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Design Note

Project	Steel Reuse Inspector & Scheme Tool
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Revision	Description	Issued by	Date	Approved (signature)
P01	User Guide for the "Steel Reuse Inspector & Scheme Tool"	GA	01/10/2025	

1. Description

The Steel Reuse Inspector and Scheme Tools are two Revit Plugins developed by Buro Happold to assist structural engineers in conducting fast preliminary assessments of the potential for reuse of existing steelwork within a refurbishment project. All the process runs inside the Revit environment generating outputs both as Revit dashboards/sheets and as external worksheets, json datasets.

The use of the two tools is aimed to allow BH engineers to be drivers of sustainable solutions with architects and clients. Allowing to present dismantled steel data in a comprehensive and digestible format is key to encourage clients to adopt structural grids and loading that suits the reused steel early in the design process as well as to secure bids in areas where planning is heavily dependent on retaining and reusing existing structures.
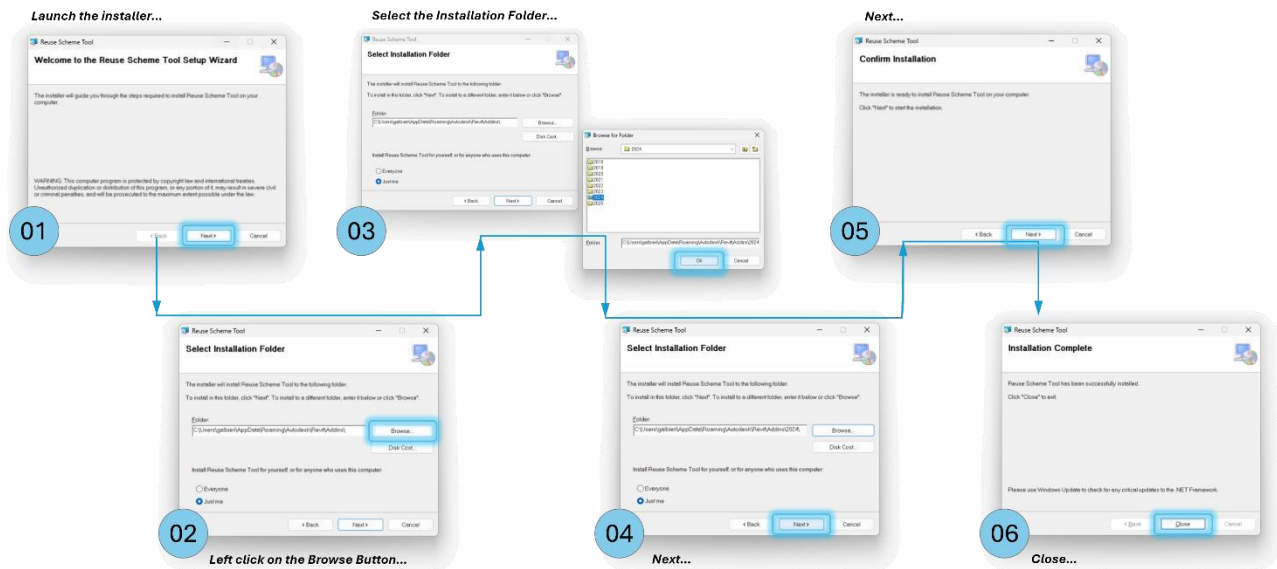

Figure 1: Overview on main features of the Inspector and Scheme Tool

2. Installation

The process of installation of the plugin is very simple. It's just a matter of running the provided msi installer and follow the step-by-step process below (see it also in Figure 2).

1. Close any Revit instance currently running on the machine.
2. Launch the msi installer.
3. In the wizard window popping up, select the location of the Installation Folder.
   - i.e. : *C:\Users\<username>\AppData\Roaming\Autodesk\Revit\Addins\<versionNumber>*
4. Click on Next until installation is complete.

Figure 2: Installation process via msi installer - step-by-step

The installer creates two new folders and two new addin files inside the *Revit\Addins\<versionNumber>* folder.

The two folders, called RevitRibbonTabsFactory and ReuseSchemeTool (see image below), contain the two relevant assemblies of the plugin.
The first is a program running in the background when opening Revit and that sets up the Ribbon Tab and Panels configuration that are going to be used by the second.
In addition to the two folders, the installer also creates two manifest files, respectively __RevitRibbonTabsFactory.addin and 01_ReuseSchemeTool.addin. The manifest files are the key documents allowing Revit to register the assemblies stored in the corresponding folders.
DO NOT DELETE or RENAME these folders/files. Otherwise, the Steel Reuse Tool won't work.

Figure 3: Files created by the .msi installer in the Revit Addins/ folder

3. Revit Model Setup

3.1. Introduction

Here below the list of items and checks that have to be setup/carried out on the Revit model prior to running the tools. These are also displayed in the AboutBox Window of both tools when running the Tools.
If any of the below conditions are not met, do not continue running the tools and do that only once all the following conditions are met.

3.2. Revit Version

The version of the Revit Model must be 2020 or later.

3.3. Key Revit Parameters - Set Up

The Revit parameters that MUST be assigned to all existing steel frame elements in the model are:

- **BHE_Material**
    - Parameter used to read the material property of the elements. Elements not having this parameter or having it assigned with no value, won't be included in the computations carried out by the tool.

- **BHE_Reuse Strategy**
    - Parameter used to filter out elements that are already deemed not suitable for reuse.
    - Elements not having this parameter or having it assigned with no value, won't be included in the computations carried out by the tool.
    - Based on the information gathered from the visual inspection / dimensional survey of the existing structure, make sure all existing elements are assigned with one the following parameter values:
        - **EXISTING TO REMAIN – MAKE GOOD**
        - **EXISTING TO DISMANTLE – TO RECYCLE**
        - **EXISTING TO DISMANTLE - UNKNOWN**

- **BHE_Reuse Rating**
    - Parameter where the tool saves the rate of each analysed existing frame element at the end of the scheming process. Any value pre-assigned to this parameter will be overwritten by the tool while running.
    - IMPORTANT Notes
        - It's likely that this parameter isn't set up by default in the Revit Model.
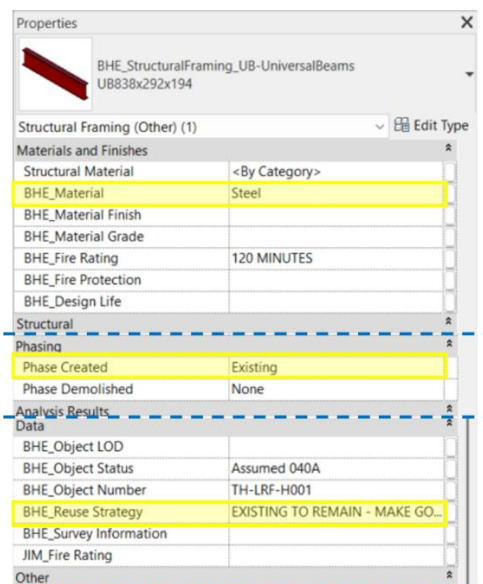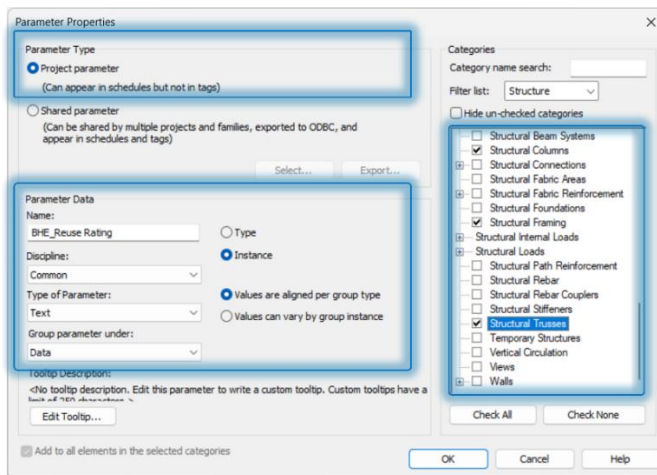   Follow instructions below to set it up.

Figure 4: Parameters in Revit Properties Window

In case one of the parameters listed above is not already set up in the Revit Model, make sure to add it as a Project Parameter following the steps below in the Revit interface:

1. "Manage" Ribbon Tab -> "Settings" Panel -> Left click on "Project Parameters"
2. Left click on "Add..." in the Dialog Box popping up -> the "Parameter Properties" window pops up
3. Define the parameter as per example below

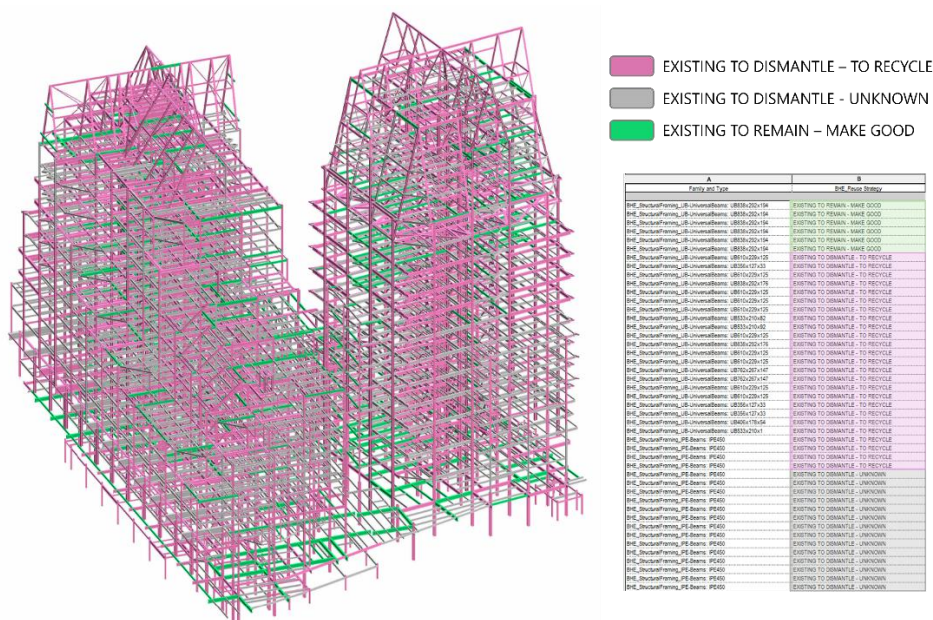**Figure 5:** "Parameter Properties" Window

3.4. Key Revit Parameters - Assignment

- **BHE_Material**

    - Only elements having it assigned with value "Steel" will be considered by the tool.

- **BHE_Reuse Strategy**

    - All existing elements in the Revit model shall be assigned with one of the following values.
        - **EXISTING TO REMAIN – MAKE GOOD**
        - **EXISTING TO DISMANTLE – TO RECYCLE**
        - **EXISTING TO DISMANTLE – UNKNOWN**

    - Only elements having the value "EXISTING TO DISMANTLE - TO RECYCLE" will be considered by the tool.

Figure 6: BHE_Reuse Strategy Parameter Assignment – Revit 3D View (left), Revit Schedule (right)

- **BHE_Reuse Rating**

  - Keep this parameter empty as the tool will populate it automatically.

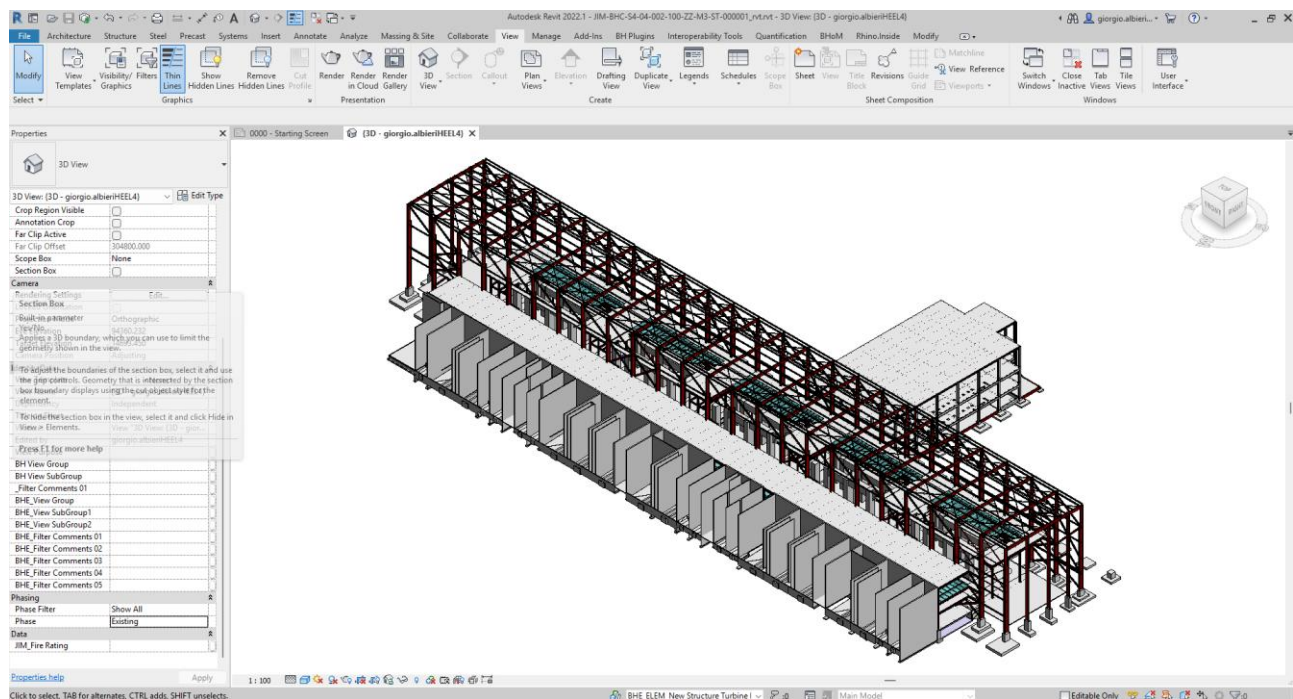## 3.5. Naming Conventions for Revit Parameters

Whatever family/element doesn't abide by the following conventions, the corresponding parameter values won't be extracted from the model by the tool and won't be taken into account in the computations.

- Weight -> "Nominal Weight" or "W"
- Length -> "Length"
- Area -> "Section Area" or "A"

3.6. Naming Conventions for Revit Parameters

To make sure the set up of the Revit model is in line with the requirements of the Inspector and Scheme Tool, we have prepared the following Test Revit Models that are based on real refurbishment projects designed by the BH Structures Team from London.

- JIM-BHC-S4-04-002-100-ZZ-M3-ST-000001_rvt.rvt [JIOM Project – Jeddah, KSA]
- MSC-BHE-XX-ZZZ-M3-SE-000001.rvt [Domino Project – London, UK]
- GRS-BHE-ZZ-ZZ-M3-S-00001.rvt [Gresham Project – London, UK]

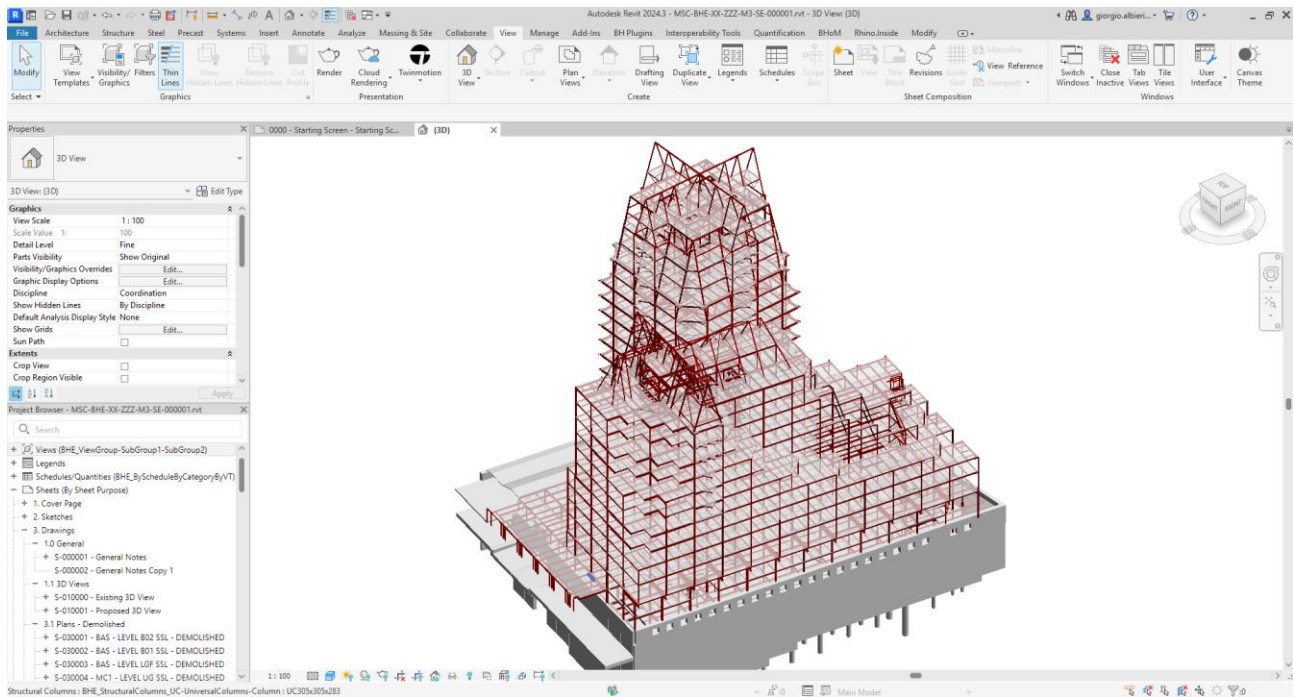**Figure 7:** Test Revit2022 Model JIM-BHC-S4-04-002-100-ZZ-M3-ST-000001_rvt.rvt [JIOM Project – Jeddah, KSA]

Figure 8: Test Revit2024 Model MSC-BHE-XX-ZZZ-M3-SE-000001.rvt [Domino Project – London, UK]
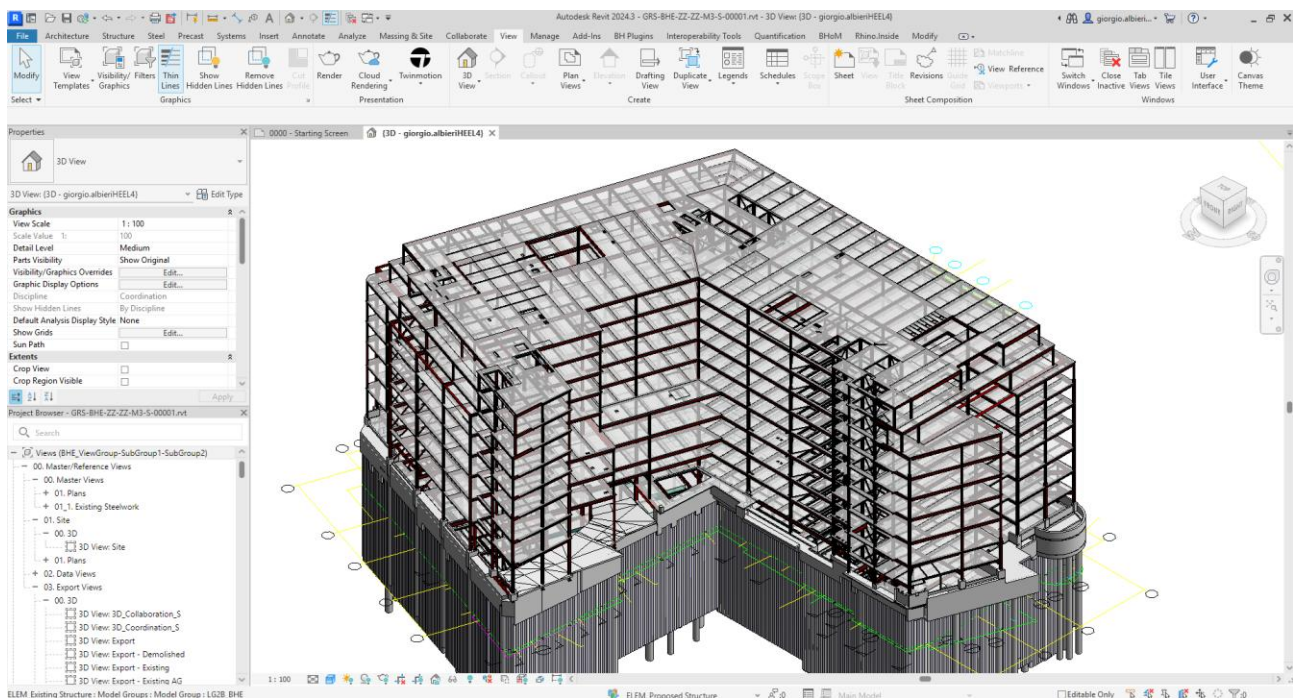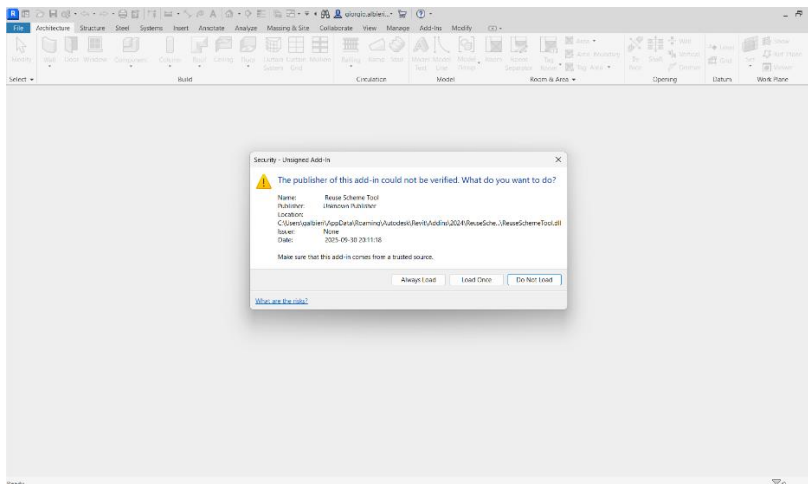

Figure 9: Test Revit2024 Model GRS-BHE-ZZ-ZZ-M3-S-00001.rvt [Gresham Project – London, UK]

4. Access the Tool

Open whatever version of Revit that has been chosen in the installer wizard.
As soon as the Revit session starts, the following window will get displayed on the screen asking for permission to use the Steel Reuse Tool plugin. Choose "Load Once" or "Always Load" (recommended).
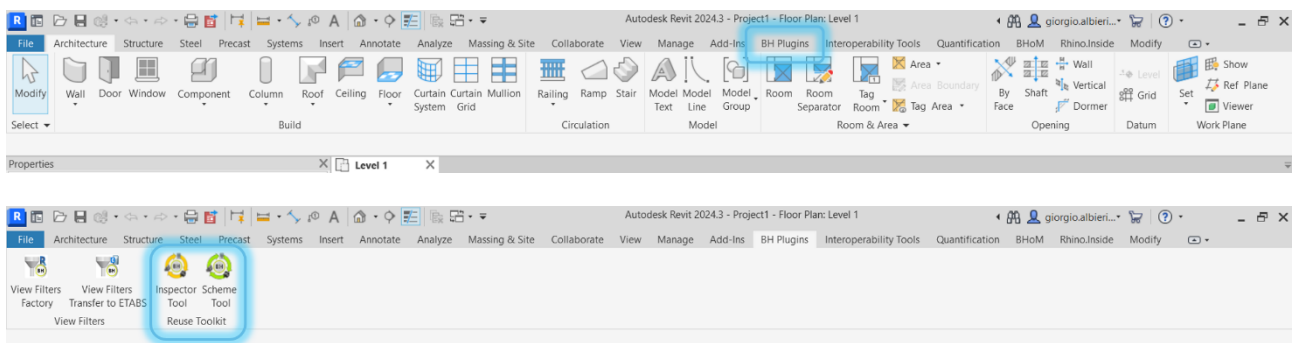

Figure 10: Warning Message Window asking for permission to load the tools

Create a new model / open an existing one and find the Ribbon Tab "BH Plugins" at the top of the window. Left click on it and find the panel "BH Plugins" containing two buttons. One for launching the Inspector Tool (orange) and one for launching the Scheme Tool (green).
It is always recommended to run the Inspector Tool first.
This is to allow and drive the user to inspect the existing assets present in the model prior to conducting the assessment of potential reuse by running the Scheme Tool.
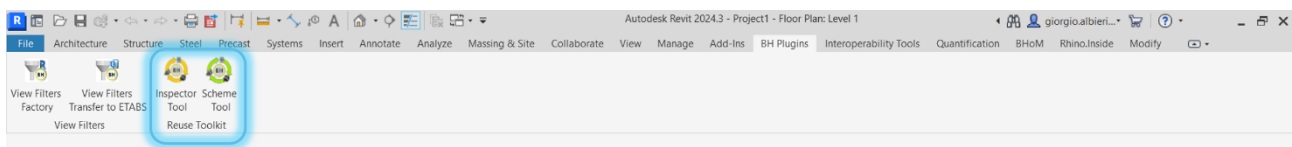

Figure 11: Detail of the "BH Plugins" Ribbon Tab and "Reuse Toolkit" Panel

5. User Interface

5.1. Reuse Toolkit

Access the "BH Plugins" Ribbon Tab in Revit and the panel "Reuse Toolkit" will appear with the buttons corresponding to the Inspector Tool and the Scheme Tool Respectively.

Figure 12: Access to the Tool via the Revit UI

5.2. Inspector Tool

SplashScreen

As soon as we click on the tool's icon and the Plugin starts running, a Splashscreen window will appear on the screen. This contains the logo of the tool, the name, the version and the copyright.
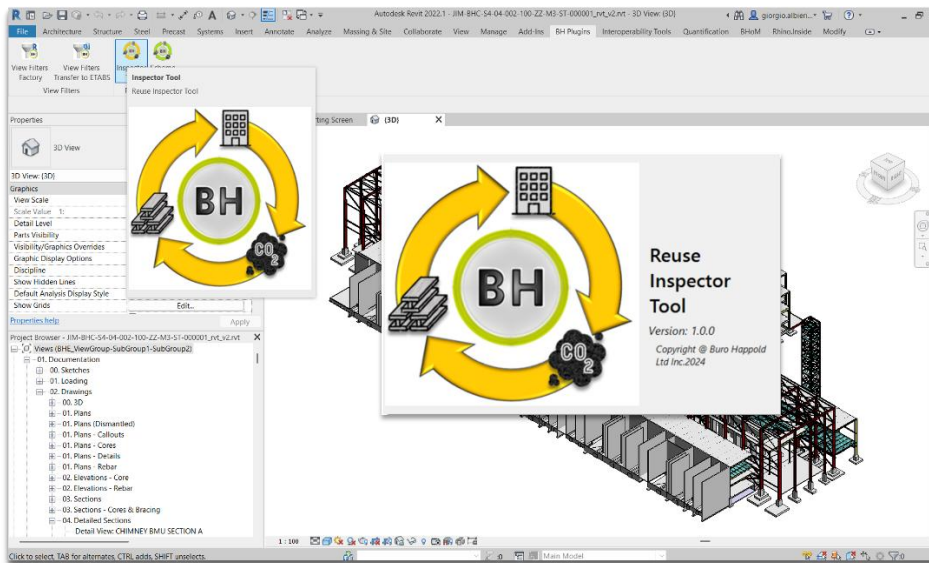After few seconds it will disappear leaving space to the AboutBox window.

Figure 13: Inspector Tool - Splashscreen

AboutBox

The AboutBox window is a very important part of the tool's UI as it contains relevant information about the use of the plugin. In addition to the logo and the versioning/copyright information, it contains a textbox where the strengths and limitations of the tool are reported and regularly updated.
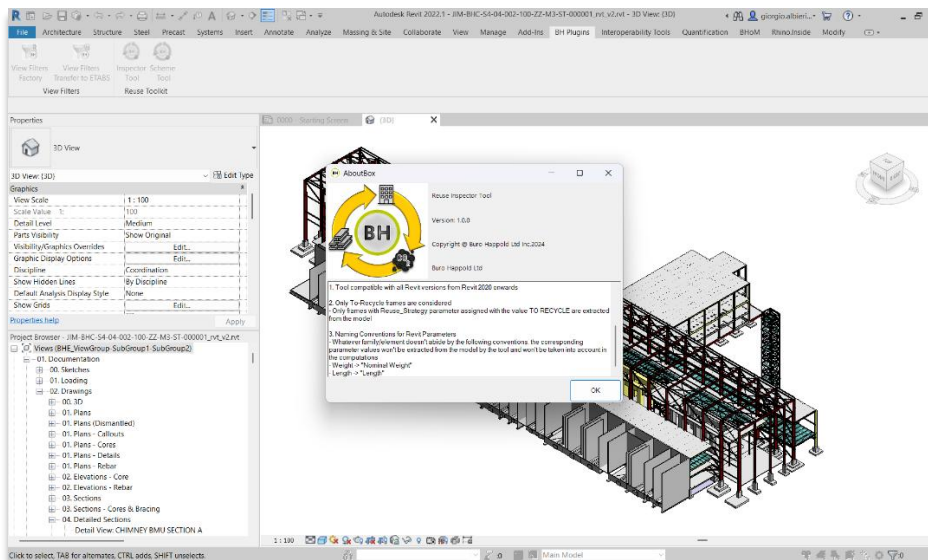It is strongly recommended that, whenever a new version of the tool gets released, the user takes the chance to read all this information before moving on using the tool.
The information reported is subdivided in the following sections:

- *DESCRIPTION*
  - o High level description of the scope of the tool.
- *ALGORITHM*
  - o Step-by-step process followed by the tool to compute the outputs.
- *UI FEATURES*
  - o List of main inputs to be collected from the user via the User Interface
- *LIMITATIONS*
  - o Current limitations the user has to be aware of before using the tool.
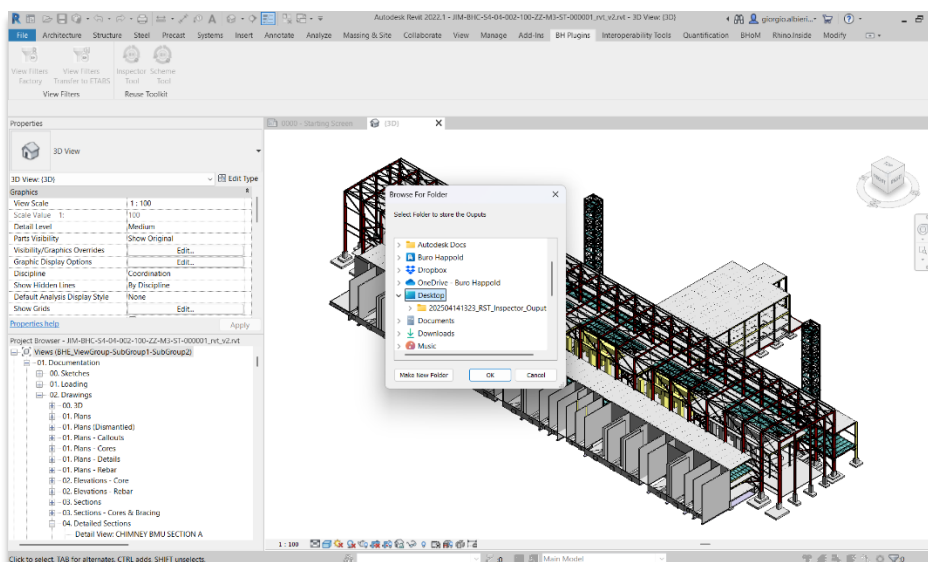
Once finished reading, left click on the "OK" button in the bottom right corner of the window to move on to the Inputs Form.

Figure 14: Inspector Tool – AboutBox

Select Outputs Folder Dialog

Figure 15: Inspector Tool - Outputs Folder Dialog

As soon as we click on the "OK" button of the AboutBox Window, a Folder Selection Dialog pops up on screen.
The user shall select/create the folder that will be used by the tool to save and store all the outputs that will be generated at the end of the session.
Once selected the folder, left click on the "OK" button to move on.
This will automatically launch the inspection process of the revit model.

Inspection Progress Bar

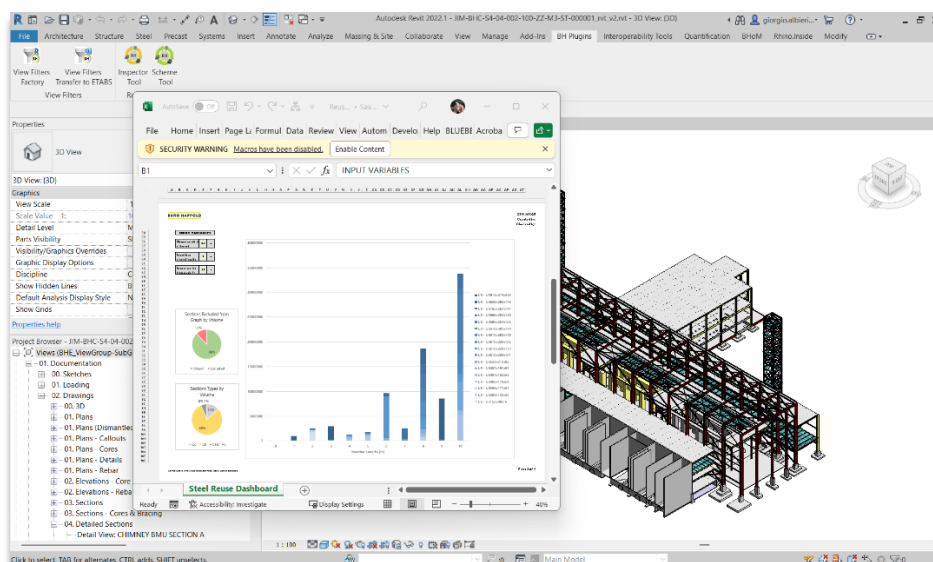**Figure 16:** Inspector Tool – Progress Bar

While the tool is carrying out the inspection of the model, a progress bar gets shown on screen allowing the user to keep track of the status and progress of the inspection.

During the process, the tool collects all the information present in the model regarding the existing steelwork assets, groups them and categorizes them based on multiple criteria based on section properties, material, length and weight. As soon as the process is completed, the progress bar reaches 100% completion and the Outputs Summary gets automatically displayed on screen in Excel format.

Inspection Summary Outputs via Excel

Figure 17: Inspector Tool - Excel Dashboard

The Inspection Outputs Summary gives the user an overview of all the existing steelwork assets available in the Revit model. Based on their section type, material, length and weight, the summary file provides multiple visuals and analytics allowing the user to get a good understanding of quantity, quality and diversity of the existing steelwork elements. With the use of a series of pie-charts and bar-charts defined based on multiple criteria, the Outputs Summary allows the user to get a very comprehensive grasp of the distribution of different steel section sizes, frame element lengths as well weights across the entire model.

Thanks to all this information, the user is assisted in making very fast, effective and well thought assessments as well as decisions on how to develop the reuse strategy for the project and identify the potential cost savings achievable thanks to steelwork reuse.

The Summary Excel file, on top of being immediately displayed on screen, gets also automatically saved in excel and in pdf format in the outputs folder.

5.3. Reuse Tool

SplashScreen

As soon as we click on the tool's icon and the Plugin starts running, a Splashscreen window will appear on the screen. This contains the logo of the tool, the name, the version and the copyright.

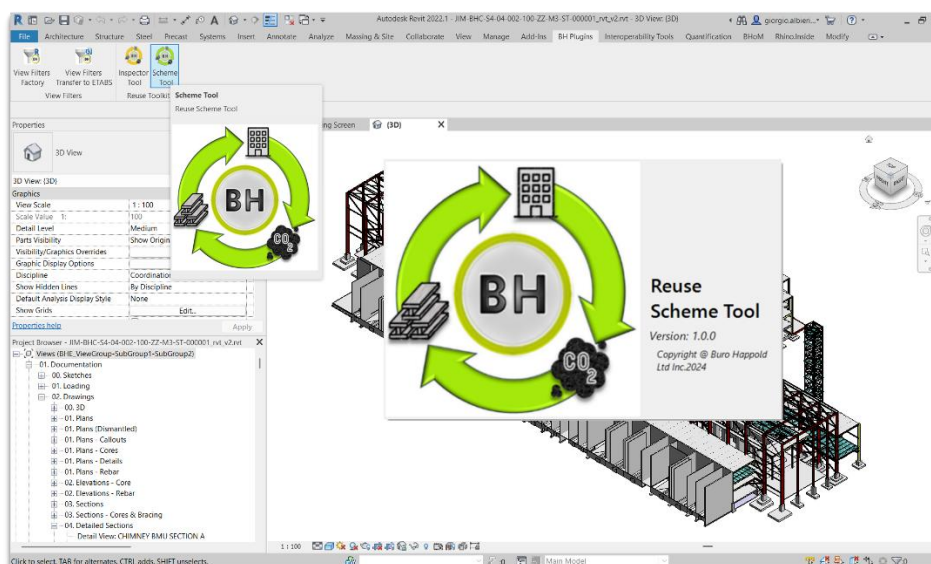After few seconds it will disappear leaving space to the AboutBox window.

Figure 18: Scheme Tool - Splashscreen

AboutBox

The AboutBox window is a very important part of the tool's UI as it contains relevant information about the use of the plugin. In addition to the logo and the versioning/copyright information, it contains a textbox where the strengths and limitations of the tool are reported and regularly updated.

It is strongly recommended that, whenever a new version of the tool gets released, the user takes the chance to read all this information before moving on using the tool.

The information reported is subdivided in the following sections:

- ***DESCRIPTION***
  - High level description of the scope of the tool.
- ***ALGORITHM***
  - Step-by-step process followed by the tool to compute the outputs.
- ***UI FEATURES***
  - List of main inputs to be collected from the user via the User Interface
- ***LIMITATIONS***
  - Current limitations the user has to be aware of before using the tool.

Once finished reading, left click on the "OK" button in the bottom right corner of the window to move on to the Inputs Form.
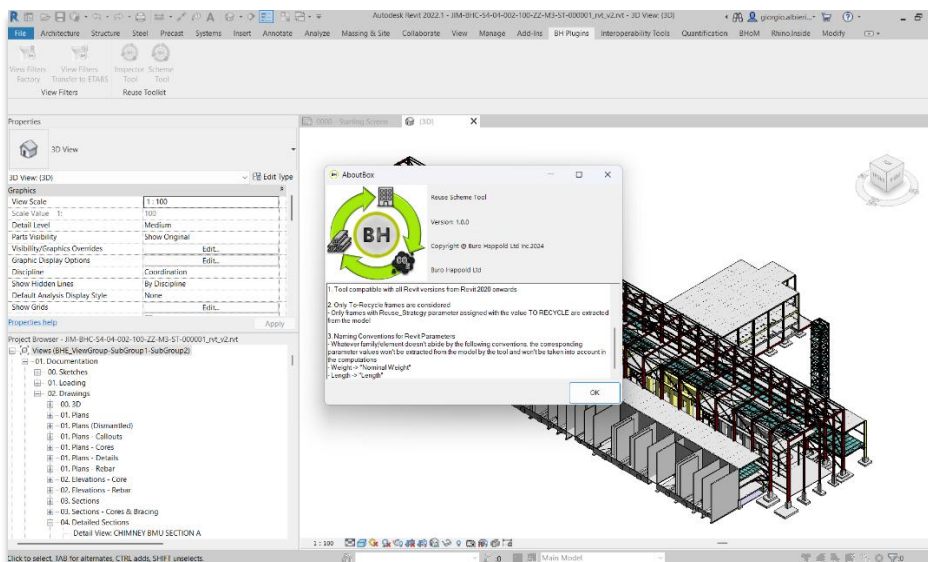
Figure 19: Scheme Tool - AboutBox

Inputs Form

The Inputs Form is the main window of the tool. It's the window that reads data from the Revit model currently running, allows the user to select the inputs required, runs the scheming process and informs the user when the process finishes.

The Form is designed to be as simple as possible and is subdivided into 3 main sections:
- SECTION and MATERIALS SELECTION ListBoxes
  - Subdivided into two CheckedListBoxes: one for Section Sizes and one for Steel Grades.
  - The Section Sizes and Steel Grades displayed in them are the ones that the tool has found to be assigned to the existing steelwork assets in the Revit Model.
- GEOMETRY and WEIGHT CRITERIA Sliders
  - Consists of a set of sliders allowing the user to define the range of frame lengths and frame weights per unit length that are considered to be optimal together with the value of the desired end cut-off.
- RUN Button
  - Left click on the button to let the tool start the scheming process based on the inputs/criteria selected in the two sections above.

A more detailed description of both Inputs and Outputs is reported in the following paragraphs of this document.
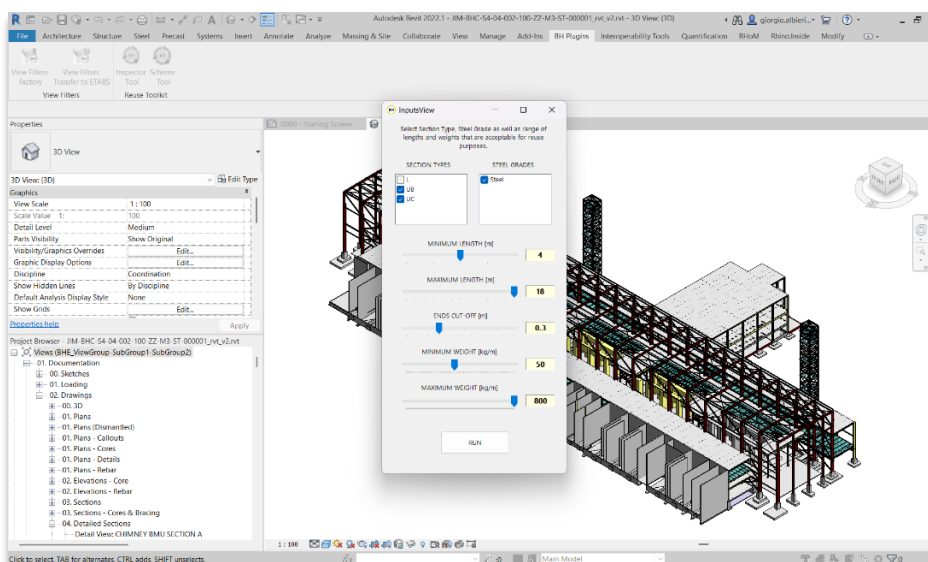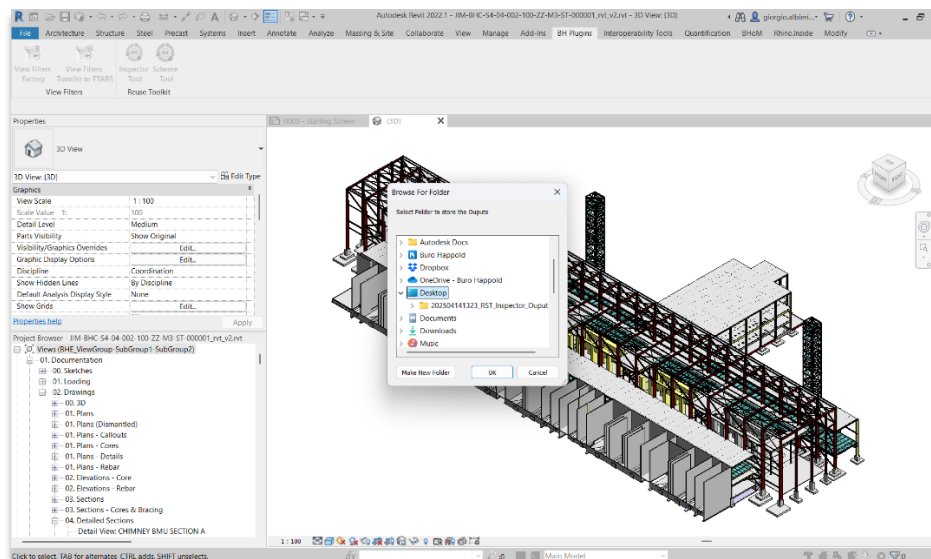

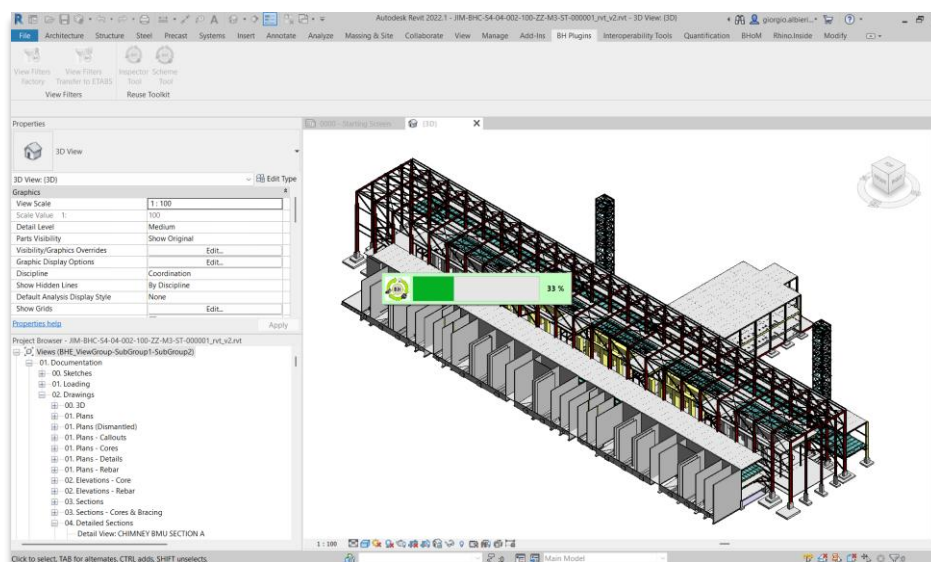**Figure 20:** Scheme Tool – Inputs View

Select Outputs Folder Dialog

Figure 21: Scheme Tool - Outputs Folder Dialog

As soon as the "RUN" button of the Inputs Form Window is clicked, a Folder Selection Dialog pops up on screen.
The user shall select/create the folder that will be used by the tool to save and store all the outputs that will be generated at the end of the session.
Once selected the folder, left click on the "OK" button to move on.
This will automatically launch the scheming process carried out by the tool.

Scheming Progress Bar

Figure 22: Scheme Tool - Progress Bar

While the tool is carrying out the reuse scheming process, a progress bar gets shown on screen allowing the user to keep track of the status and progress of the computation.
During the process, first of all the tool collects all the existing steelwork assets that abide by the optimisation criteria defined in the Input Form (see previous step) – i.e. section size and material belonging to selection made by the user, length and weight within the range specified and feasibility of end cut-off based on input length value.

Once this step is completed, the tool assigns to each of the existing steel frames a Reuse_Rate based on a customizable algorithm that defines the value and quality of the element based on the ease and potential of its reuse.
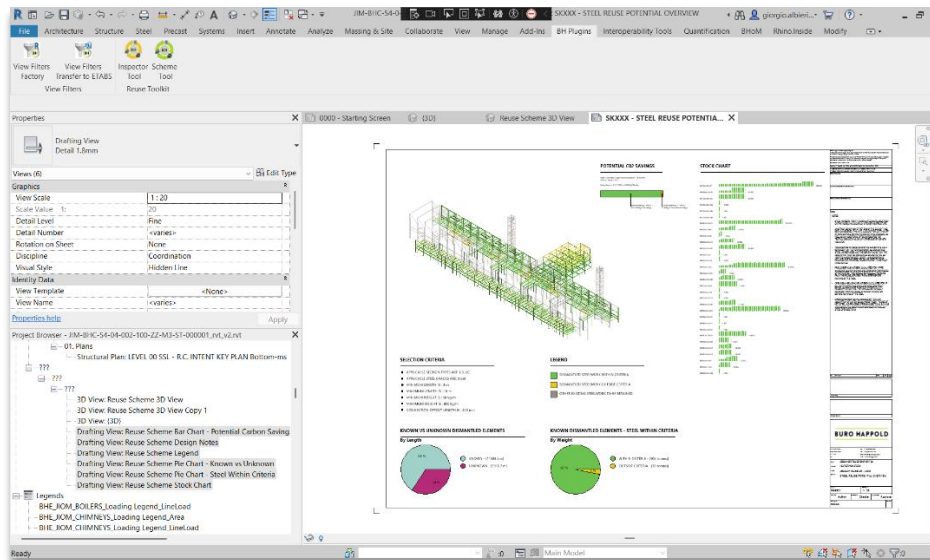
Scheming Summary Outputs in Revit

Figure 23: Scheme Tool - Overview Revit Sheet

Once the computation and scheming process is complete, the tool produces a JSON Dataset containing all the outputs of the assessment as well as a set of graphics and analytics directly within the Revit environment (see Revit View Sheet in image above) and outside, in the form of Excel and PDF files.

6. Inputs

Figure 24: Scheme Tool - Inputs Form

6.1. Section Types and Steel Grades

The two checked listboxes at the top of the inputs window contain respectively the list of section types (e.g. UB, UC, PFC…) and the list of materials (e.g. Steel) that are assigned to the existing structural elements within the Revit model. When launching the the Scheme Tool, it runs a quick screening of all the existing structural elements that are in the model collecting this information in order to allow the user to get already all other sections/materials filtered out from possible selection.

Currently, these properties are extracted ONLY from the structural elements that have the following Revit parameters and only the elements having the following parameter values will be considered and analysed by the tool.
* **Phase:** Existing
* **BHE_Reuse Strategy:** EXISTING TO DISMANTLE - TO RECYCLE

Once the user has completed the selection of section sizes and materials, the Scheme Tool will progress its computations taking into account also the elements that are included in the selection made.

Minimum and Maximum Length

These two sliders allow the user to define the minimum and maximum length that the existing structural elements shall have to be considered for potential reuse. This is mainly driven by what are the typical floor spans of the proposed building for which the user is aiming to recycle existing assets from the existing building.
All existing structural elements that are shorter or longer than the chosen length range, will be disregarded by the tool.

6.2. Ends Cut-Off

The ends cut-off is a typical length measure that defines the portion at the two ends of the existing beams that will need to be chopped off due to the presence of existing connections (i.e. holes for bolts, welds for connection plates etc.). Since such end portions of the length of the existing beams cannot be reused, the Tool will subtract such length from the total original length of the existing beam prior to run the scheming algorithm.

6.3. Minimum and Maximum Weight

Another figure that the user is allowed to input is a min-max range on the value of the weight per unit length (i.e.: kg/m). Based on the requirements of the proposed building, the user might not be interested in recycling beams that are lighter or heavier than some specific threshold values.
Again, like for min-max length range, the tool will disregard any existing frame element that has a specific weight per unit length that is not within the range specified by the user.
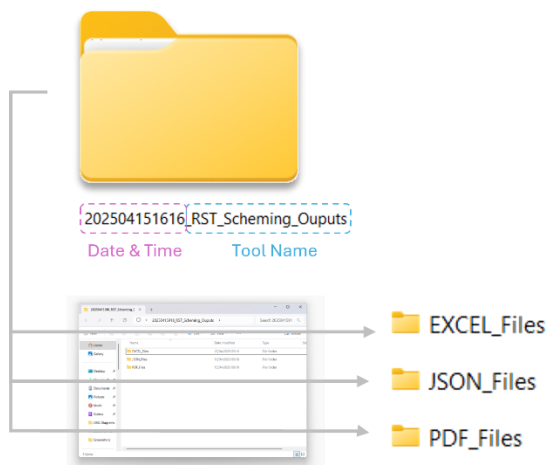
7. Outputs

7.1. Overview

The Inspector and the Scheme Tool come with a different set of outputs to assist the user in shaping the reuse strategy for their project.

The **Inspector Tool** provides outputs in terms of **Excel and PDF Files**. Both show a set of data analytics and graphs in the form of bar charts and pie charts that highlight quantities of different existing steel elements in the Revit model depending on their section size, length, volume, weight and potential for reuse.

The **Scheme Tool**, instead, provides a more comprehensive set of outputs consisting of a **JSON Dataset**, containing all the existing steel frames that have been recognized to be good for reuse enriched with post-processed metadata, a **Revit View Sheet** showing the summary of the assessment in the form of mapped 3d views, pie charts, bar charts and stockcharts (a document ready to go for presentation both internally and externally) and finally **Excel and PDF files** containing further data analytics and graphs produced by the tool.
All outputs are automatically saved in a folder located at the path selected by the user and labelled with Date, Time and Tool Name (see image below).

Figure 25: Scheme Tool Outputs - Outputs Folder

7.2. Inspector Tool

Excel Dashboard

Set of graphs and charts highlighting different key properties of the existing steel elements currently present in the Revit model.
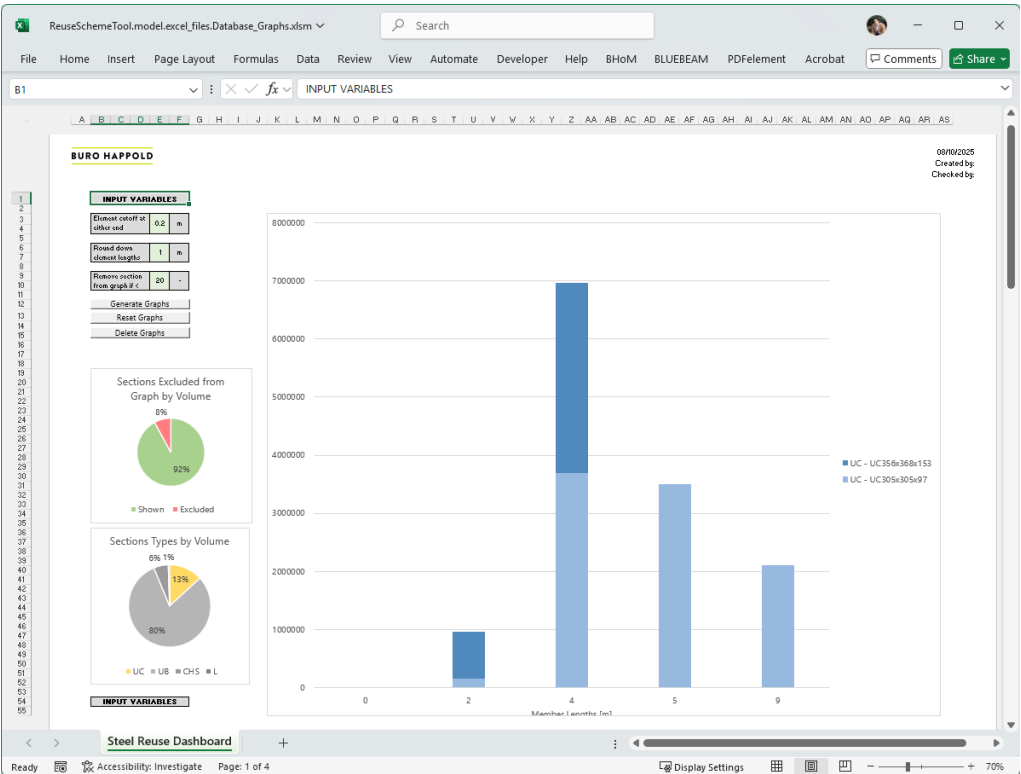

Figure 26: Inspector Tool Outputs - Excel Dashboard

PDF Files

PDF version of the set of graphs and charts available in Excel with additional formatting for re-use in documents/reports.
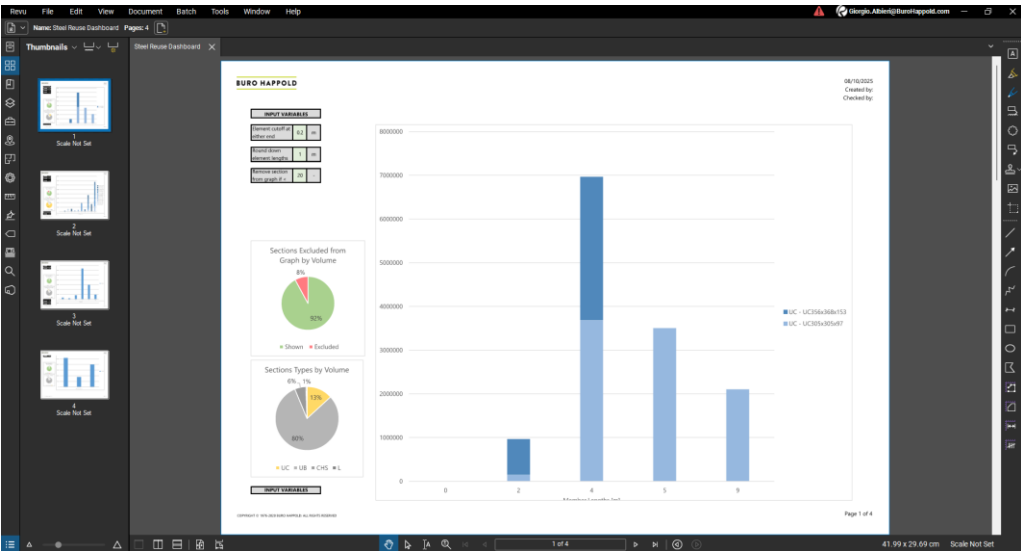

Figure 27: Inspector Tool Outputs - PDF Report

7.3. Scheme Tool

Overview Revit View Sheet

A1 Revit View Sheet showing the following graphics:
- **3D View** of the Revit Model color-mapped based on different reuse-rating assigned to different existing elements based on reuse rating algorithm embedded in the tool.
- **Pie Chart** "Known vs Unknown" showing percentage proportion by length between existing steel elements with known/unknown section size. A good indicator of how much information we currently have in our Revit model about the existing assets.
- **Pie Chart** "Known Dismantled Elements" showing percentage proportion by weight between known existing steel elements that have been assessed to be reusable/non-reusable by the rating algorithm.
- **Bar Chart** "Potential CO2 Savings" showing the amount of CO2 savings corresponding to the reuse of existing steel elements found to be suitable for reuse.
- **Stock Chart** showing list of all instances of reusable existing steel frames based on different steel section size
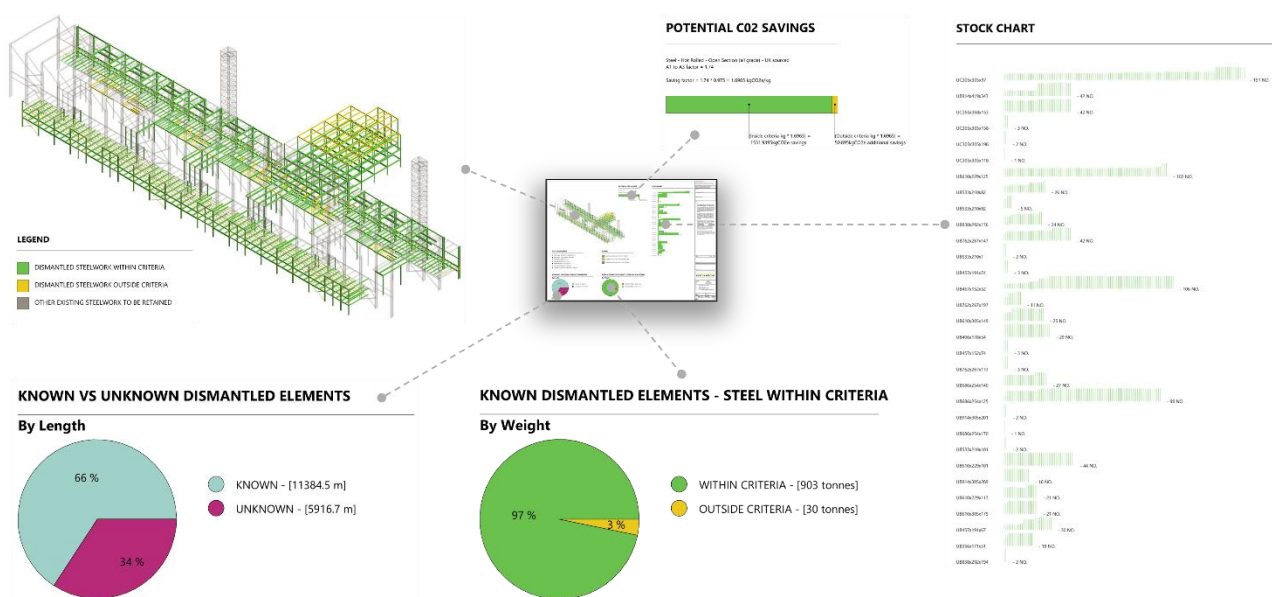

Figure 28: Scheme Tool Outputs - Summary Revit Sheet (Exploded)

Data set serialized in JSON

The main output of the tool is a list of data sets, serialized in json, containing all the results of the scheming process.

For each existing steel element that has been found to be reusable by the tool, the json file contains the record containing all the key properties of the element extracted from Revit plus all the essential metadata output by the tool.

This includes the end cut-off length set-up by the user, the resultant length suitable for reuse, the reuse strategy, the reuse rating assigned to the element as well as condition and dimension survery information (the last two items are only place-holders for now but ready for future development and implementation).

Serializing this information in JSON allows to minimize the size of the output (thus allowing to use the tool on models of significant size without the risk of producing heavy output files) as well as maximize its readability making it retrievable in the widest range of software packages possible.

For instance, once the JSON file has been produced by the tool, it is possible to visualize the outputs graphically in Rhino via Grasshopper just simply using a specific C# gh component de-serializing json files.
The data imported in the Grasshopper environment can then be visualized, manipulated and used in whatever computational workflow the user might need.

Thanks to story all the information in a JSON dataset, it's also possible to re-visualize, post-process and present the outputs in Jupyter Notebook (see below).
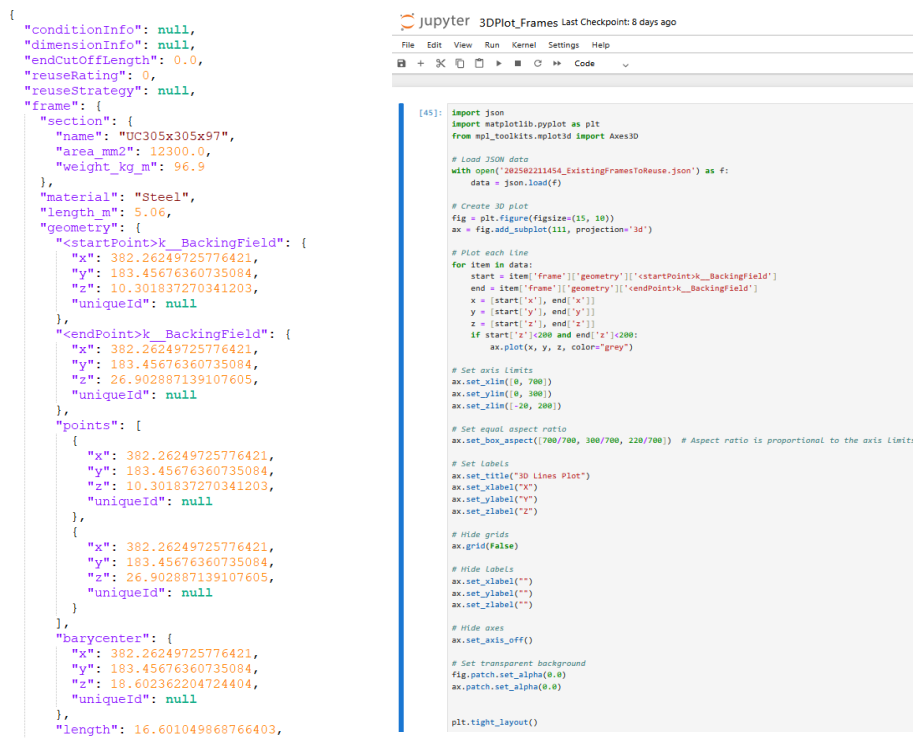

Figure 29: JSON File Content (left), Jupyter Notebook postprocessing the JSON file (right)

Summary Excel Spreadsheet

Similarly to the Inspector Tool, also the Scheme Tool generates an excel spreadsheet containing all the relevant outputs computed by the tool.

The excel spreadsheet contains multiple bar charts, pie charts and graphics that expand and enrich the key information provided by the Revit View Sheet.

In this way, the user has got the chance to have immediately a full report of the outputs and more in-depth insight in the outputs of the tool with the possibility of adding extra-layers of postprocessing directly in the Excel environment, if required.
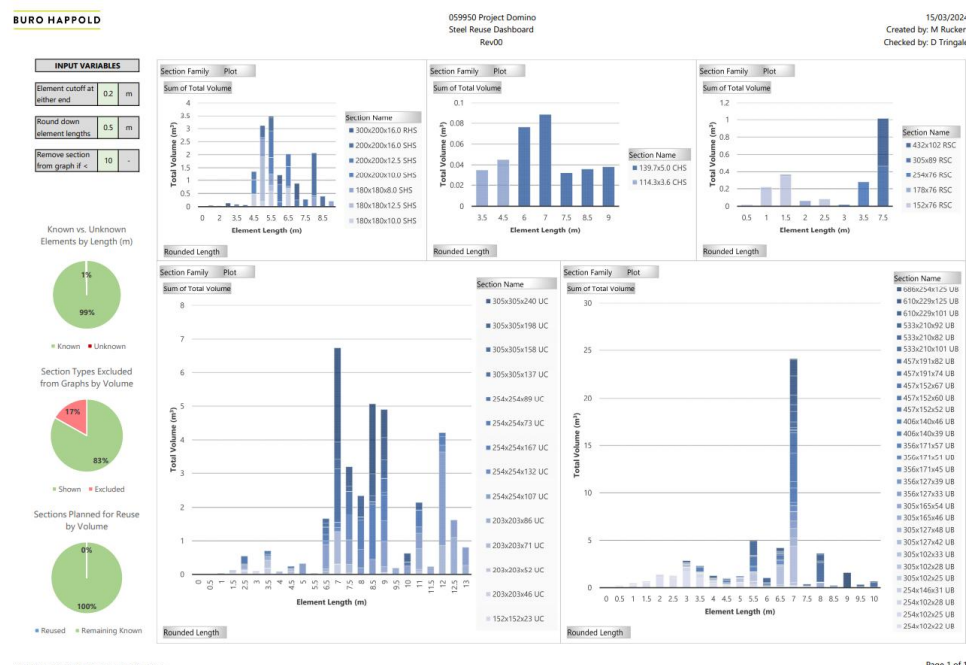

Figure 30: Scheme Tool Outputs – Excel Dashboard

PDF Files

The graphs and data analytics displayed in the excel file are also formatted and printed as pdf files to allow their immediate use in reports and documents depending on users' needs.

8. Troubleshooting and Bug Fixing

8.1. Unable to cast COM object Error

Unable to cast COM object of type 'Microsoft.Office.Interop.Excel.ApplicationClass' to interface type 'Microsoft.Office.Interop.Excel._Application'. This operation failed because the QueryInterface call on the COM component for the interface with IID '{000208D5-0000-0000-C000-000000000046}' failed due to the following error: Element not found. (Exception from HRESULT: 0x8002802B (TYPE_E_ELEMENTNOTFOUND)).
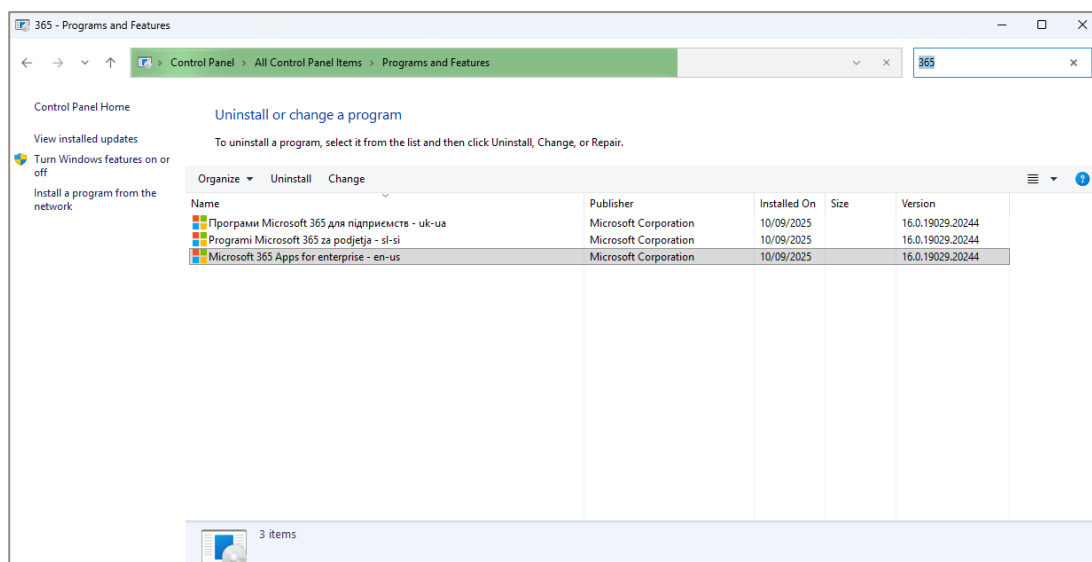
Figure 31: Detail of Revit Warning Message

If an error similar to the above gets displayed in Revit when running one of the tools, it's likely to be caused by a broken or missing COM registration for Excel due to something gone wrong in the automated Microsoft Office updates.
To sort out this issue, it is recommended to carry out a Repair of Microsoft Office following the steps below.

1. Access Control Panel -> Programs and Features -> Search for Office / 365 in the search toolbox in the top right hand corner. (see Figure 32)
2. Right click on Microsoft Office – e.g. "Microsoft 365 Apps for enterprise – en-us" – and select "Change" in the pop-up window that gets displayed on screen. (see Figure 33)
3. Enter the Admin Login details.
4. Select "Quick Repair" in the window asking how we want to carry out the repair of Microsoft 365 and Office programs. (see Figure 34).
5. Wait until the Repair has been completed.

Now, try re-running the Inspector/Scheme Tool in Revit and the problem should be sorted.
If not, try to go again through all the steps above and choose "Online Repair" instead of "Quick Repair" (Step 4) for a more in-depth repair of Microsoft Office Apps. This should sort out any remaining issue.

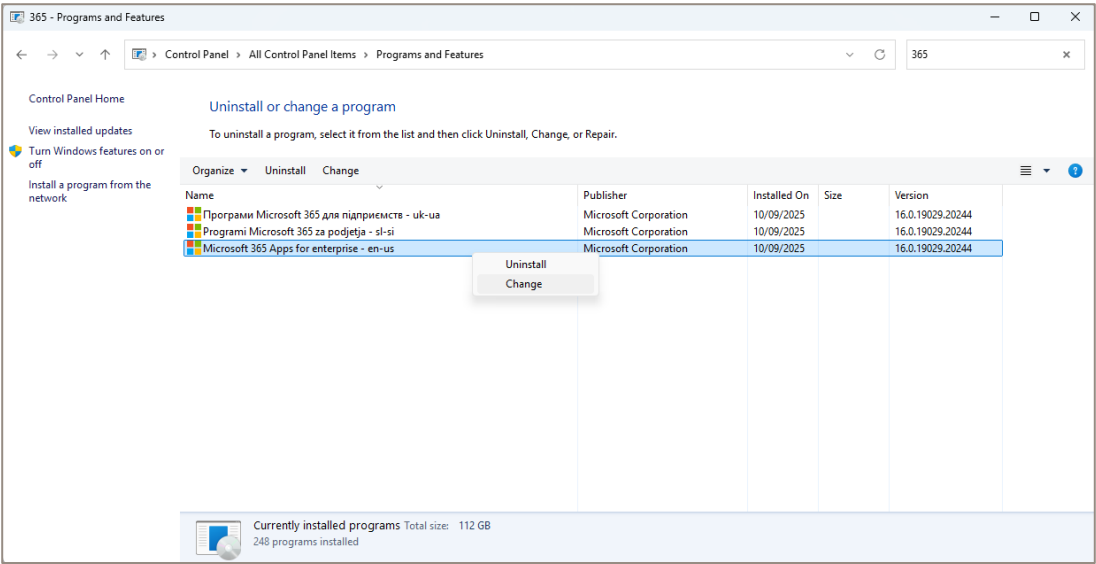**Figure 32:** Step 01 - Access Control Panel + Search for Office /365

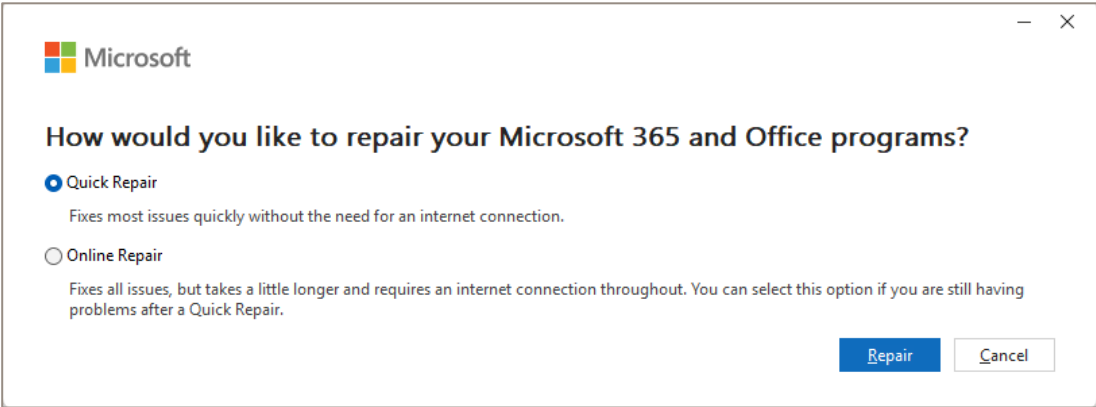**Figure 33:** Step 02 - Right Click on Office 365 + Select "Change"

Figure 34: Select Quick Repair