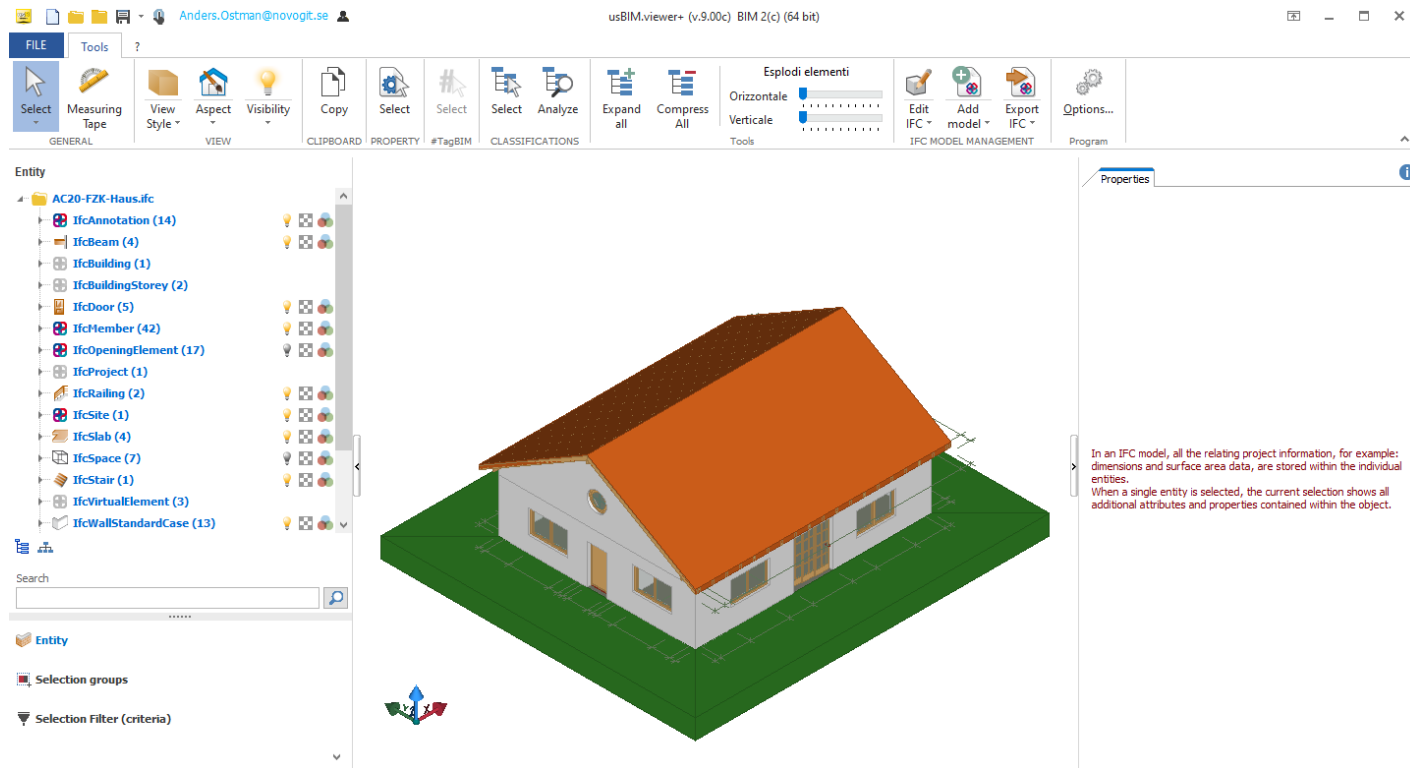
6.1.3.34.2 Inherited definitions from supertypes

Entity inheritance




Source: https://standards.buildingsmart.org/IFC/RELEASE/IFC4/ADD2_TC1/HTML/

Analysing an IFC file using usBIM



Open the IFC file in a text editor

 AC20-FZK-Haus.ifc - Anteckningar

Arkiv Redigera Format Visa Hjälp

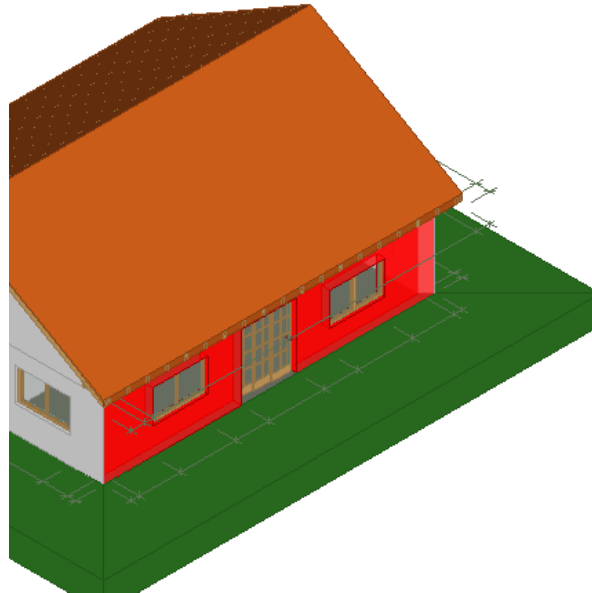
```
ISO-10303-21;  
HEADER;FILE_DESCRIPTION(('ViewDefinition [, QuantityTakeOffAddOnView, SpaceBoundary2ndLevelAdd  
metry: As boundary representation (BRep)]','Option [IFC Site Location: At Project Origin]','Op  
FILE_NAME('S:\\[IFC]\\[COMPLETE-BUILDINGS]\\FZK-MODELS\\FZK-Haus\\ArchiCAD-20\\AC20-FZK-Haus.i  
FILE_SCHEMA(('IFC4'));  
ENDSEC;
```

```
DATA;  
#1= IFCPERSON($,'Nicht definiert',$,$,$,$,$);  
#3= IFCORGANIZATION($,'Nicht definiert',$,$,$);  
#7= IFCPERSONANDORGANIZATION(#1,#3,$);  
#10= IFCORGANIZATION('GS','GRAPHISOFT','GRAPHISOFT',$,$);  
#11= IFCAPPLICATION(#10,'20.0.0','ARCHICAD-64','IFC2x3 add-on version: 4009 GER FULL');  
#12= IFCOWNERHISTORY(#7,#11,$,.ADDED,$,$,$,1482339244);  
#13= IFCSIUNIT(*,.LENGTHUNIT,$,.METRE.);  
#14= IFCSIUNIT(*,.AREAUNIT,$,.SQUARE_METRE.);  
#15= IFCSIUNIT(*,.VOLUMEUNIT,$,.CUBIC_METRE.);  
#16= IFCSIUNIT(*,.PLANEANGLEUNIT,$,.RADIAN.);  
#17= IFCMEASUREWITHUNIT(IFCPLANEANGLEMEASURE(0.0174532925199),#16);  
#18= IFCDIMENSIONALEXPONENTS(0,0,0,0,0,0,0);  
#19= IFCCONVERSIONBASEDUNIT(#18,.PLANEANGLEUNIT,'DEGREE',#17);  
#21= IFCSIUNIT(*,.SOLIDANGLEUNIT,$,.STERADIAN.);  
#22= IFCMONETARYUNIT('EUR');  
#23= IFCSIUNIT(*,.TIMEUNIT,$,.SECOND.);  
#24= IFCSIUNIT(*,.MASSUNIT,$,.GRAM.);  
#25= IFCSIUNIT(*,.THERMODYNAMICTEMPERATUREUNIT,$,.DEGREE_CELSIUS.);
```

STEP file structure

- STEP (ISO 10303-21) is the default encoding of IFC files
- Main structure of a STEP file
 - Header
 - Data section
 - #InstanceNumber = EntityType(Links and properties)
 - InstanceNumber must be a positive integer and unique -> Do not merge two IFC data files
 - Unset property values are written as a "\$"-character
- Example (AC20-FZK-Haus)
 - #10= IFCORGANIZATION('GS','GRAPHISOFT','GRAPHISOFT',\$,\$);
 - #11= IFCAPPLICATION(#10,'20.0.0','ARCHICAD-64','IFC2x3 add-on version: 4009 GER FULL');

Finding entity number



Properties	
Characteristics	
ContainedInStructure	ContainedInStructure IfcBuildingStorey 'Erdgeschoss' (;
General Data	
Class	IfcWallStandardCase
GlobalId	16DNNqzfP2thtfaOfIvsKA
Name	Wand-Ext-ERDG-4
Geometrical Representation	
Axis	Curve2D
Body	SweptSolid
Bounding Box (Altezza)	2.7000 [Meters]
Bounding Box (Lunghezza)	12.0000 [Meters]
Bounding Box (Spessore)	0.3000 [Meters]
Box	BoundingBox
SurfaceColor	[255, 255, 255, 255]
Volume	6.6049 [Metri Cubi]
Z Max	2.7000 [Meters]
Z Min	0.0000 [Meters]
IfcObjectPlacement	
Axis	[0.0000; 0.0000; 1.0000]
Location	[12.0000; 0.0000; 0.0000] [Metri]
PlacementRelTo	IfcBuildingStorey 'Erdgeschoss'
RefDirection	[-1.0000; 0.0000; 0.0000]
IfcOwnerHistory	
IfcOwnerHistory	
ChangeAction	.ADDED.
CreationDate	21/12/2016 16:54:04
OwningApplication	
Identifier	IFC2x3 add-on version: 4009 GEI
Name	ARCHICAD-64
Version	20.0.0

#27421= IFCWALLSTANDARDCASE('16DNNqzfP2thtfaOfIvsKA',#12,'Wand-Ext-ERDG-4',\$,,\$,#27374,#27416,'A6C3DE63-3731-4F6A-94-7E-DE8A8295779F',\$);

Entity inheritance

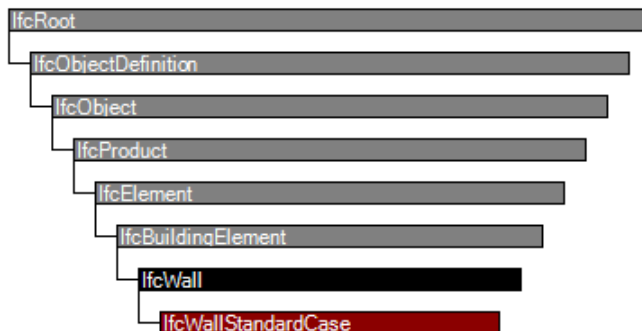
Search for IfcWallStandardCase in the Index chapter

Formal Propositions

Rule	Description
HasMaterialLayerSetUsage	A valid instance of IfcWallStandardCase relies on the provi

6.1.3.48.2 Inherited definitions from supertypes

Entity inheritance



Attribute inheritance

Inherited properties for #27421

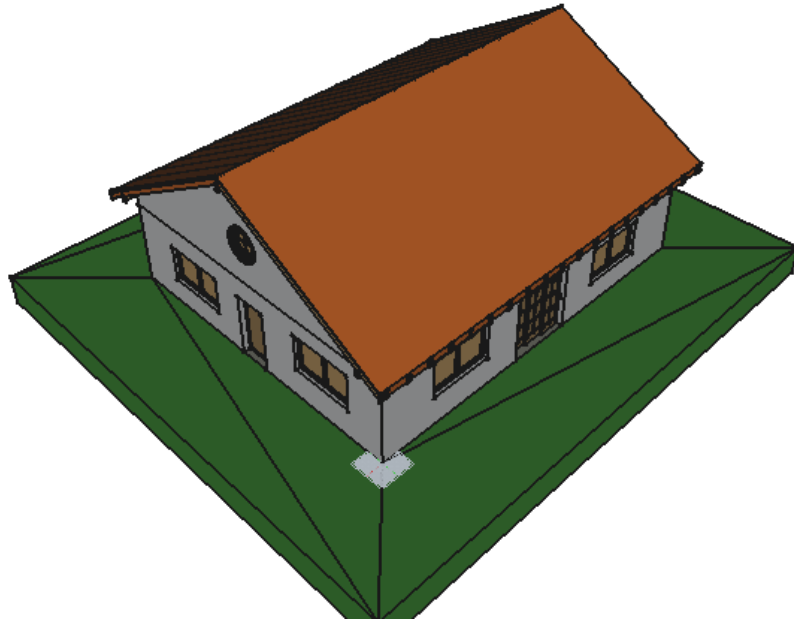
```
IfcRoot(GlobalId, OwnerHistory, Name, Description)
  IfcObjectDefinition()
    IfcObject(ObjectType)
      IfcProduct(ObjectPlacement, Representation)
        IfcElement(Tag)
          IfcBuildingElement()
            IfcWall()
```

```
IfcWallStandardCase(GlobalId, OwnerHistory, Name, Description, ObjectType, ObjectPlacement, Representation, Tag,
IfcMaterialLayerSetUsage)
```

```
#12= IFCOWNERHISTORY(#7,#11,$,.ADDED.,$,,$,1482339244);
#27374= IFCLOCALPLACEMENT(#477,#27373);
#27416= IFCPRODUCTDEFINITIONSHAPE($,$,(#27399,#27405,#27413));
```

```
#27421= IFCWALLSTANDARDCASE('16DNNqzfp2thtfaOfIvsKA',#12,'Wand-Ext-ERDG-4',$,$,#27374,#27416,'A6C3DE63-3731-4F6A-94-7E-DE8A8295779F',$);
```

Analysing an IFC file using FreeCAD



Finding entity number in FreeCAD

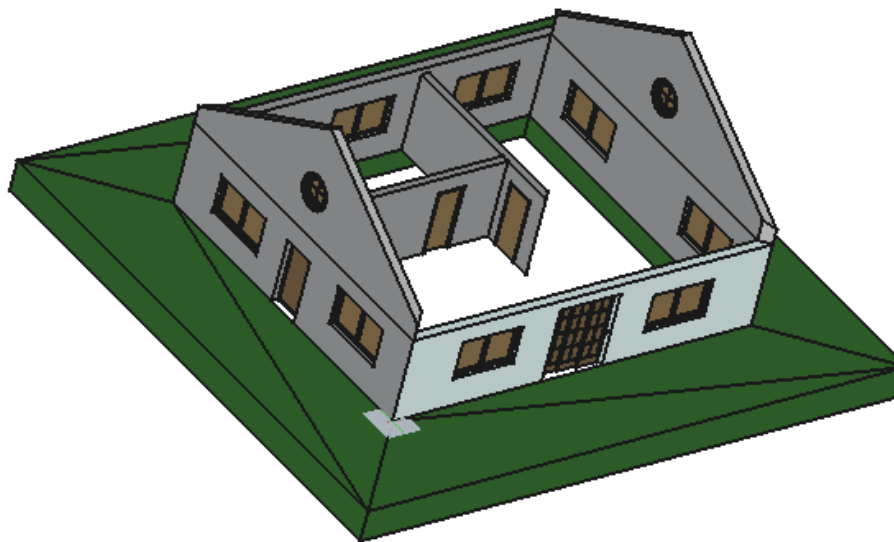
Lista med valda objekt

Uppgifter

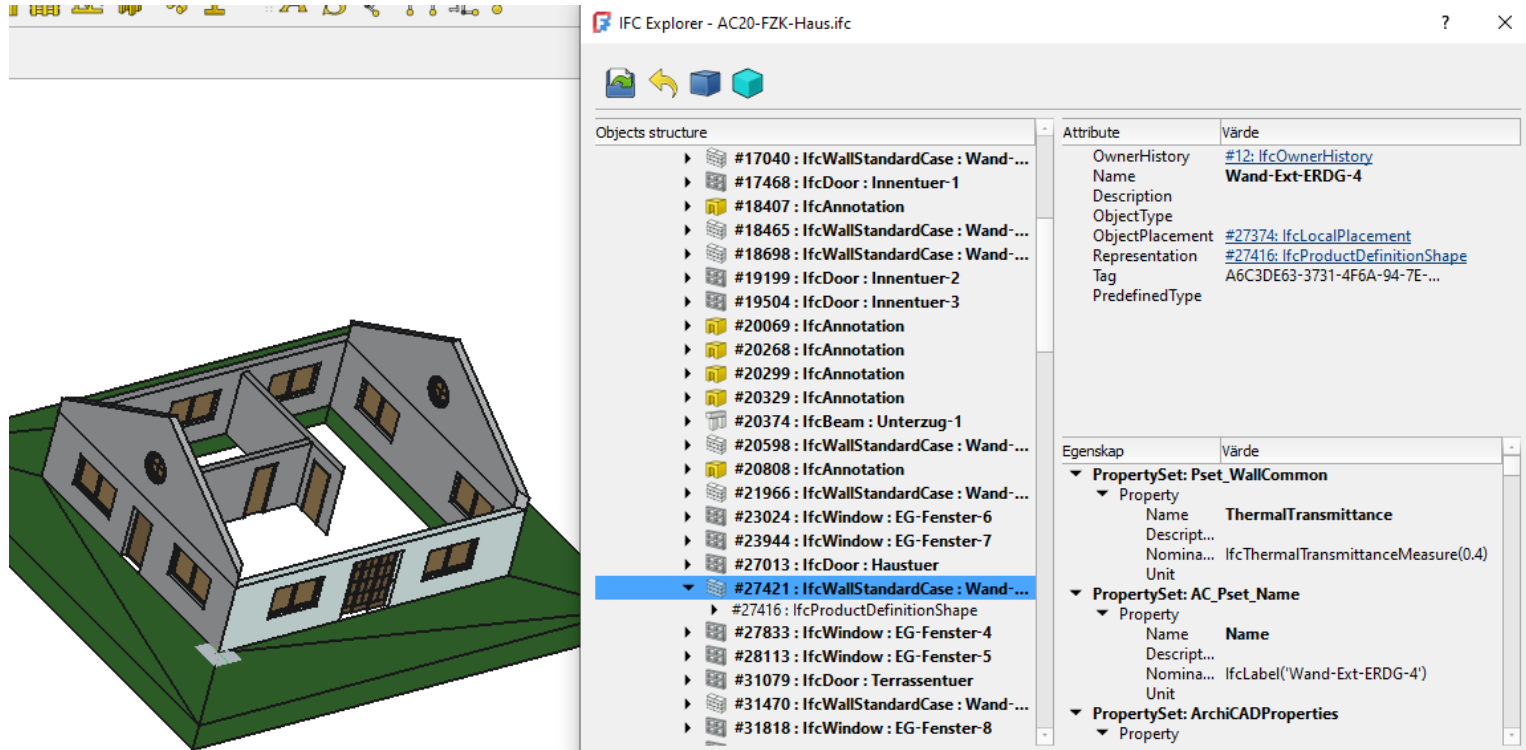
Modell

- Projekt-FZK-Haus
 - Gelaende
 - Layers
 - _IfcVirtualElement
 - _IfcVirtualElement001
 - _IfcVirtualElement002

Class	IfcWallStandardCase
Description	
Global Id	16DNNqzfP2thtfaOfivsKA
Object Type	
Predefined ...	NOTDEFINED
Step Id	27421
Tag	A6C3DE63-3731-4F6A-94-7E-DE8A829...



Analysing IFC file in FreeCAD



The image shows the FreeCAD software interface with the IFC Explorer plugin loaded. On the left, a 3D isometric view of a house model is displayed. The main window is titled "IFC Explorer - AC20-FZK-Haus.ifc". It features a tree view on the left labeled "Objects structure" and a property editor on the right.

Objects structure

- #17040 : IfcWallStandardCase : Wand-...
- #17468 : IfcDoor : Innentuer-1
- #18407 : IfcAnnotation
- #18465 : IfcWallStandardCase : Wand-...
- #18698 : IfcWallStandardCase : Wand-...
- #19199 : IfcDoor : Innentuer-2
- #19504 : IfcDoor : Innentuer-3
- #20069 : IfcAnnotation
- #20268 : IfcAnnotation
- #20299 : IfcAnnotation
- #20329 : IfcAnnotation
- #20374 : IfcBeam : Unterzug-1
- #20598 : IfcWallStandardCase : Wand-...
- #20808 : IfcAnnotation
- #21966 : IfcWallStandardCase : Wand-...
- #23024 : IfcWindow : EG-Fenster-6
- #23944 : IfcWindow : EG-Fenster-7
- #27013 : IfcDoor : Haustuer
- #27421 : IfcWallStandardCase : Wand-... (selected)
- #27416 : IfcProductDefinitionShape
- #27833 : IfcWindow : EG-Fenster-4
- #28113 : IfcWindow : EG-Fenster-5
- #31079 : IfcDoor : Terrassentuer
- #31470 : IfcWallStandardCase : Wand-...
- #31818 : IfcWindow : EG-Fenster-8

Attribute

Attribute	Wärde
OwnerHistory	#12: IfcOwnerHistory
Name	Wand-Ext-ERDG-4
Description	
ObjectType	
ObjectPlacement	#27374: IfcLocalPlacement
Representation	#27416: IfcProductDefinitionShape
Tag	A6C3DE63-3731-4F6A-94-7E-...
PredefinedType	

Eigenschaft

Eigenschaft	Wärde
PropertySet: Pset_WallCommon	
Property	
Name	ThermalTransmittance
Description	
Nomina...	IfcThermalTransmittanceMeasure(0.4)
Unit	
PropertySet: AC_Pset_Name	
Property	
Name	Name
Description	
Nomina...	IfcLabel('Wand-Ext-ERDG-4')
Unit	
PropertySet: ArchiCADProperties	
Property	

IFC Model Views and File Management

- Model Views are standardised subsets of the entire IFC model.
- In the future, the Model View standards may be superseded by IDS (Information Delivery Specification).
- In large projects or large organizations, a database-oriented management of data is required.

Summary

- IFC is mainly used for transferring BIM data between actors participating in a BIM project
- Basic IFC concepts have been reviewed
 - Objects and entities, inheritance, properties
 - Basic IFC entities, such as IfcWallStandardCase, IfcOwnerHistory etc, are specified in the IFC technical guidelines
- An Ifc file in STEP format consists of
 - A header
 - A set of entities compliant with the IFC standard, with links to other entities and properties assigned.

List of references

ACCAsoftware, 2020. IFC file structure (part 1): the IfcObjectDefinition.
<https://biblus.accasoftware.com/en/ifc-file-structure-the-ifcobjectdefinition/>

buildingSMART, 2018. Industry Foundation Classes 4.0.2.1.
https://standards.buildingsmart.org/IFC/RELEASE/IFC4/ADD2_TC1/HTML/

Van Berlo L, Krijnen T, Tauscher H, Liebich T, van Kranenburg A, Paasiala P, 2021.
Future of the Industry Foundation Classes: towards IFC 5.
https://www.buildingsmart.org/wp-content/uploads/2021/06/IFC_5.pdf.

Thank you for your attention



<https://birgitproject.eu/>

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