

**Erasmus+ Project 2022-1-NO01-KA220-HED-000087893**

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**BIM-LCA Construction Project**

**Title: Open BIM software workflow for LCA, an introduction.**



## 1 – Aims

The objectives of this tutorial about Open BIM and LCA workflow are as follows:

- Learning about the importance of Open BIM.
- Knowing about Open BIM Technologies of Cype as an example of Open BIM approach.
- Knowing BIMserver.center, a Common Data Environment that works with Open BIM formats.
- Learning about a workflow that uses Open BIM technologies to perform Live Cycle Analysis (LCA) of Buildings
- Knowing about some software involve in Open BIM workflow to perform LCA.

## 2 - Learning methodology

The teacher will give an explanation about Open BIM software workflow for LCA of about 30 minutes.

Students will read this tutorial and follow the steps shown in the tutorial, namely:

- Open BIM.
  - What is Open BIM
- Open BIM technology of Cype
  - Open BIM of Cype
  - BIMserver.center
- Open BIM workflow for LCA
- LCA Excel Project app.
- CYPE software for OpenBIM - LCA workflow.
  - CypeCad
  - Cype Architecture
  - Open BIM Construction Systems.
  - Open BIM Quantities.

In order to evaluate the success of the application, a questionnaire will be held for the students.

## 3 - Tutorial duration

The implementation described in this tutorial will be carried out through the BIM-LCA Project website by self-learning.



2 lesson hours are suitable for this training.

#### **4 – Necessary teaching recourses**

Computer room with PCs with internet access.

Required software: Microsoft Office.

## 5 – Contents & tutorial

### 5.1 – Open BIM.

#### 5.1.1. What is Open BIM

Basically, **Open BIM** means making use of the BIM methodology but using open BIM formats, such as the IFC, to exchange information between the agents involved in the process of design, construction or maintenance of a building or an infrastructure.

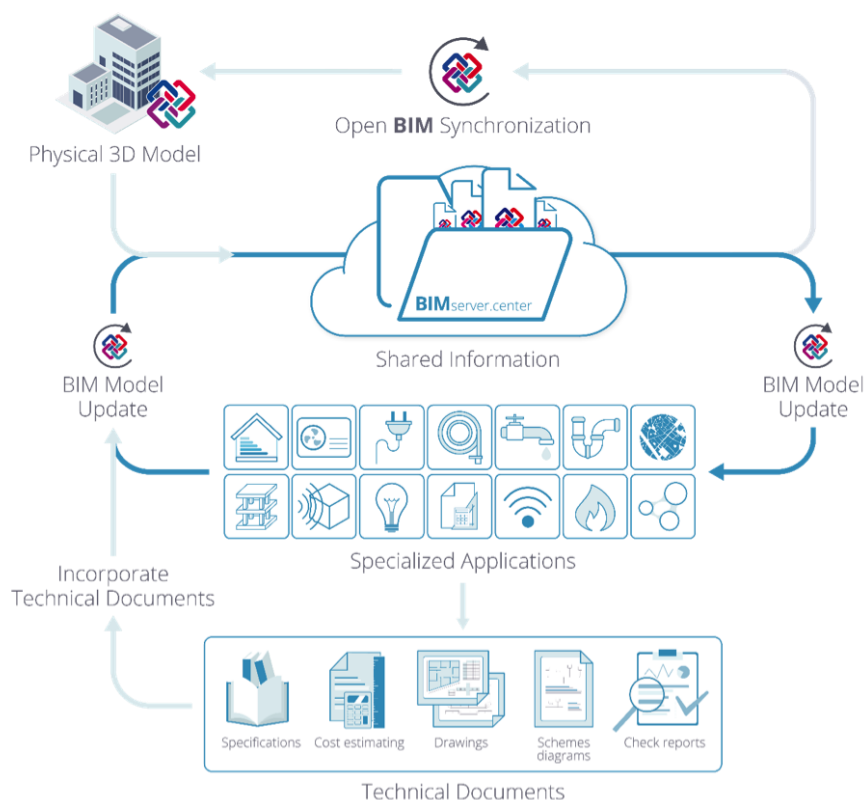
According to buildingSMART, **Open BIM** [1] is a collaborative process that extends the benefits of **BIM** (Building Information Modeling) by improving the accessibility, usability, management, and sustainability of digital data in the built asset industry. These are some important aspect about openBIM:

- **Vendor-Neutral Collaboration:** At its core, openBIM is a **vendor-neutral** approach. It allows different stakeholders involved in a building or infrastructure project to collaborate seamlessly. Unlike proprietary solutions, openBIM processes focus on sharable project information that supports collaboration for all project participants<sup>1</sup>.
- **Interoperability:** openBIM facilitates **interoperability** by using **neutral, non-proprietary file formats**. This means that every project member can use the best tools for their specific workflow without being locked into a single vendor. Additionally, any stakeholder can access the BIM model without interfering with the native design [2].
- **Benefits and Standards:** The benefits of openBIM include flexibility of technology choice, long-term sustainability through interoperable data standards, and enhanced collaboration workflows. The organization responsible for determining the standards that apply to openBIM is **buildingSMART International**. They develop and maintain industry standards such as **IFC** (Industry Foundation Classes), **bSDD** (buildingSMART Data Dictionary), and **BCF** (BIM Collaboration Format). IFC, in particular, is standardized by the International Standards Organization (ISO), providing a common language for exporting and importing data across the AECO (Architecture, Engineering, Construction, and Operations) community<sup>1</sup>.
- **Software Certification:** In 2019, buildingSMART introduced **IFC4 software certification**, which ensures that software applications adhere to openBIM standards. Certification enables clients to specify the delivery of services and data without worrying about format, compatibility, or versioning of platforms used by service providers or internally by the client. The certification includes specific view definitions, such as the Design Transfer View, which supports the transfer of model data for further design, analysis, estimating, and facility management tasks<sup>1</sup>.

In summary, openBIM promotes collaboration, interoperability, and sustainable data standards, benefiting projects and assets throughout their lifecycle.

## 5.2 – Open BIM technology of Cype.

Open BIM technology [3] enables a collaborative workflow for architecture, engineering, and construction projects. It fosters coordination among all technical specialists within the project team.

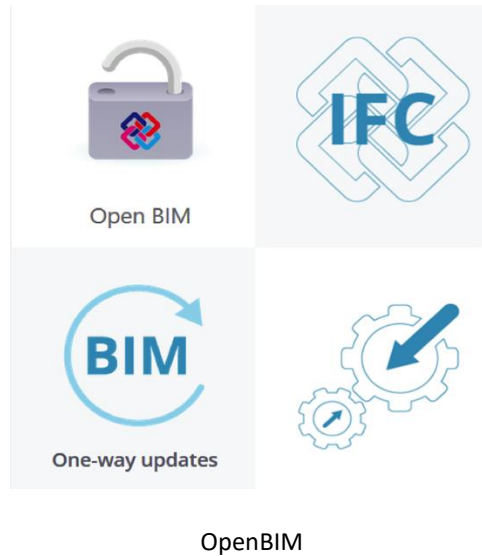


OpenBIM workflow of Cype

The key feature of Open BIM is its use of **IFC (Industry Foundation Classes)** standard interchange formats. By using IFC, which is both standardized and publicly accessible, the durability of project work is assured. It doesn't rely on specific software applications used during the project. Even the application-specific data files become auxiliary, as the IFC file contains the final project information. For example, a structural analysis performed in one application can be easily verified using the IFC file in another application.

Moreover, Open BIM facilitates efficient communication among users. Since these formats are widely supported by various project development applications, real-time collaboration becomes seamless.

### 5.2.1. Open BIM of Cype



OpenBIM of Cype is:

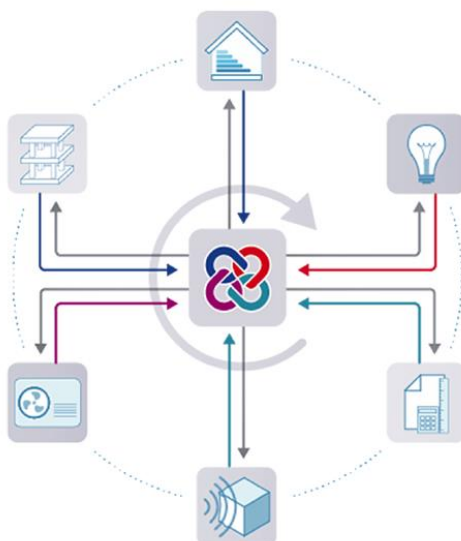
- A Collaborative Approach:
  - In an Open BIM environment, everyone involved in a construction project (like architects, engineers, and planners) works together.
  - They propose ideas and solutions for different aspects of the project, such as building structures, services, urban planning, and even furniture and surroundings.
- Duality and Privacy:
  - Here's the interesting part: There's a duality between private and shared spaces.
  - The files created by each specialist (using their specific software) remain private. These are like their secret workspaces.
  - But the magic happens when they generate IFC files (Industry Foundation Classes). These files contain the final project results and solutions.
  - These IFC files are then shared on a platform called BIMserver.center.
  - So, while the private work stays private, the collaborative development happens using these shared IFC files.

### 5.2.2. BIMserver.center

BIMserver.center is a platform for the collaborative development of projects in the cloud and, therefore, is designed to share information.

With BIMserver.center, direct communication occurs among all users and applications involved in a project developed using the Open BIM workflow.

By utilizing a cloud-based updating service, BIMserver.center enables efficient management and sharing of all files related to a BIM project. This platform ensures well-organized collaboration and communication among authorized project participants.



BIMserver.center: A Common Data Environment

Moreover, project administrators can control permissions and access for each project, allowing authorized users to contribute and propose ideas to any BIMserver user interested in participating in a project.

With BIMserver.center you can develop and share your projects with users you have authorised within a collaborative workspace.

Within the Open BIM workflow, all the information of the project, each piece of data or file that is being worked on, is located in a specific place.

This data can only be modified by the user that has generated them.

This way, all the project files move in the same direction, avoid duplicated and files with obsolete versions.

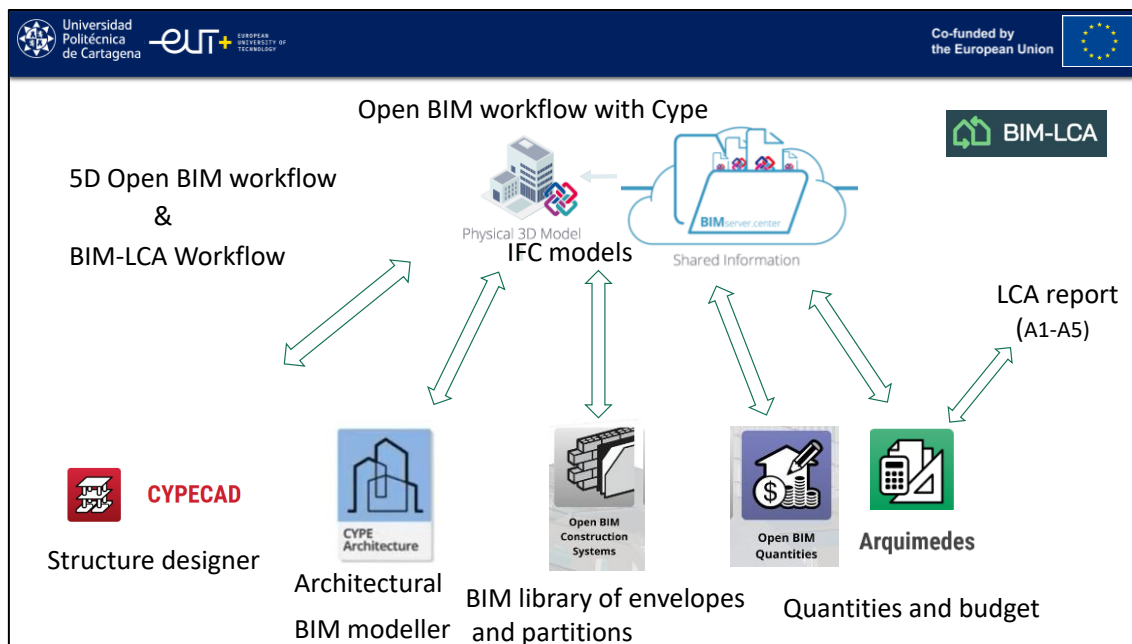
### 5.3 – Open BIM workflow for LCA

In the Spanish Case Study of this BIM-LCA project, Cype's Open BIM software package has been used (see next Figure):

- With them we design the structure of the house (using CypeCad) and its corresponding Open BIM model, that is, its BIM model in IFC format. We upload this BIM model of the housing structure to a server (BIMServerCenter).

- Then we use another software (**Cype Architecture**) to create the BIM model of the architectural part of the house.
- Next, we enrich the BIM model of the house by incorporating information about the housing envelope with **Open BIM Construction Systems**.
- And finally, we use the **Open BIM Quantities** and **Arquimedes** software to build the Bill of Quantities of the construction, from the measurements that the software makes in the elements of the BIM model. Arquimedes is able to print the LCA report that has been made by adding impacts of each of the budget items using the Cype LCA database.

This LCA only contains stages A1 to A5. Next Figure shows the workflow and data exchange in the Spanish Case Study using Cype software and BIMServerCenter. In this workflow each software exchanges information with the OpenBIM model of the house that is stored in a BIMServerCenter Project.



Workflow and data exchange in the Spanish Case Study . BIM – LCA Construction Project

With the workflow followed to develop the Spanish case study, the integration between the BIM model and the LCA assessment is perfect since the same database that serves to build the Bill of Quantities serves to perform the Construction Life Cycle Analysis.

The Cype Architecture software is explained in a tutorial of this BIM-LCA Construction E+ Project.

The software OpenBIM Quantities is also explained in a tutorial of this Erasmus + Project.



## 5.4 – LCA Excel Project app

As a result of this project (BIM-LCA Construction), a web application has been developed that, based on quantities of material used in the construction of a building (single-storey housing, multi-storey building or industrial warehouse), makes an LCA to show a series of environmental impacts of construction in phases A1-A3 (extraction and manufacture of construction products). This app is available on the BIM-LCA Construction Project website (<https://bimlca.eu>)

An LCA Excel App has also been developed with the aim of performing building LCAs and showing the cost and environmental impacts of building construction (A1-A5). This Excel app is also available on the Project's website, and includes the options to choose among various materials for the structure (concrete, steel or wood), and to choose various types of foundations, doors, windows, insulation materials, floors, partitions, facades and roofs.

The LCA Excel project app, has a user guide, in tutorial format, that is part of the results of the BIM-LCA Construction project in the work package 3. This user guide is also available on the Project website.

## 5.5 – CYPE software for OpenBIM - LCA workflow.

This section shows the various characteristics and links to more info of the software used in Cype's OpenBIM workflow to perform LCA analysis.

### 5.5.1. CYPECAD



**CYPECAD**

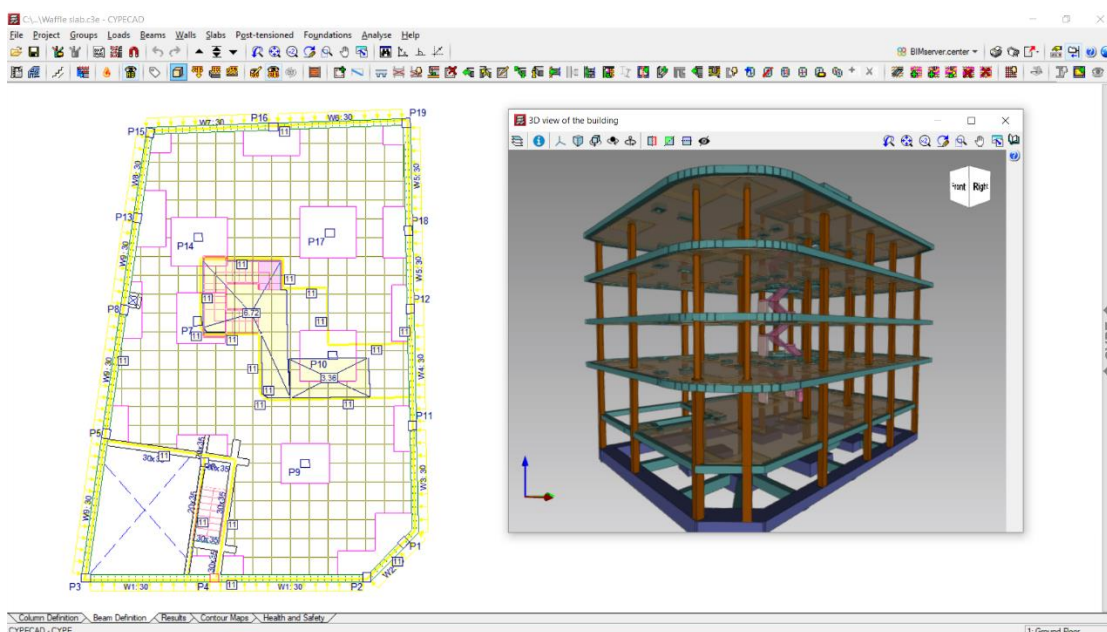
Analysis and Design of Building Structure [CYPECAD](#) [4]

CYPECAD carries out the design, analysis, and sizing of structures for building and civil works, which are subject to vertical and horizontal forces, as well as fire exposure.

It analyses and designs:

- **Supports.** Columns (concrete, steel, composite, and timber), shear walls (concrete) and walls (concrete, masonry, and block walls).
- **Beams.** Concrete, steel, and composite.

- **Slabs.** One-way slabs, hollow-core slabs, composite slabs, waffle slabs, flat slabs, post-tensioned slabs (one-way, waffle, and flat).
- **Node and bar structures** Concrete, steel, aluminium, timber, and generic material (only forces are analysed in this last case)
- **Foundations.** Slabs, foundation beams, footings, and pile caps
- **Steel connections.** Welded and bolted (including the baseplates).
- **Flat shells.** For analysis of concrete, rolled steel, cold-formed steel, aluminium, or generic-material shells.



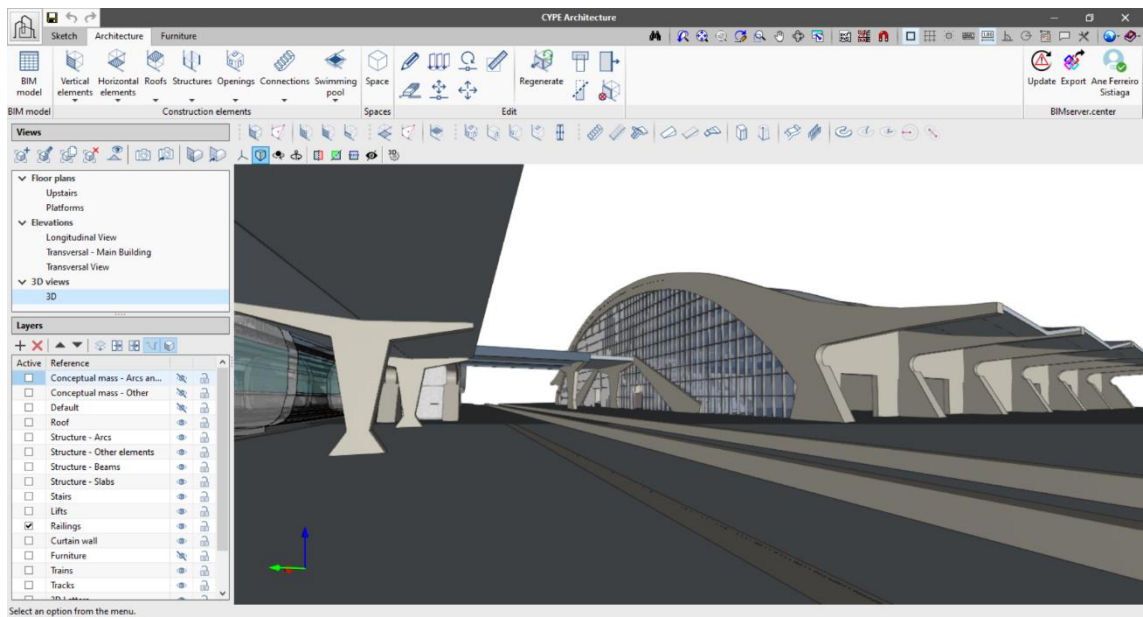
### 5.5.2. CYPE Architecture



## CYPE Architecture

Cype Architecture is an architectural BIM modeller. [CYPE Architecture](#) [5]

Its design was based on two fundamental phases in the digital development of a project: the architectural design phase and the 3D/BIM modelling phase. Thus, it was designed to adopt both traditional modelling tools (surface areas, edges, intersections, extrusions, curves, etc.) and the new BIM modelling tools (walls, floor slabs, roofs, columns, etc.), which when combined allow users to move from sketches to architecture effortlessly.



### 5.5.3. Open BIM Construction Systems

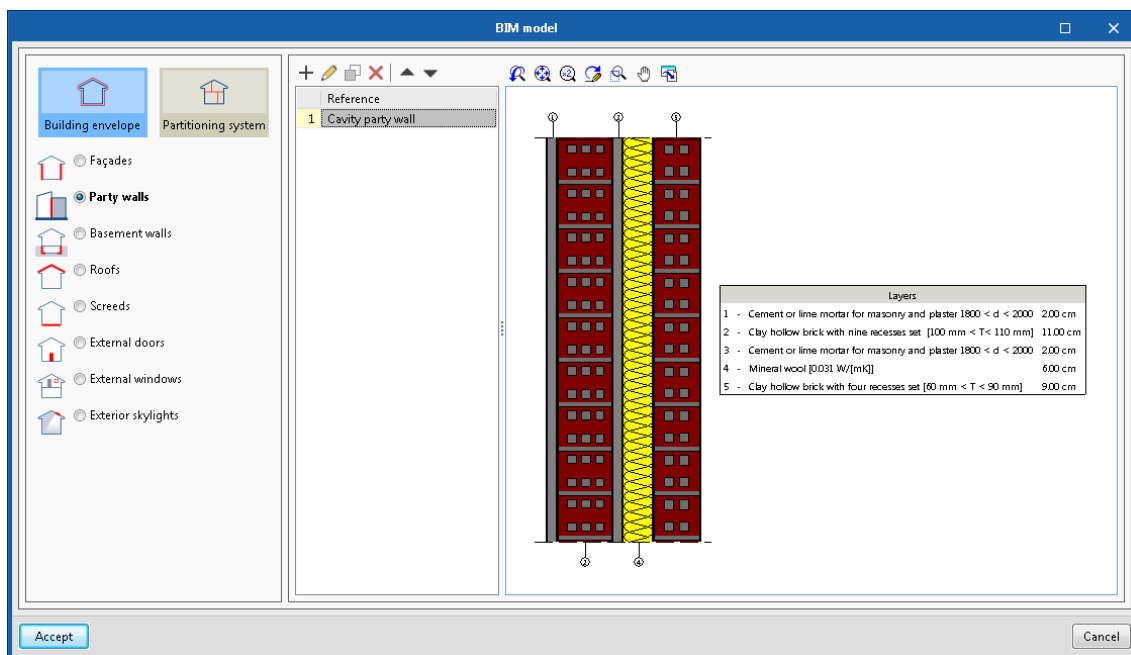


## Open BIM Construction Systems

OpenBIM Construction Systems enriches the building's BIM model by including information about wall layers into partitions and façades. [Open BIM Construction Systems \(cype.com\)](http://www.cype.com) [6]

CYPE Construction Systems allows users to indicate the following properties of the construction solutions of the project:

- General description of the systems by defining their type and construction properties.
- Definition of the layers that make up the system, by indicating their thickness, materials and properties.
- Relationship with the construction systems and the elements of the architectural BIM model.



### 5.5.3. Open BIM Quantities

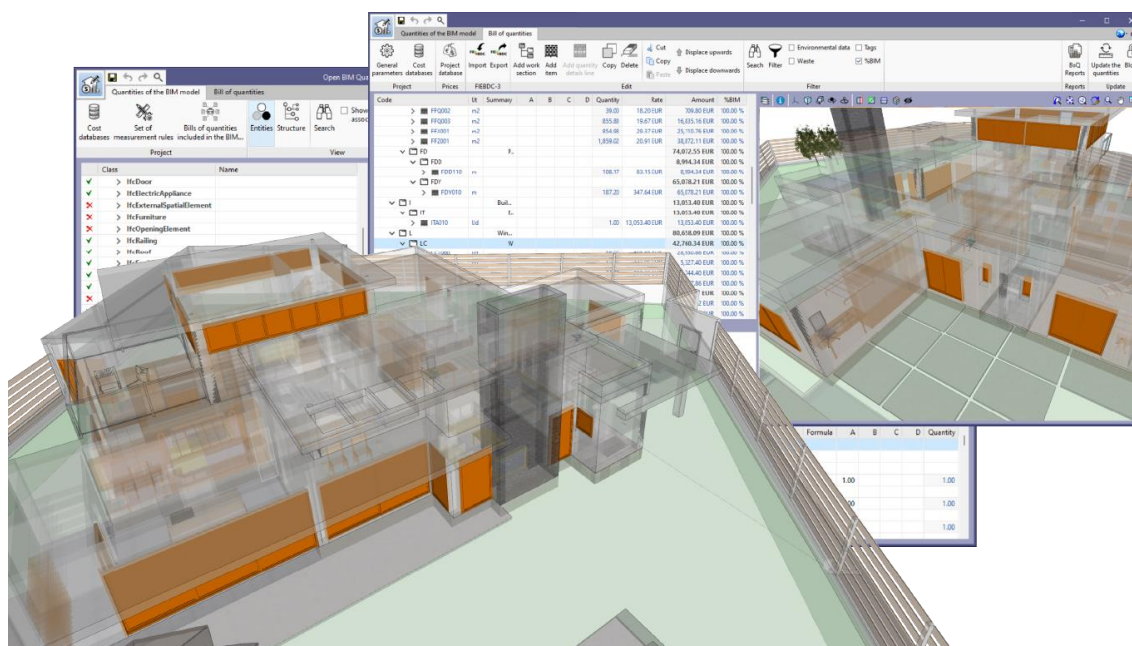


## Open BIM Quantities

Create the Bill of Quantities taking measurements from the IFC model.

[Open BIM Quantities \(cype.com\)](http://cype.com) [7]

Open BIM Quantities is a tool for extracting quantities and creating bills of quantities based on BIM models that have been defined using the IFC standard. This tool allows users to establish the quantity criteria that they consider appropriate, in order to transform the data contained in the elements or components of the model into items.



## References

- [1] 'openBIM - buildingSMART International'. Accessed: May 12, 2024. [Online]. Available: <https://www.buildingsmart.org/about/openbim/>
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- [7] 'Open BIM Quantities', CYPE. Accessed: May 12, 2024. [Online]. Available: <https://info.cype.com/en/product/open-bim-quantities/>

## 6 - Deliverables

To evaluate the success of the application, students will have to answer an online questionnaire.

## 7- What we have learned

What is Open BIM.

The importance of working with interoperable BIM formats.

Cype Open BIM solutions as an example of Open BIM approach.

One Open BIM Workflow to performance LCA of buildings.

The existence of a new excel tool to perform building LCAs developed in the BIM-LCA Construction Project.

An introduction of several software of the Open BIM – LCA workflow.