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The Project Quantity Takeoff Process

Introduction

Quantity takeoff (QTO from now on) is the process in construction project management that involves the review of project specifications, blueprints, and other technical documents to accurately estimate the quantities of materials and labor hours needed for each construction phase, rooted in the principles of **honesty**, **accuracy, clarity**, and **communication**.

Quantity takeoff accuracy is vital in the cost estimation and budgeting process, enabling the creation of realistic budgets, reducing the risk of financial overruns or underspending, and promoting more competitive bidding while safeguarding profitability.

QTO involves obtaining the dimensions of building elements, such as area, volume, and length, and is prone to human error, including mistakes in data entry, arithmetic calculations, and material selections, even when the measurements are revised, there is no guarantee that they are correct, leading to inaccurate estimates.

Additionally, designers and quantity surveyors often have differing interpretations of project documentation, leading to discrepancies in their respective Quantity Take-Offs, even when working from the same design documents and specifications."

The irruption of technology in the construction industry has revolutionized how we conduct the quantity takeoff process with the aim of saving time and reducing errors, however, this does not negate, or replace, the human judgment and experience in the takeoff process for achieving precise and reliable results.

To facilitate a comprehensive understanding of this document, the subsequent section will present an introductory overview of the basics, principles and concepts underlying quantity take-off procedures.

Section 2 will then proceed to examine the different types of QTO (manual, digitally assisted, and BIM-automated), with a comprehensive analysis of estimation methodologies, processes, and implementation considerations.

Finally, some considerations on the critical aspects of accurately maintaining quantity properties will be exposed.

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Basics of Measurement

The QTO process consists of breaking down a construction project into construction elements, assigning specific unit of measurement to each, enumerating their quantities, and deriving their geometric characteristics (Figure 1 and Figure 2) according to technical regulations, rules and local customs.

The construction elements are the fundamental components in the budgeting and quantity take-off processes, and usually referred to a classification system for building elements, systems, and assemblies as Uniformat, Masterformat, ...

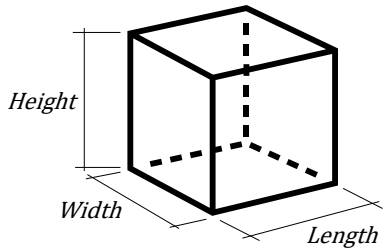


Figure 1 Length, Width / Breath, and Height / Depth

Client:
Project Name:
Project ID
Last Updated

S.No.	Item Description	Unit (UM)	Measurement				Subtotal	Total Qtty	Notes
			Qty Repeats	Length	Width / Breadth	Heigth / Depth			

Figure 2 Regular QTO sheet

Quantity repeats or Timesing

Timesing, multiplication, or repeats, is used to denote the frequency or number of repeats of a particular item within a measurement.

Quantity Item Description

It consists of a brief description that will help to identify the item in the project, and usually includes a drawing reference tag, the location, and the project level among others.

Units of measurement (UM)

Defines the metrics for measuring the amount of work for the functional components. The common units of measurement (UM) for civil engineering works within the International System of Units (SI) are:

- **Unit (un)**: The items are measured as units of quantity, also known as *timesing*. The unit can be established as zero units, being considered as a header of the following quantity items.
- **Lump sum (L.S.)** may be considered when the contractor's experience in executing a specific work item is limited or uncertain, or the project involves a large number of small-quantity work items, making detailed unit pricing impractical or inefficient.
- **Linear (m)**: The items are measured by the projection of the most representative dimension on a horizontal plane (Linear length), or over a vertical plane (Linear Height).
- **Area (m^2)**: The items are measured considering the projection of two dimensions over a plane. It can be:
    - **Real area** refers to the actual area of a given surface.
    - **Horizontal footprint** refers to the area of the surface created when a 3D object is projected onto the horizontal plane.
    - **Vertical area** refers to the area calculated by projecting the two primary dimensions of a 3D element onto its primary plane.
    - **Projected area**, when the projection is executed onto an arbitrarily oriented plane.
    - **Total Surface** Area is the sum of the areas of all the external faces of a three-dimensional object.
- **Cubic volume (m^3)**: The items are measured considering the three dimensions of the item.
- **Weight (Kg, Tm)**: Defined as the amount of matter in an object and obtained by multiplying the density of an object by its volume.
- **Time (hr, day)**: The measurement of the item is based on the length of time it will be utilized, for instance, in the case of recurring expenses like salaries and rent.

What shouldn't be measured

During the quantity take-off phase, not all elements must be measured, but addressed during the pricing phase. These concepts that typically do not must be directly measured include, among others:

- Transportation or any other cost associated with the delivery of materials.
- Unloading materials
- Hoisting requirements
- Labor setting, fitting, or fixing in position of Scaffolding
- Scraps, cuts, Lapping, or waste of materials
- Stripping formwork

Repeat Dimensions

To enhance efficiency and minimize errors, it's advisable to leverage previously measured quantities when feasible. For instance, block walls typically require both plastering and painting on both sides. While reusing initial measurements can streamline the process, careful consideration is crucial as adjustments are often necessary for subsequent items.

Gross vs net measurements

Decisions regarding the deduction of voids or openings within an area or volume must be made based on the specific measurement rules in place. Two general rules should be considered:

- Boundary Openings: Openings located at the boundaries of the work are always deducted, regardless of their size.
- Boundary Voids: When voids occur within the boundary of the work, resulting in narrow widths, these widths are measured as part of the overall area, even if they appear to fall into other width categories.

	Area		Volume	
	Gros	**Net**	**Gros**	**Net**
LHS Wall	*7.50*	*7.50*	*0.75*	*0.75*
Center Wall	*10.50*	*7.50*	*1.05*	*0.75*
RHS Wall	*10.50*	*7.50*	*1.05*	*0.75*

Table 1 Gross and net area and volume for Figure 3

Table 1 shows gross and net area and volume for a wall with different opening conditions exposed in Figure 4.

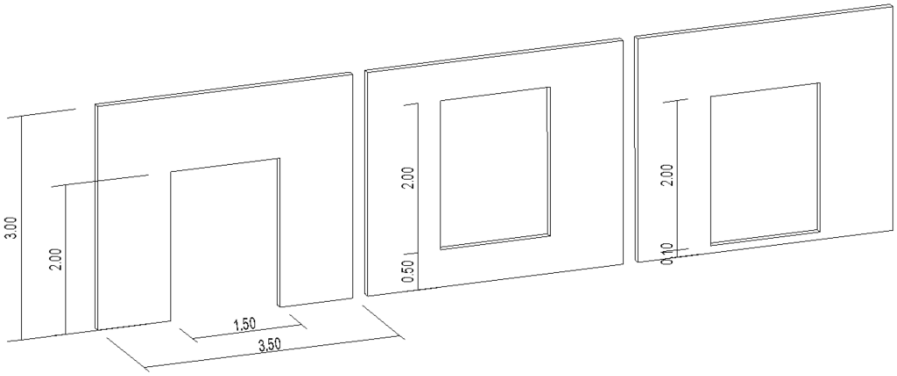


Figure 4 Boundary Opening (LHS), Void, and Boundary Voids (RHS)

Types of quantity takeoffs

The advent of technology has significantly transformed the quantity takeoff process within the construction industry. However, despite these advancements, the human element remains crucial. Two primary methods for conducting quantity takeoffs are prevalent: manual and digital.

Manual takeoff

The manual takeoff consists of manually extracting and measuring quantities from construction documents, even being assisted by computer tools as spreadsheets, generating the work measurements required for building the project.

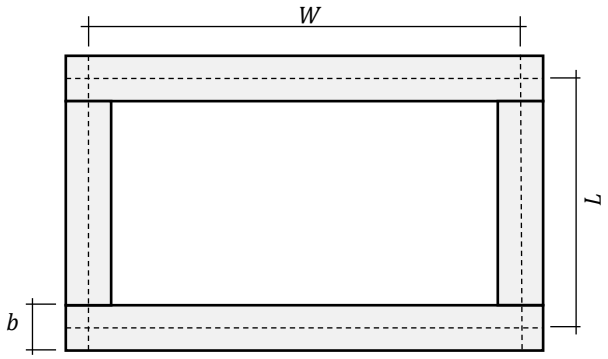
For accurate results, the manual takeoff process requires a deep understanding of both project plans and their corresponding specifications, and, furthermore, the estimator must possess a keen eye for detail to ensure no element is overlooked during the estimation process.

Estimators employ various methodologies to guarantee accuracy, clarity, and comprehensive coverage during the estimation process. Three primary estimation methods are commonly utilized: the Center Line Method, the Long and Short Wall Method, and the Crossing Method.

Estimation methods

Centre Line Method.

This method consists of measuring the length of the center line of the elements to measure (Figure 5), and calculate the area and volume as follows:



$$CenterLine = 2 \cdot (W + L)$$
$$Area = CenterLine \cdot b$$
$$Volume = Area \cdot Depth$$

Figure 5 Centre Line Method example

This method is well-suited for walls with consistent cross-sections, offering a quick and straightforward calculation process. However, it may not provide accurate results for complex structures or walls with varying thickness. Furthermore, careful attention should be paid to junctions and crosswalks to prevent the duplication of areas during calculations (Figure 6).

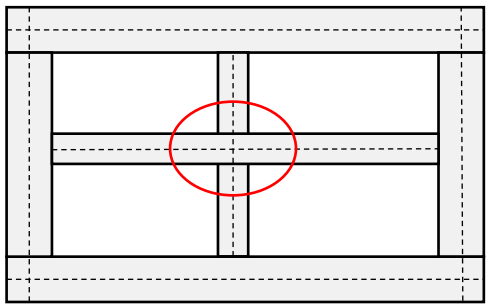
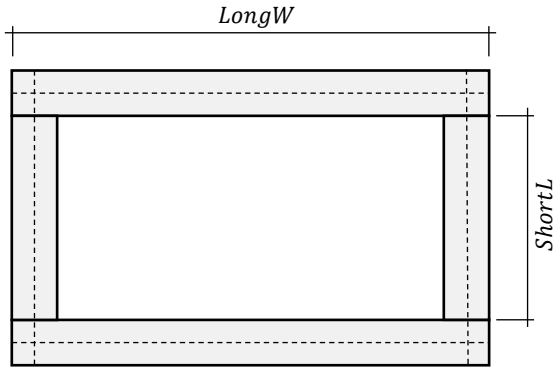


Figure 6 Duplicates check in junctions and cross-walls

Long and Short Wall Method

The Long and Short Wall Method distinguishes between long walls (external walls) and short walls (internal walls) and calculates their lengths separately:



$$Length = 2 \cdot (LongW + ShortL)$$
$$Area = Length \cdot b$$
$$Volume = Area \cdot Depth$$

Figure 7 Long and Short Wall Method example

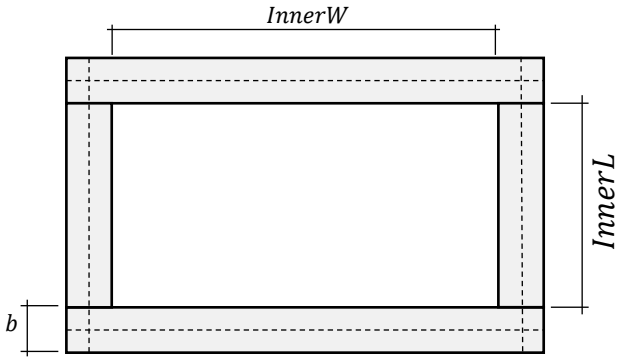
This method is Suitable for Load-bearing structures, being more accurate than the center line method for complex structures.

As a disadvantage, the Long and Short Wall Method is more time-consuming than the center line method.

The Long and Short Wall Method is also known as “general method”, “separate method”, “out-to-out & in-to-in method”, or “individual wall method”:

Crossing Method

The Crossing Method measures the length of walls that intersect at right angles that account for wall intersections accurately, being suitable for structures with multiple intersecting walls (Figure 8).



$$Length = 2(InnerW + 2 \cdot b + InnerL)$$
$$Area = Length \cdot b$$
$$Volume = Area \cdot Depth$$

Figure 8 Crossing Method Example

This method presents as a disadvantage that can be complex for irregular structures.

Manual takeoff estimating process

As stated previously, even being assisted by computer tools, the manual takeoff consists of directly taking the measures from the blueprints, and latterly process them.

The quantities belonging to an activity item are displayed in the quantities grid, located into the BIM manager panel, and can be sized by moving the scroll from left to right (Figure 9), corresponding the columns in gray to not editable fields.

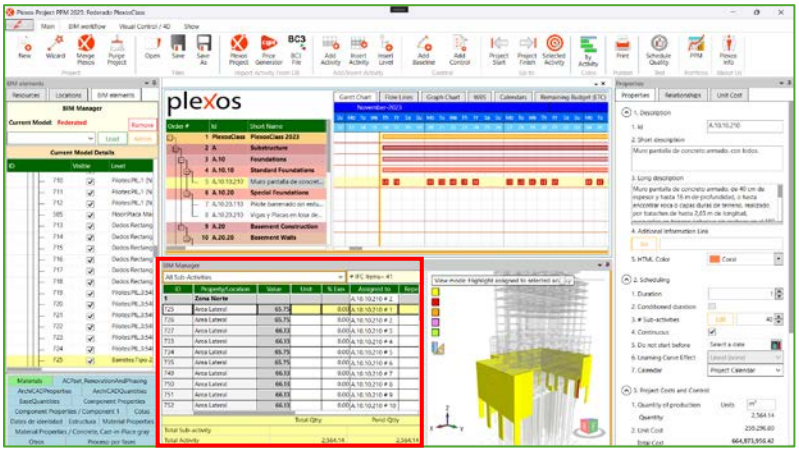


Figure 9 Quantities grid

Adhering to principles of **honesty**, **accuracy**, **clarity**, and **effective communication**, all work elements, as can be seen in Figure 10, must be:

- Precisely located: Determine their position within the project.
- Accurately counted: Include all instances, considering any repetitions.
- Defined the unit of measurement: Establish the appropriate unit for quantity measurement.
- Measured dimensionally: Determine the geometric dimensions of each element.
- Assessed for deductions: Define criteria for deducting volumes or areas for voids, openings, and other exclusions, by negating the number of repeated voids and openings (Figure 11).

For adding new quantity items, you must locate at the end of the grid, in the blank row (marked in red in Figure 10) and start typing the desired values. You can navigate between columns/field by typing the [tab] and [shift tab] keys, and finish by typing the [Enter] key. If you press [ESC] the new entry will be cancelled.

ID	Property/Location	Value	Unit	% Exe	Assigned to	Repeats	Length	Width	Height
1	Sótano 1	6.30	m^3	0.00	All Sub-Activities	9.00	0.50	0.50	2.80
2	Planta baja	23.20	m^3	0.00	All Sub-Activities	29.00	0.50	0.50	3.20
3	Planta 1	15.88	m^3	0.00	All Sub-Activities	28.00	0.45	0.45	2.80
4	Planta 2	15.88	m^3	0.00	All Sub-Activities	28.00	0.45	0.45	2.80
5	Planta 3	12.54	m^3	0.00	All Sub-Activities	28.00	0.40	0.40	2.80
6	Planta 4	9.60	m^3	0.00	All Sub-Activities	28.00	0.35	0.35	2.80
7	Planta 5	7.06	m^3	0.00	All Sub-Activities	28.00	0.30	0.30	2.80
8	Planta 6	7.06	m^3	0.00	All Sub-Activities	28.00	0.30	0.30	2.80
9	Planta 7	7.06	m^3	0.00	All Sub-Activities	28.00	0.30	0.30	2.80

Figure 10 Spreadsheet entries for a manual takeoff with Plexos Project

ID	Property/Location	Value	Unit	% Exe	Assigned to	Repeats	Length	Width	Height
1	Solera sobre el terreno Zona A	108.75	m2	0.00	All Sub-Activities	1.00	15.00	7.25	0.00
2	A Deducir Ajardinamiento zona A	-9.00	m2	0.00	All Sub-Activities	-1.00	3.00	3.00	0.00

Figure 11 Deduction of voids and openings

The Item ID, Location and Unit

The quantity item Id is a numeric value that identifies the item or group of items. The value is established by the user in a discretionary way in the case of manual quantity Items.

The Location determines the position of the quantity item within the project.

The Unit defines the metrics for measuring the amount of work.

Item titles

If an item is a manual quantity and its value is zero, Plexos considers that the item is a title, highlighting it with bold font and light-gray background, increasing and improving the clarity and effective communication (Figure 12).

ID	Property/Location	Value	Unit	% Exe	Assigned to	Repeats	Length	Width	Height
1	**Inicio de actuación**				All Sub-Activities				
2	cruce TF-320	15.85	m	0.00	All Sub-Activities	1.00	15.85	0.00	0.00
3	**Lateral izquierda**				All Sub-Activities				
4	cruce calle el aderno	7.00	m	0.00	All Sub-Activities	1.00	7.00	0.00	0.00
5	Final de actuación	7.00	m	0.00	All Sub-Activities	1.00	7.00	0.00	0.00
6	**Lateral derecha**				All Sub-Activities				
7	cruce calle la guancha	3.85	m	0.00	All Sub-Activities	1.00	3.85	0.00	0.00
8	cruce calle santa úrsula	6.10	m	0.00	All Sub-Activities	1.00	6.10	0.00	0.00
9	cruce calle la orotava	6.10	m	0.00	All Sub-Activities	1.00	6.10	0.00	0.00
10	cruce calle icod de los vinos	6.15	m	0.00	All Sub-Activities	1.00	6.15	0.00	0.00
11	cruce calle república dominicana	6.40	m	0.00	All Sub-Activities	1.00	6.40	0.00	0.00
12	cruce calle jamaica	4.00	m	0.00	All Sub-Activities	1.00	4.00	0.00	0.00
13	**SECTOR "A"**				All Sub-Activities				
14	**Lateral este**				All Sub-Activities				
15	- primer tramo	28.90	m	0.00	All Sub-Activities	2.00	14.45	0.00	0.00
16	- segundo tramo	25.80	m	0.00	All Sub-Activities	2.00	12.90	0.00	0.00
17		33.30	m	0.00	All Sub-Activities	2.00	16.65	0.00	0.00

Figure 12 Titles in quantity items

This feature is available for all types of quantity take-offs.

Repeating quantities and dynamic links

For repeating the measure of a work element into another quantity item by getting the total quantity of the donor element, is a good practice to stablish the location as "$idem\ as\ Activity\ ID$", and then set the length as the donor total quantity (Figure 13 upside).

This is especially useful for elements requiring identical treatments on multiple sides, such as walls typically needing both plastering and painting, we can import the total quantity from the donor work and define the number of sides as the repeat factor (Figure 13 downside).

This procedure necessitates tracking modifications made to the donor item to ensure accurate updates to the destination item. To facilitate this, Plexos enables the creation of a dynamic link, created by incorporating the donor item ID within brackets, and preceded by the @ symbol, as illustrated in Figure 13.

When the quantity of the donor item is modified, the quantity of the destination item will be automatically recalculated. This recalculation will account for the defined number of repetitions, ensuring accurate quantity updates.

ID	Property/Location	Value	Unit	% Exe	Assigned to	Repeats	Length	Width	Height
1	Idem @[Act - 1]	99.75		0.00	All Sub-Activities	1.00	99.75	0.00	0.00

ID	Property/Location	Value	Unit	% Exe	Assigned to	Repeats	Length	Width	Height
1	Idem @[Act - 1]	199.50		0.00	All Sub-Activities	2.00	99.75	0.00	0.00

Figure 13 Repeating quantities with Plexos Project

This feature is available from all types of quantity take-offs.

Dynamic link to duration

Plexos facilitates dynamic duration linking for items with a measurement unit of days. By utilizing the unit specifiers $@d$ or $@D$, for effective working days or total duration respectively, ensuring that the quantity of days is automatically synchronized with any changes made to the duration (Figure 14).

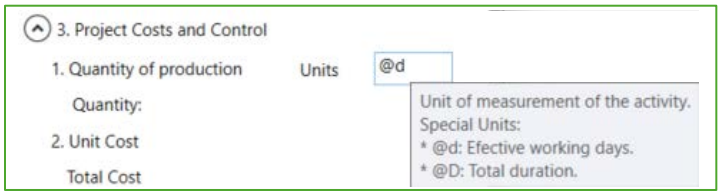


Figure 14 Dynamic duration link

This feature is available for all types of quantity take-offs.

Sub-activity assignment

Plexos allows linking the quantity item to the item location by the column "*Assigned to*" in two different ways: to *All Sub-activities*, or to a *specific Sub-activity*[1]. Figure 15 shows the effects of assigning 30 units to an activity and sub-activities. If the assignment is to *All sub-activities*, the quantity will be equally distributed between all sub-activities.

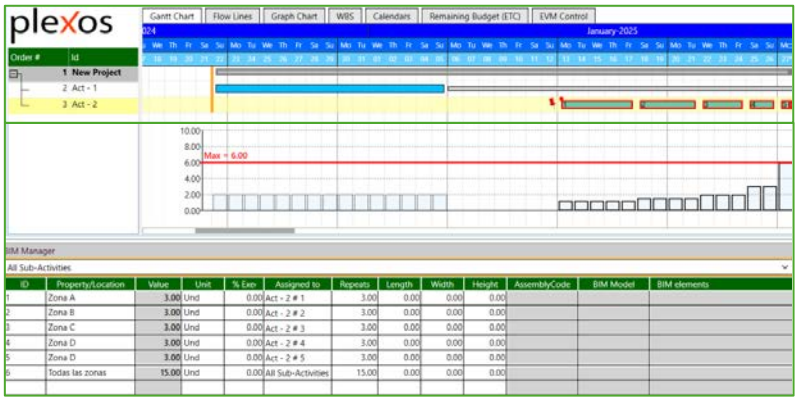


Figure 15 Quantity assignment to activities and sub-activities

This feature is available for all types of quantity take-offs.

Quantity Items management

The management of the quantity items are made from the contextual menu or by the "Input Gesture Text", as can be seen in Figure 16.

[1] View the whitepaper PDM Graphs for further information about working with sub-activities

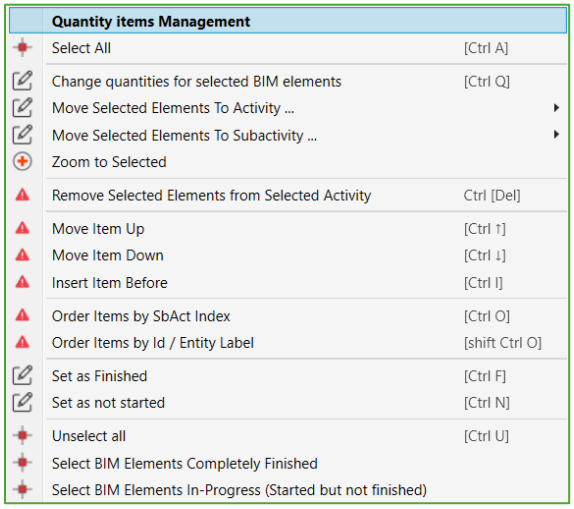


Figure 16 Quantity Items management

The management features for the quantity items are:

- **Select All.** Select all the items. This feature is useful for massive modifications such as move, and remove, and Set as finished or not started.
- **Change quantities for selected BIM elements.** This feature is only for BIM quantity items and will be faced later in the BIM take-off section.
- **Move selected items to Activity**. Moves the selected quantity items to another Activity, being very useful for massive item moves from one activity to another. Once you click this option, a combo box will appear to select the destiny activity. The assigned sub-activity in the destiny activity will be *All Sub-Activities (*Figure 17*)*.

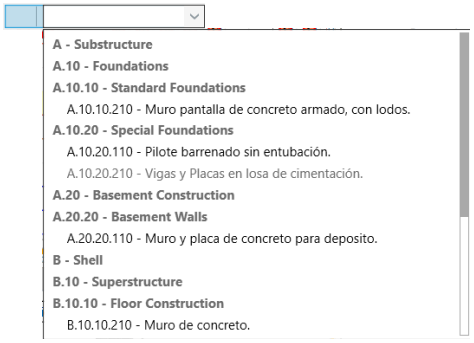


Figure 17 Move selected elements to another Activity

- **Move selected items to Sub-Avtivity**. As in the previous option, moves the selected quantity items to another sub-Activity of the selected activity, being very useful for massive item moves from one sub-activity to another.

Once you click this option, a combo box will appear to select the destiny sub-activity.

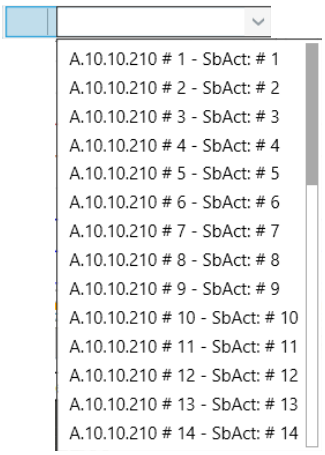


Figure 18 Move selected elements to another Sub/Activity

- **Zoom to Selected Item**. This feature is only for BIM quantity items and will be faced later in the BIM take-off section.
- **Remove selected items from selected activity**. Removes the selected quantity items from the selected activity.
- **Move Item Up /Down**. Moves the selected item one position Upward or Downward
- **Insert Item before**. Insert one quantity item before the selected items. The new Id will be the grid index and the Property/Location "New Quantity Item". Initially, the quantity value will be set to zero and treated as a title. The quantity item will become active, and its value will be considered for calculations, only after the user modifies the dimension values and/or the number of repeats.
- **Order Items by Sub-Activity Index or by Id / BIM Entity label.**
  Orders the quantity items according to the sub-activity index (not sub-activity name) or its Id. The items assigned to *All Sub-Activities* will be placed first.
- **Set as Finished / Set as not started**
  Sets the quantity item execution status as not started or finished.
  This feature will be faced more in depth in the Project Control whitepaper.
- **Unselect All.** Unselect all the quantity items. Useful for cleaning the 3D panel of selected items when working with quantities from IFC elements. This feature will be faced more in depth in the BIM takeoff section.
- **Select BIM Elements Completely Finished.** Useful for massive modifications.

- **Select quantity items In-Progress (Started but not finished).** Useful for massive modifications.

Digital takeoffs

Manual quantity takeoffs demand significant skill, time, and meticulous attention to detail to achieve the desired accuracy. Extracting data manually from drawings and inputting it into computers is a time-consuming and labor-intensive process, inherently susceptible to human error, and the likelihood of inaccuracies escalates with increasing data volume and project complexity.

The construction industry has witnessed a technological revolution, significantly impacting quantity takeoff processes. While technology offers significant advantages in terms of timesaving and error reduction, the crucial role of human judgment and experience in ensuring precise and reliable results cannot be overstated.

In some cases, even considering that all work items have been considered, we may encounter challenges such as:

- **Unavailable blueprints**, impeding the QTO progress, or
- **Insufficient or inadequate blueprint information,** leading to misinterpretations and costly errors, or
- **Unverified measurements** with unconfirmed values, that can introduce significant inaccuracies.
- **The IFC quantity property isn't available** for some BIM 3D element.

To ensure project success, accurate measurements are paramount, and in these scenarios, the use of digital measurement tools becomes indispensable.

The quantity measurement tool for 3D IFC Models

Plexos Project provides a digital takeoff tool for IFC models[2].

[2] For information about how to load IFC BIM models go the section Import BIM Elements:

Figure 19 Measurement tool for 3D IFC Models

This tool is activated by clicking on the button shown in Figure 19 of the 3D manager panel, appearing the window shown in Figure 20.

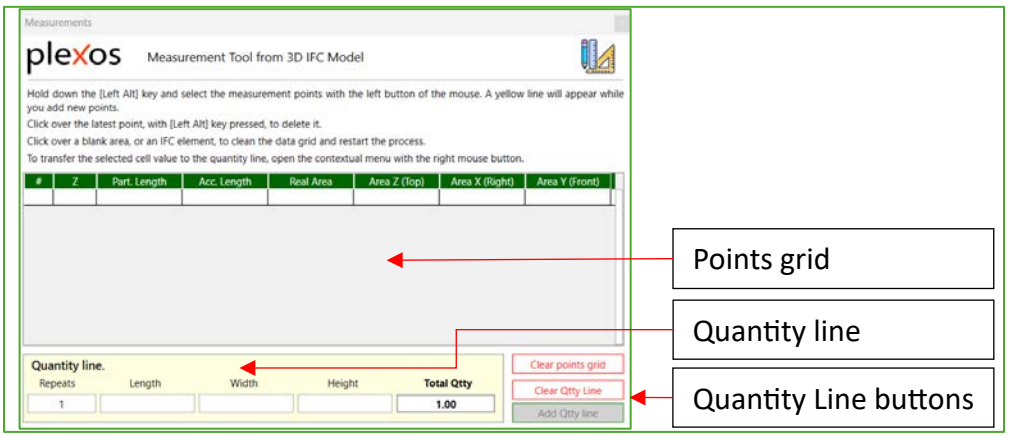


Figure 20 Digital Measurement Tool

The columns of the points grid correspond to:

- **#.** Order of the surface point.
- **Z**. Value of the Z axis point
- **Part. Length**. Partial length
- **Acc. Length**. Accumulated length
- **Real Area**. Real area of the surface defined by the points.
- **Area Z (Top)**. Projected area of the surface defined by the points, over the horizontal (Z) plane.
- **Area X (Right)**. Projected area of the surface defined by the points, over the X plane.
- **Area Y (Front)**. Projected area of the surface defined by the points, over the Y plane.

Surface points management

To compute the area of a surface and/or the volume of a 3D element, it´s necessary to select the points that define the surface by clicking with the left mouse button while pressing the [Left Alt] key. The available actions are:

- **Add point**: [Left Alt] + Left mouse button.

- **Remove Last point**: Mouse left-click over the last point. This action also cleans the points grid.

The points will be added to the points grid, and the measurement tool will calculate the values of the areas of the surface between the first and last point.

Figure 21 Roof digital measurement from an IFC 3D Model

Figure 21 depicts the measurement of a roof using five points. Four points are used to define the roof's shape, and a fifth point is added to close the polygon, ensuring a complete and accurate calculation of the perimeter defined by the Acc. Length, even if it's not necessary to calculate the area. It's interesting to highlight the difference between the real area surface (153.56 m²) and the projected surface over the Z plane (135.14 m²).

If any points fail to meet the coplanarity criterion with the other points, an alert message will be displayed above the quantity line, indicating 'Non-coplanar Polygon,' as illustrated in Figure 22.

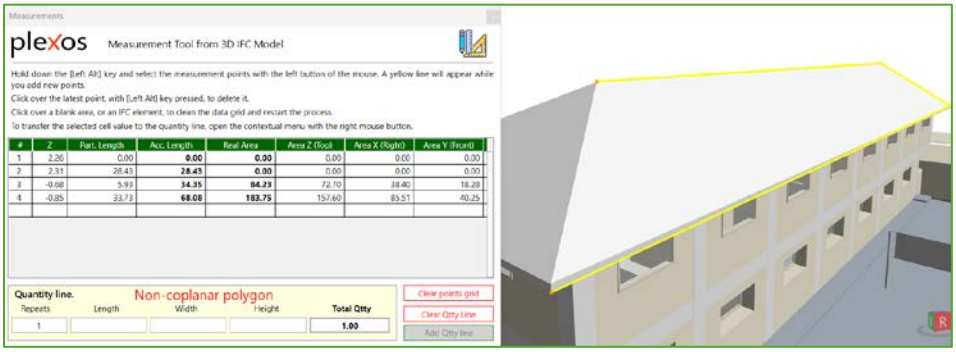


Figure 22 Non-coplanar polygon

Creating and Adding quantity items to the quantities grid

When selecting a cell of the points grid, it will be highlighted in yellow, and by the context menu (mouse right-click) you'll be able to add the value of the selected cell to the Length, Width, or Height to the quantity line (Figure 23).

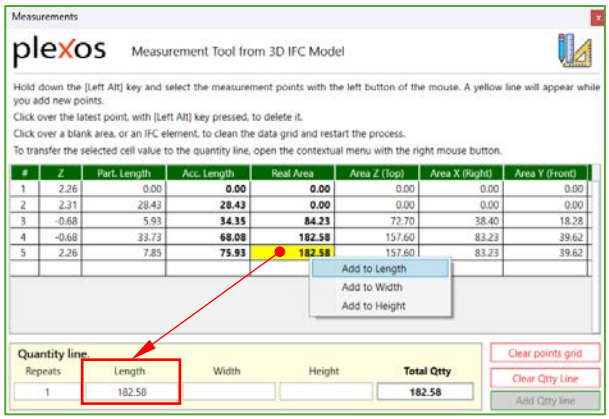


Figure 23 Adding values from points grid to the quantity line

You can add several values from different cells in the points grid to the quantity line. For example, you can use the height to calculate the volume (Figure 24).

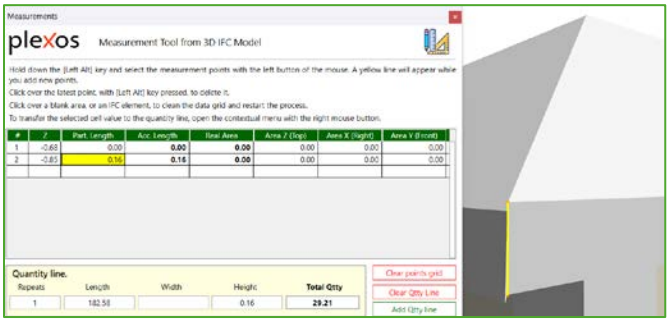


Figure 24 Adding value to Height for calculating the volume

The actions that can be performed over the quantity line are:

- **[Clear points grid]**: Clears the points grid.
- **[Clear Qtty line]**: Clears the current values in the quantity line.
- **[Add Qtty line]**: Adds the quantity line to the quantities grid as a new item (Figure 25).

ID	Property/Location	Value	Unit	% Exe	Assigned to	Repeats	Length	Width	Height
1	No Description	182.58		0.00	All Sub-Activities	1.00	182.58	0.00	0.00

Figure 25 New quantity item in the quantities grid

The [Add Qtty line] button is disabled (grayed out) when the selected activity is a chapter (Figure 26 LHS), because quantity lines cannot be added to chapters. To enable the button, select a valid activity item, and the button will become active (white background) (Figure 26 RHS).

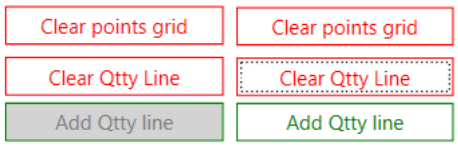


Figure 26 [Add Qtty line] button background

Gross and Net quantity measurements

Two techniques can be used to calculate net quantities: Two-measures method and one-measure method:

1. Two-measures method. The first measure is for the gross value, and the second for deducting voids, setting the repeats as a negative value for the second one (Figure 27).

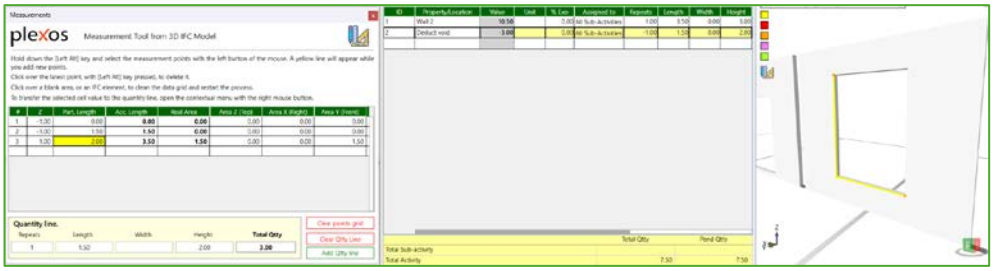


Figure 27 Net quantity by two measures

2. One-measure method. This method requires following a continuous path without crossing, or in other words, considering the clockwise and anticlockwise criteria. The starting criterion will be the positive criterion for surfaces and the opposite will be the negative one.
   In Figure 28, the gross surface area is calculated clockwise. To account for the void, the measurement transitions to an anticlockwise direction starting from the fifth point and proceeding from the sixth to the tenth point.

Figure 28 Net quantity by one measure

While the first method, utilizing two measurements, necessitates a greater number of quantity lines, it offers several advantages. Notably, it is more user-friendly, enhances clarity, and minimizes the risk of errors. This method eliminates the need to account for clockwise or anticlockwise directions during measurement.

BIM takeoffs[3]

BIM Quantity Take-Off (QTO), often referred to as 5D BIM, can be seen as a subset of digital quantity take-off methods. However, 5D BIM software primarily manages and extracts data from Building Information Models (BIM), typically in IFC[4] format, rather than directly calculating measurement values. This unique characteristic distinguishes it as an independent method within the broader context of digital quantity take-off.

BIM quantity take-offs are considered faster and more accurate than manual and digital takeoffs, because they automatically and directly take information from the models, ensuring that the cost estimator has not missed anything, but as stated in the introduction, this does not negate, or replace, the human judgment and experience in the takeoff process for achieving precise and reliable results.

BIM quantity take-offs offer significant advantages over traditional manual and even other digital methods. By directly extracting data from the 3D model, they can automate the process, minimizing the risk of human error and ensuring comprehensive data capture and guaranteeing that the cost estimator has not missed anything. However, it's crucial to emphasize that BIM-based take-offs should not be considered a completely automated

[3] For an accurate BIM quantities take-off, readers should first familiarize themselves with the fundamental concepts outlined in the document 'Building Information Modeling (BIM) Basics'.

solution. The expertise of a qualified cost estimator remains indispensable. Their judgment and experience are vital for interpreting the model data accurately, resolving ambiguities to achieve precise and reliable quantity take-offs.

The Quantities Grid with BIM entities.

Working with BIM entities, the quantities grid is equal as in the previous cases, but with some columns that are enabled, or non-enabled, for this type of quantity items (Figure 29).

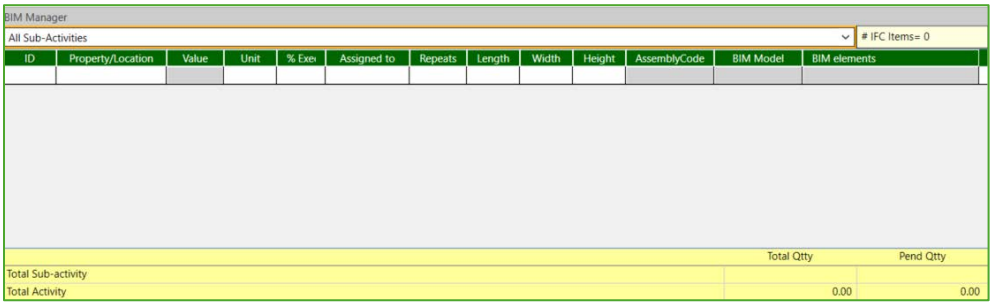


Figure 29 The quantities grid for BIM quantity items

- **ID**: Label of the Element. This value is read-only, stablished by the modelling software for BIM quantity Items, and cannot be modified in the case of BIM quantity items.
- **Property**: Quantity property used to measure the element. As special case, the value can be Zero or Unit instead of a quantity property. This value is read-only, established by the selected quantity property, and cannot be edited.
- **Value**: Value of the property selected for the element. This value is read-only, established by the selected quantity property, and cannot be edited.
- **Assigned-to**: Sub-activity where the element is assigned to. This value is established by the user.
- **Assembly Code.** Code assigned to the BIM element for its classification following a standard classification system. This value is read-only, established in the modelling software.
- **BIM Model.** Name of the BIM model whom the BIM element belongs to. The quantity items of specific work item can be from different models in a federated structure. This value is read-only.
- **BIM elements.** The name of the BIM element established in the modelling software. This value is read-only.

BIM Elements Assignment

The process of assigning BIM elements and their BIM quantities to work items consists of firstly assigning the BIM elements, and then selecting the desired property of quantity. There are three ways to assign the BIM elements:

- **Manual Selection:** Choose individual BIM elements (Figure 30).
- **Criteria-Based Selection:** Select sets of elements that meet specific criteria (e.g., material type, location) (Figure 30).
- **Automated Assignment:**
    - **Import BIM Elements:** Seamlessly integrate BIM elements into existing projects.
    - **Automated Project Creation:** Use Plexos Wizard to automatically generate project items and link them to their corresponding BIM elements.

Assignment by Manual Selection

The manual assignment is useful for adding elements to activity items by selecting them in the 3D model or in the BIM models manager. The workflow is:

1. Select the Activity Item (Several Items can be selected).
2. Select BIM elements in the 3D model, or BIM Models Manager, using the left mouse button. For multiple selections, hold down the [Ctrl] key while clicking.
3. Open the context menu by right click, and the dialog shown in Figure 30 will appear.

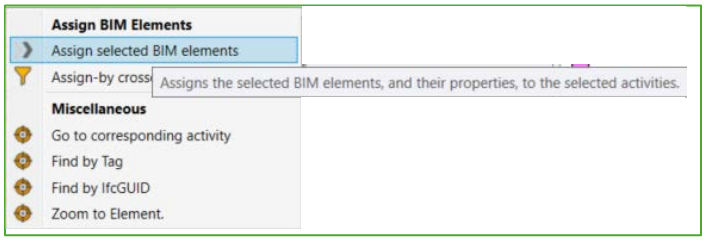


Figure 30 Manual elements assignment context menu

4. Choose the option [Assign selected BIM elements], and the dialog of Figure 31 for establishing the quantity property will appear.

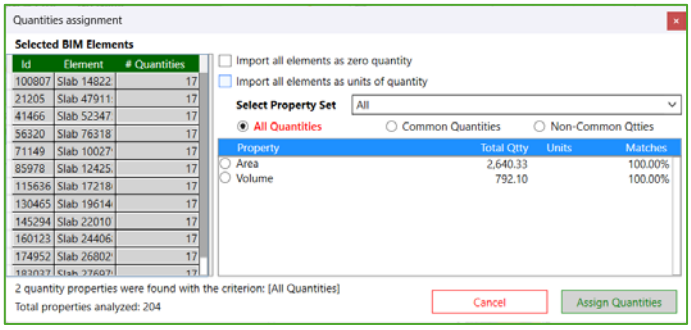


Figure 31 Quantity Property assignment dialog

The available options are:

- **Import the selected elements as zero quantity**. This is useful when you want to assig the elements but without considering any quantity property.
- **Import the selected elements as units of quantity**.
- **Select the Property Set**. Let the user filter the quantitative properties by property set.
- **All / Common / Non-Common Quantities**. Allow filter the properties based on the matches of each property over the selected elements. The matches can be seen in the column 'Matches', as a percentage of selected elements that have each property. The elements that don´t have the selected property will remain unchanged (Figure 32).
  The total quantity for each property is shown in the column 'Total Qtty'.

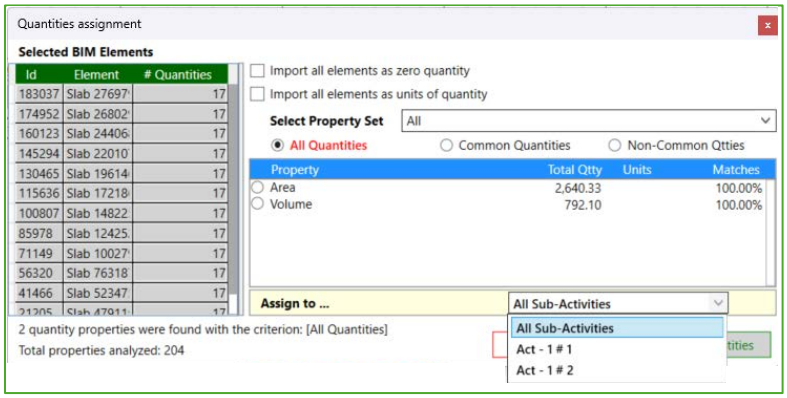


Figure 32 Assign quantity property to sub-activity

- **Assign to**. Allow select the sub-activity where the quantities will be assigned. This option is only visible for activities with sub-activities.

- **Information labels**. The information labels display the total count of properties matching the filter criteria (All, Common, or Non-Common) within the selected property set. Additionally, the total number of properties processed is shown. If no properties meet the filter criteria, an alert message will be displayed.

5. Finish by clicking over the button [Assign Quantities].

Assignment by Criteria-Based Selection

The criteria-based assignments consist of selecting the BIM elements that match several filters simultaneously. The workflow is:

1. Select the Activity Item (Several Items can be selected).
2. Open the context menu by right click, and the dialog shown in Figure 33 will appear.

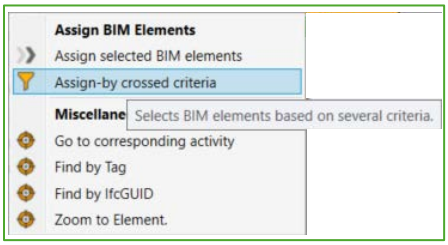


Figure 33 Criteria-Based element assignment context menu

3. Choose the option [Assign by Crossed criteria], and the dialog of Figure 31 for establishing the elements selection criteria will appear (Figure 34).

Figure 34 Elements selection by Criteria-Based Selection

4. The available filters are:

- **Category**: Revit utilizes Categories to broadly classify building elements in an intuitive manner. Common Categories include Walls, Windows, Doors, Ducts, Pipes, Structural Framing, Columns, and many more.
- **Phase**: Provides the capability to assign a construction stage to each element. Valid stages include Existing, Demolished, Temporary, and New, allowing for accurate representation of the project's lifecycle.
- **Level**: Levels provide a structured framework for organizing the vertical dimensions of the project and serve as horizontal references for elements like walls, floors, roofs, and ceilings. To maintain project organization, **it's crucial to assign a specific level to each element**.
- **Family**: A Revit Family is a pre-defined, reusable collection of objects that function as a single, customizable component within a building model. Key types of Revit Families are system, loadable and in-place families.
- **Material**: Defines the substance of BIM elements. It can be assigned to elements as a single material or as a composite of multiple layers.
- **Assembly Code**: See The Quantities Grid with BIM entities.
- **OmniClass Code**: See BIM Basics.
- **Keynote**: Are text annotations related to specific elements in the project to enhance the clarity and readability of the project information.
- **Type and Element Mark**: Are annotations used to provide a more in-depth identification of the types and elements in the model.

Additionally, there is a check box for selecting only unassigned elements, and a button for a preview of the selection.

5. Finish the elements selection by clicking over the button [Assign BIM Elements] and proceed as in Assignment by Manual Selection.

Automated assignment[5].

BIM element assignment to a project can be automated at two levels: by incorporating elements from a new IFC model into an existing project, or by generating a new project, or extending an existing one, entirely from the information contained within the IFC model.

Import BIM Elements:

This option is recommended for creating new projects from a database, by adding models to it. There are three ways to add a BIM IFC[6] model, and its elements, to Plexos:

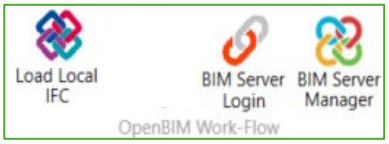


Figure 35 Load IFC from local and BIM server-center

1. **From local folder:** Locate the file on your computer and load it (Figure 35, left).
2. **From BIMserver.center:** Access and select the BIM IFC model from BIMserver.center (Figure 35, right).
3. **By Drag and Drop:** Drag and drop the BIM IFC file directly onto the Plexos interface.

Each time that the users add a model, Plexos shows the 'Classification System Selection' dialog shown in Figure 36.

This dialog allows users to select the desired classification system, establish the BIM elements structuration preferences and preview the effects on the project structure, and select the mode that better fits with the current project.

Clicking the [Next] button displays a new dialog that presents options for the IFC Model Import process (Figure 37).

If no options are selected, Plexos will function as a visualizer for the IFC model. The first option, '**Assign the corresponding BIM elements to activities**', initiates a search for activities within the current project where their unique identifier (ID) matches the Assembly

[5] Complementary information can be found in the document “Project Information Structure”.
[6] IFC models can be loaded in two formats: IFC and IFCZIP. IFCZIP is a ZIP archive containing an IFC model file.

Code of the corresponding BIM elements. This matching process is guided by the selection criteria defined within the 'Classification System Selection' dialog.

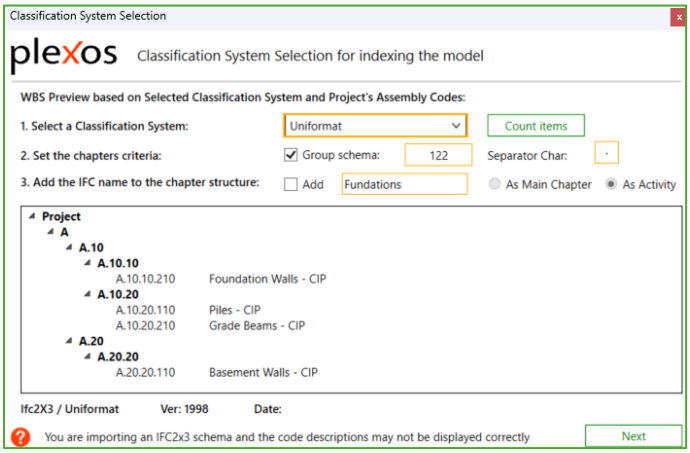


Figure 36 Classification System Selection dialog

By the option **Create sub-activities in the activities**, Plexos will organize the BIM elements corresponding to each activity in sets of sub-activities according to the level, from lower to higher, to which they belong.

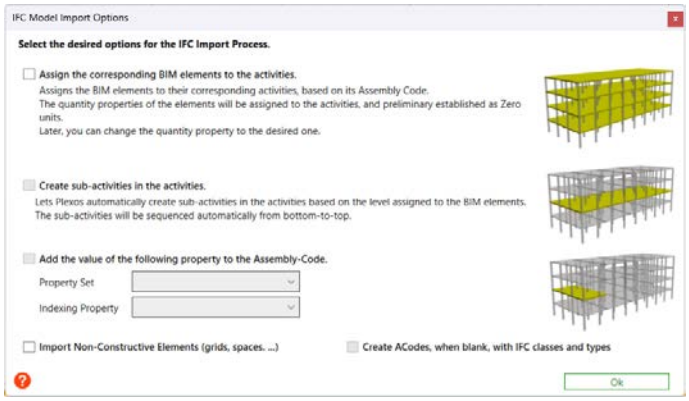


Figure 37 IFC Model Import options

The '**Add the value of the following property to the Assembly Code**' option allows users to incorporate a property value into the assembly code, and is particularly valuable for referencing project-specific locations. This is enabled by checking the option, selecting the property set containing the desired property, and then selecting the specific property.

The last option, '**Import Non-constructive Elements (grids, spaces, …)**', is typically unchecked because such entities are generally excluded from quantity take-offs.

Upon completion of each model import into Plexos, the sub-activities are automatically reordered. A subsequent dialog will prompt you to confirm the deletion of any empty activities without quantities (Figure 38).

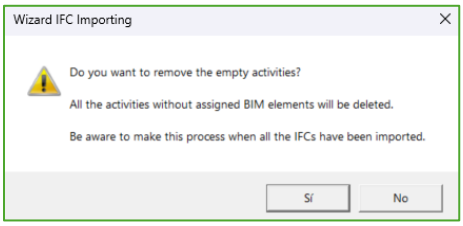


Figure 38 Remove empty activities

It's recommended to execute this final operation after importing all models. Alternatively, you can manually purge the project by clicking the [Purge Project] button (Figure 39), which offers more purge criteria (Figure 40).

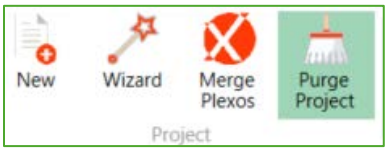


Figure 39 Purge project

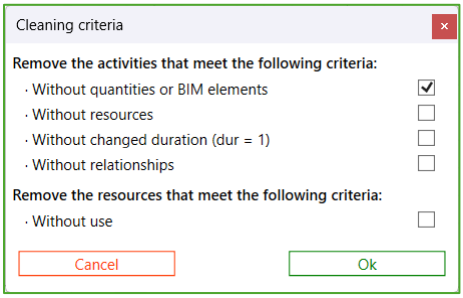


Figure 40 Purge Project criteria

Finally, If the default sub-activity order doesn't align with your project's specific needs (common in top-down construction), you can easily customize it. Simply click the [Edit] button within Section 3 of the [Properties panel] and rearrange the sub-activities to the desired sequence (Figure 41).

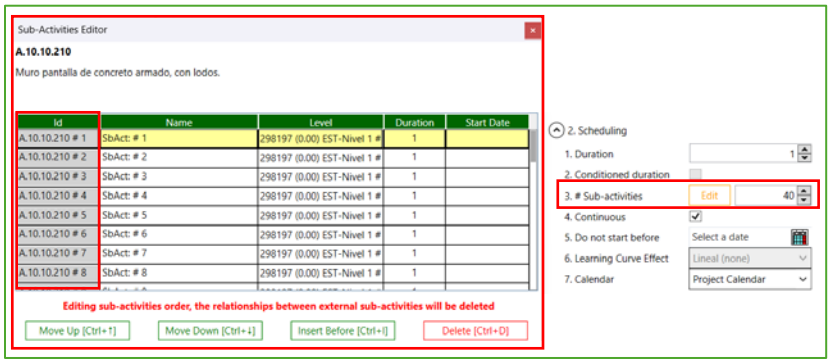


Figure 41 Sub-activities Edition.

Following the assignment of BIM elements to the project, continue with the process outlined in Assignment by Manual Selection.

Automated Project Creation:

The previous automate assignment method is useful when working with premeasured items, However, it excludes elements whose IDs do not correspond with any activity IDs.

Figure 42 Wizard for Automated Project Creation

This automated assignment method (Figure 42) creates or extends a Project based on the information of the IFC model. It dynamically generates new project items or extends existing ones, establishing links between project items and corresponding BIM elements. This process guarantees the inclusion of all BIM elements with assigned assembly codes within the project. Additionally, if the 'Create Acodes, when blank with IFC classes and type' option is checked, elements without assembly codes are also included using their IFC classes and types.

The process begins by selecting the project source: either a local file or BIMserver.center. You can then choose to create a new project or add the model information to an existing project. (Figure 43).

Thereafter, the process adheres to the same methodology as the preceding automated approach.

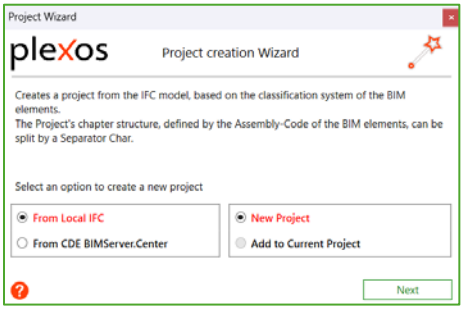


Figure 43 Project Creation Wizard

The quantities maintenance process

The dynamic nature of the project life cycle, with its evolving project models, necessitates not only robust CDE processes but also tools capable of assessing the impact of these changes on project take-off.

The IFC models stored in a CDE are subject to changes, so when a project IFC model is loaded, Plexos verify automatically if the BIM elements in the IFC model match with the ones stored in the project.

Four possible states can be encountered: broken element, missing element, or missing property. The first two states are always assessed, while the third and fourth states are evaluated only when a change is detected.

<u>Broken element.</u>

This condition occurs when the BIM element's corresponding IFC model has not been loaded into the system. As a result, no information about the element is accessible, and its quantities remain unchanged, potentially missing any updates.

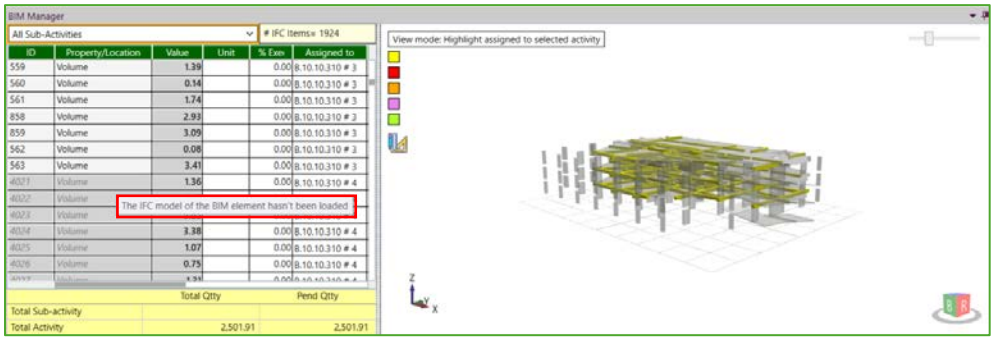


Figure 44 Alert of broken elements in the quantities grid

In such cases, the quantities grid will alert the user by (Figure 44):

- Highlighting the affected items in gray.
- Displaying a tooltip that reads: 'The IFC model of the BIM element has not been loaded.

Lost element.

When BIM elements are missing from the IFC model, a dialog will appear displaying a list of the missing elements. To resolve this issue, the user is prompted to delete the corresponding IFC links. Subsequently, the quantities will be automatically updated to reflect the changes (Figure 45).

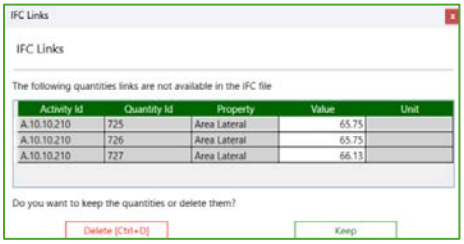


Figure 45 Relation of lost BIM elements

If the user retains the missed items, the quantities grid will display a more severe warning (Figure 46):

- Highlighting the affected items in yellow and red.
- Displaying a tooltip that reads: 'The BIM element is lost.

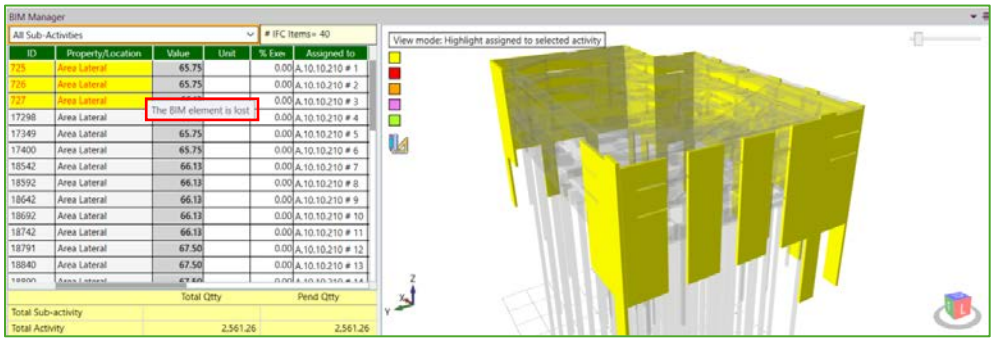


Figure 46 Alert of lost BIM elements in the quantities grid

Missed quantity property.

When the system detects that the IFC model has changed, an alert message will ask the user to perform an in-depth analysis of the BIM model to verify the accuracy of property quantity references (Figure 47).

This analysis is recommended when you suspect changes to specific properties. It can be time-consuming and may temporarily limit some functionalities while running in the background. We advise proceeding only if you're confident that changes have been made to some property involved in the project.

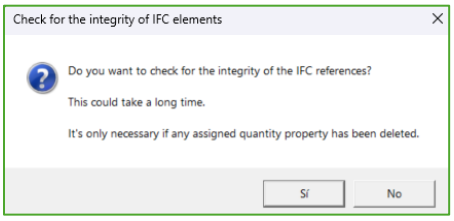


Figure 47 Check for Integrity of quantity references

In this condition, the quantities grid will display a low severe warning (Figure 48):

- Highlighting the affected items in light yellow and orange.
- Displaying a tooltip that reads: 'The quantity property has changed and isn´t available in the IFC model.

To resolve this issue, consider the following options: **Correct** any errors within the model, **Modify** the quantity property associated with the affected items, and if necessary, **Delete** the items that are causing the problem.

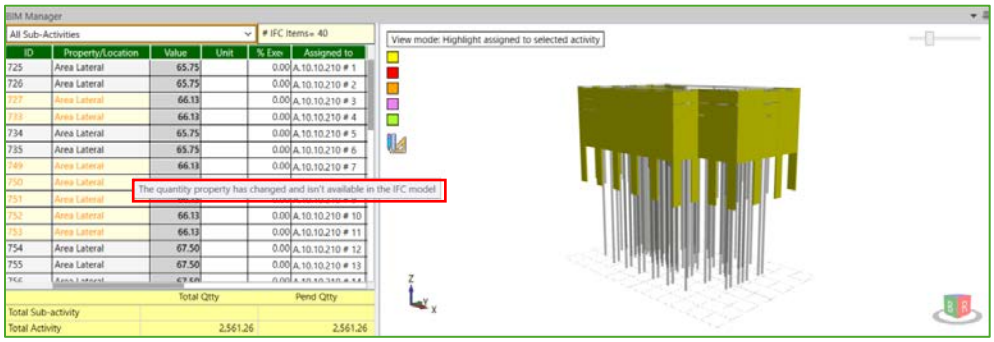


Figure 48 Alert of Missed quantity property in the quantities grid

Added element.

As previously noted, the dialog in Figure 49 indicates a model change. In addition to verifying the accuracy of property quantity references, checking for newly added elements is recommended. To do this, select the visual model and check the 'Show unassigned elements' visual option.

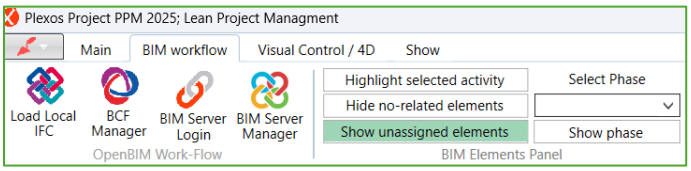


Figure 49 Show unassigned elements.