Interoperability with Structural Disciplines

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Interoperability with Structural Disciplines

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Contents

Introduction

Increasingly, new developments in ARCHICAD emphasize effective collaboration between architects and other professionals such as structural and mechanical engineers. This collaboration requires reliable methods for sharing and storing building model information, design solutions and proposals; it also requires a way to manage all the changes made to the building model by any of the participants, while also minimizing the possibility for human error.

ARCHICAD supports all major model and data exchange formats and some specialized formats, including intelligent 3D modeling, universal 2D drawing, documentation and image formats.

Typical Workflow

This section is a general description of the typical issues to consider if you plan to exchange data between ARCHICAD and a Structural application.

For more details, see also Detailed Workflows: Architectural-Structural.

Structural applications can be divided into the following main categories:

• **Analysis and design applications**

These applications carry out and document static and design (steel, reinforced concrete, timber etc.) calculations based on various techniques (such as finite element method).

• Structural Preparation/Management

These carry out preparatory tasks and ensure the connection between the analysis application and the architectural profession.

• Detailers

These create detailed construction documentation of the structure (steel, reinforced concrete, precast, etc.) and communicate with the manufacturers.

Some applications cover several of these functions.

This diagram describes the general workflow for data exchange between ARCHICAD and a structural application:
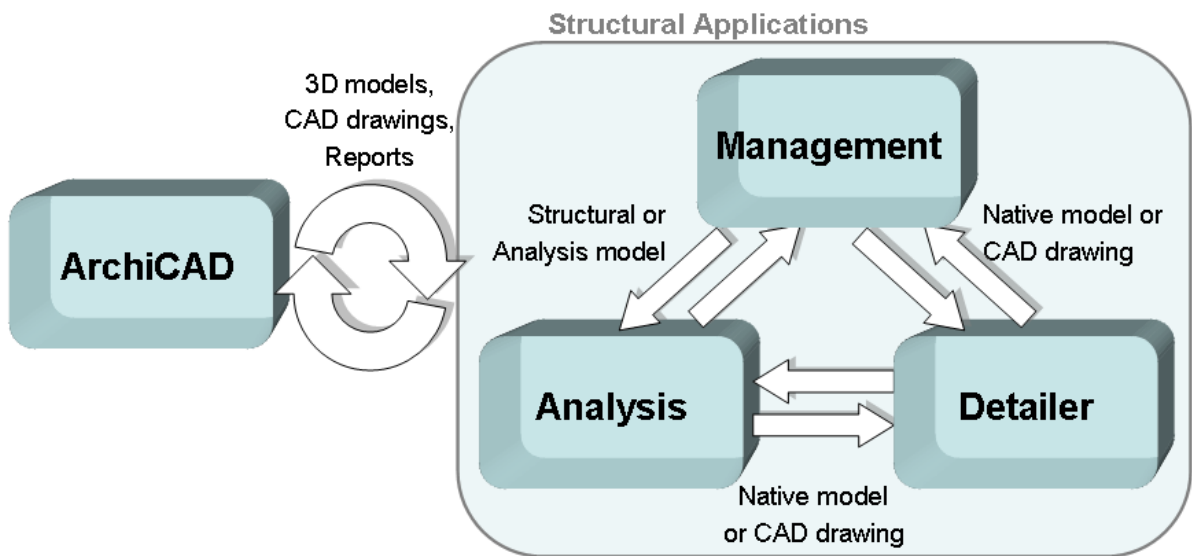
The most complete level of interoperability is achieved using an intelligent 3D model connection - as opposed to a drawing representation - in which the building model being exchanged represents 3D structural objects (slabs, walls, columns, beams, roofs etc.), each with specific, defined attributes and properties.

Model-based exchange between the architect and the structural engineer can follow one of two concepts:

• managing a reference model; or
• converting the model to native formats.

The **reference model concept** ensures the "security" of the architectural model and the structural model files, since each office remains responsible for his/her own model. Thus, the structural engineer receives a file from the architect, but does not modify it; he/she uses the architectural information as a basis for building up his own structural model. This occurs manually, using the tools of his own software, but automatic element conversion utilities also exist to speed up the process. Similarly, the architect leaves intact the file received from the structural engineer, while taking into account its suggestions for modeling load-bearing elements. This way, each discipline's own file is independent of the one received as a reference.

This is often a sensible workflow, given that the architect's model differs from that of the engineer. For example, when modeling a multi-story building, the architect might base the initial design on a multi-story column that runs through all the stories, whereas the structural engineer might put a separate column on each story. In another example, the architect would use a single slab to model an area for which the engineer or detailer would use hollow-core slab elements.

The other approach to model-based exchange is to convert the other party's model elements into the **native format** of one's own application. The converted model is transformed according to the specifications of the recipient, so the original version of the model is not preserved. This approach is most typical of data exchange between architectural and analysis programs.

*See also Analysis Applications, below.*

ARCHICAD can combine the advantages of both approaches. The 3D model obtained from the structural engineer - regardless of the method used to import it - is always transformed into native ARCHICAD elements. At the same time, it is possible to use the imported elements as a reference, since they can be automatically placed onto their own, protected layers (which are locked to prevent editing). This reference-model approach is also supported by the Merge and Link workflows.

See Merge vs. Link vs. Open.

Since the incoming elements or modifications are converted into native format, they become an active part of the architectural model, while retaining their properties (e.g. material, profile) assigned in the structural model.

The 3D models exchanged between the architectural and structural disciplines can be considered in three categories:

• Architectural model,
• Structural model,
• Analysis model.
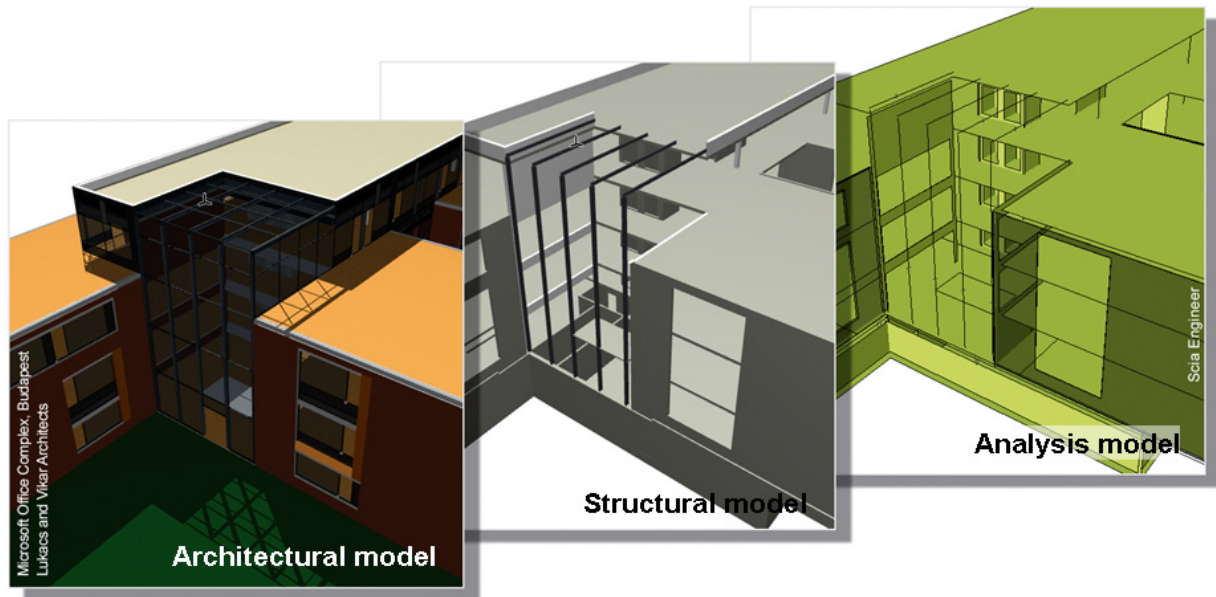
The architect works on the architectural model, based on her own design and on the client's requirements. Already during the design phase, the architect should keep in mind that the model will later be exchanged with a structural engineer.

See Prepare Architectural Model for Export.

For example, she can define the building elements' structural function; define initial materials to be used; choose columns and beams with standard profiles; define the load-bearing core of composite elements.

See Classification.

In addition to this preparatory work, she can filter the model so as to narrow down the data to be exchanged: this way, only the structural model, containing just structural elements, will be exported. Naturally, the architect can export the entire architectural model, if the structural engineer's program is capable of filtering and collecting the model data that he/she needs to work with.

Exporting a structural model from ARCHICAD is sufficient for data exchange with most structural applications (the "management" and "detailer" types). However, analysis and design softwares require the so-called Analysis model in order to run their calculations. These applications can often convert the structural model to Analysis model themselves, or they can use the Analysis model converted by a management/detailer program as the input.

An Analysis model is a 2D or 3D representation of the structural model that includes not only planes (in the case of wall, slab, roof elements) and axes (columns and beams) of elements, but also their structural characteristics (e.g. stiffness, material, profile). The simplified analysis model also differs geometrically from the structural model: for example, curved surfaces are represented as a collection of planes; element intersections may be modified.

The export and import of 3D model data often takes place using a standard known as IFC (Industry Foundation Classes), which is actively supported by many design applications. In addition, many applications provide native Add-Ons for data exchange with other specific programs.

IFC-based data exchange can be enhanced by using the so-called BIM Collaboration Format (BCF)-based communication. In this workflow, you can assign comment topics to IFC model elements.

Based on these, the other user can easily locate the referenced elements in the IFC model. BCF-based data exchange is particularly suited for identifying overlaps (e.g. collisions, modeling and other mistakes) when several models from different applications are combined in one program (e.g. ARCHICAD or a model checker).

Some engineers or applications (especially analysis applications) will just exchange data at the most basic level: they import CAD drawings (that is, the lines and points representing floor plans, sections and elevations), and use them as a reference for building the analysis model.

See *CAD Drawings for more details.*

Models and drawings are often accompanied by other documentation, such as suggestions or reports; the most commonly used format for these is PDF.

ARCHICAD contains a number of techniques for displaying the structural model and for differentiating it from the architectural design.

See *Visualization of Imported Content.*

In addition, ARCHICAD can interpret and store the imported structural data, such as the proposed or utilized materials, and the properties of profile elements.

See *Imported Properties.*

Consultation and data exchange between structural and architectural offices generally requires several "round trips". ARCHICAD's Trace and Reference tool and a model-based change management feature helps to keep this process transparent.

This general architectural-structural workflow is explained in greater detail via the example workflows described below, which involve the interchange of model data between ARCHICAD and selected structural applications.

Export Data from ARCHICAD

These sections provide detailed information on preparing your ARCHICAD model for export.

Prepare Architectural Model for Export

Recommended Export Formats

Prepare Architectural Model for Export

Partner offices usually do not require the fully detailed architectural model; a simplified model is sufficient. For example, Structural models are simplified versions of architectural models, which contain only the load-bearing building elements such as columns, beams, slabs, walls, roofs, and the load-bearing (core) parts of composite structures. If an architect plans to exchange models with a structural engineer, he/she should keep these requirements in mind when carrying out their design work, to make the eventual model exchange easier.

Classification

Connection between ARCHICAD Model and IFC Data

Using Standard Profiles with Structural Applications

Layer System

Filtering by Element Representation

Classification

In ARCHICAD, you can optionally assign one or more classifications to any project element. A classification makes parameters and functions available to these elements for use by other applications: to organize project data, to make models transparent, to locate elements, for listing purposes, to share exact data, etc.

For each construction element, classifications can be set in the Classification and Properties panel of its Settings dialog box.

The following classification and category definitions are relevant for data exchange using IFC:

Element Classifications

ARCHICAD provides a flexible way to classify elements according to any national or company standard classification system. You can assign one Classification value per Classification System in the Elements' Settings dialog, or from the Interactive Schedule.

Element classification affects the IFC export process: each element will be saved to the IFC model according to an IFC Type. This is displayed in the "IFC Type" item in the Classification and Properties panel (under IFC Properties). Thus, if you classify a slab as a ceiling in ARCHICAD, the target program will interpret this element as a ceiling.

Note: The IFC Type Mapping of ARCHICAD elements by classification depends on the Type Mapping for Export setting of the current IFC Preview Translator.
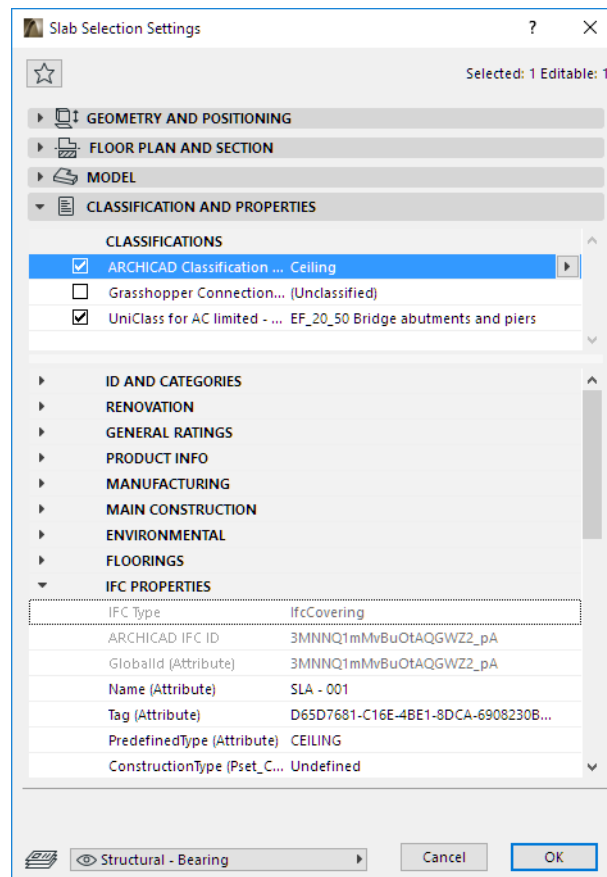
Structural Function Category for IFC

"Load-Bearing Element" or "Non-Load-Bearing Element"

In collaborating with partners who are using structural programs, you can export your ARCHICAD model to IFC format: the Structural Function classification (assigned in ARCHICAD) automatically adds the "load-bearing" property to structural elements in the export file.

> **Note:** By default, Revit Structure will display only walls that have the "load-bearing" property in the "Structural" discipline views. But, if you forget to classify required walls as "Load-Bearing Elements" in ARCHICAD, the structural engineers can also change the bearing function of walls, or they can apply another display discipline (e.g. "Architectural") in order to show all walls exported from ARCHICAD.

> The current IFC standard supports the export of the "load-bearing" IFC property only for the following elements: Wall, Slab, Column, Beam, Roof; elements classified as such in ARCHICAD; and objects having these sub-types.

If you have classified model elements as "Load-Bearing Elements", then you can use the Partial Structure Display "Core of Load-Bearing Elements Only" option to display those elements only. This is particularly useful if you wish to export only load-bearing elements to a structural engineer: in this case, just use the "visible elements" export mode on a view that uses this Partial Structure Display option.

This category is useful for listing purposes - for example, you can calculate the materials needed for all load-bearing walls or columns, separately from materials of non-load-bearing elements.

Criteria in the **Find & Select** dialog box include: search for those elements that have been defined as load-bearing or non-load-bearing, or whose Structural Function category is "Undefined". Since IFC export can be limited to selected elements only, you can - for example - export all selected elements defined load-bearing (not just their Core only, as described in the example above).

The load-bearing data is also a standard property of exported elements. Moreover, if other applications (such as a structural program) also categorize elements according to their load-bearing function, ARCHICAD can filter these elements upon importing them, and such elements will show up in the ARCHICAD model with that classification.

Position Category for IFC

"Interior" or "Exterior"

This category is useful if you plan to send an IFC file to partners (e.g. energy analyzers) who are able to differentiate elements by their location in the building. When you export the ARCHICAD model to IFC format, your model elements that are classified as "Interior" or "Exterior" will carry this information to the partner's application via IFC.

Naturally, the opposite is also true. Since Position (IsExternal) is a standard IFC property for certain building elements (e.g. Wall, Slab, Column, or Beam), if an imported IFC model contains such data, then the appropriate category is automatically added to the respective elements.

Criteria in the **Find & Select** dialog box include: search for elements categorized as either "Exterior" or "Interior", or whose position is "Undefined".

Interactive Schedule Criteria are also available to differentiate listed elements by Position.

Note: Within ARCHICAD, the Position category is fully usable as an ARCHICAD property (e.g. in **Find & Select** and **Interactive Schedule**). However, it will not be exported as an IFC property for certain element types (e.g. Ceiling (IfcCovering)) which are not supported by the IFC standard.

Connection between ARCHICAD Model and IFC Data

All IFC data behave as native ARCHICAD data: every operation involving ARCHICAD data is available as IFC data.

Since the IFC properties are native to ARCHICAD, the following functions are available:

- Assign, edit and view IFC properties in the Manage IFC Properties dialog box, accessible from the element Settings dialogs (Classification and Properties panel).
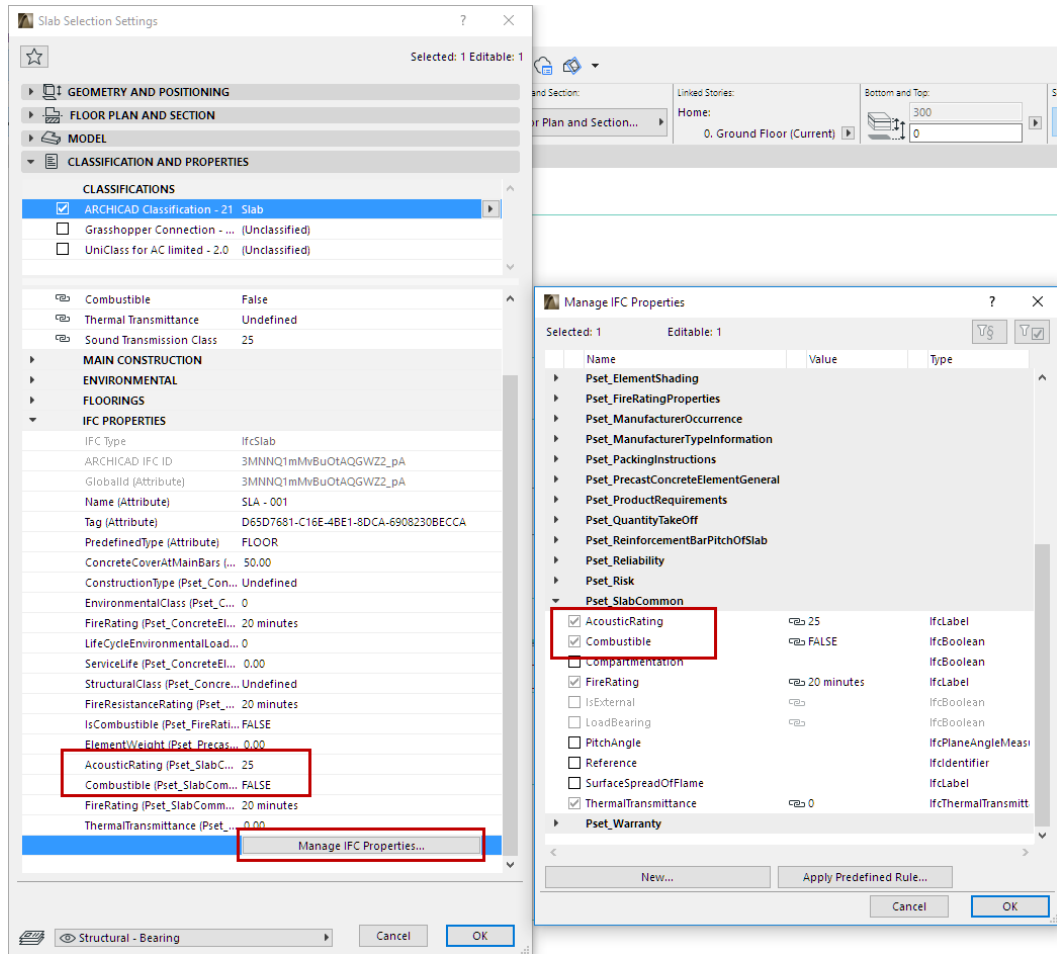
- Use the Find & Select command to search for the IFC properties of any element.
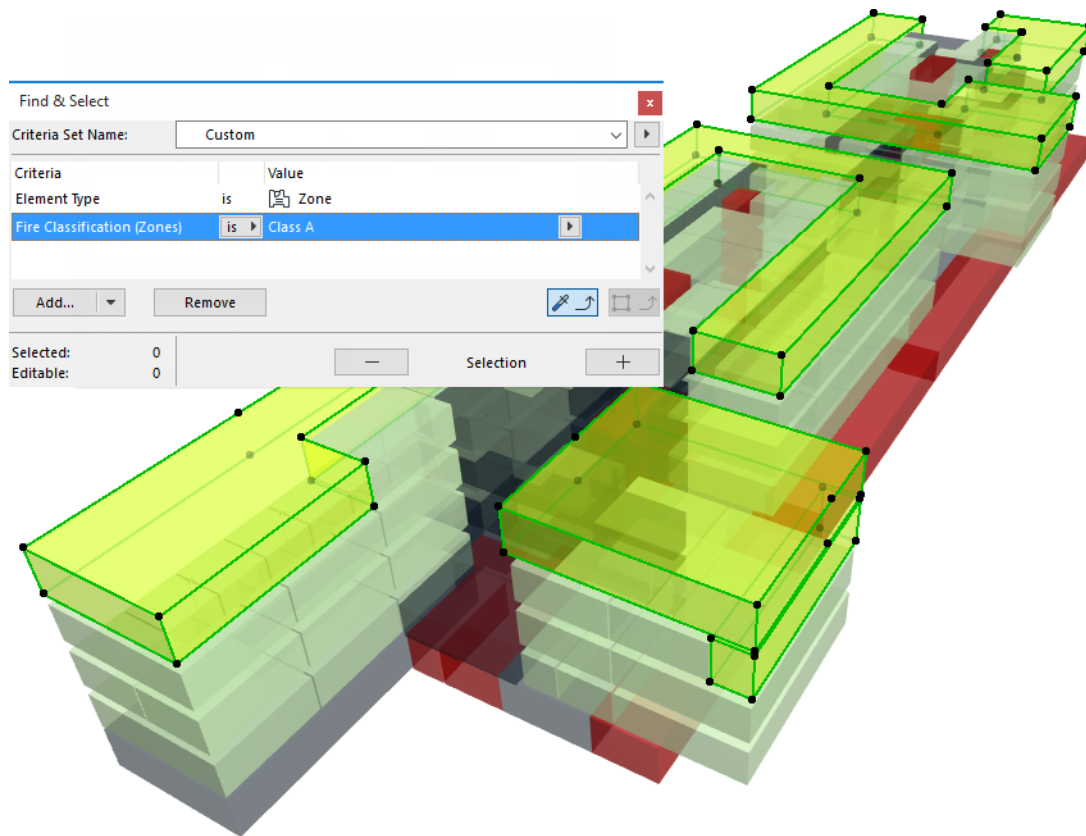
- Use Interactive Element Schedule to list the IFC properties of any element.
- You can use the Pick up/Inject Parameters shortcuts and Copy-Paste to transfer IFC properties from one element to another.
- IFC properties are included in the settings of elements saved as Favorites. Thus, you can use these Favorite elements (together with their IFC properties) in different ARCHICAD projects.
- Data (including IFC data) defined in the Classification and Properties panel of element settings can be displayed in ARCHICAD, by showing these data in Labels, Zone Stamps and Markers.
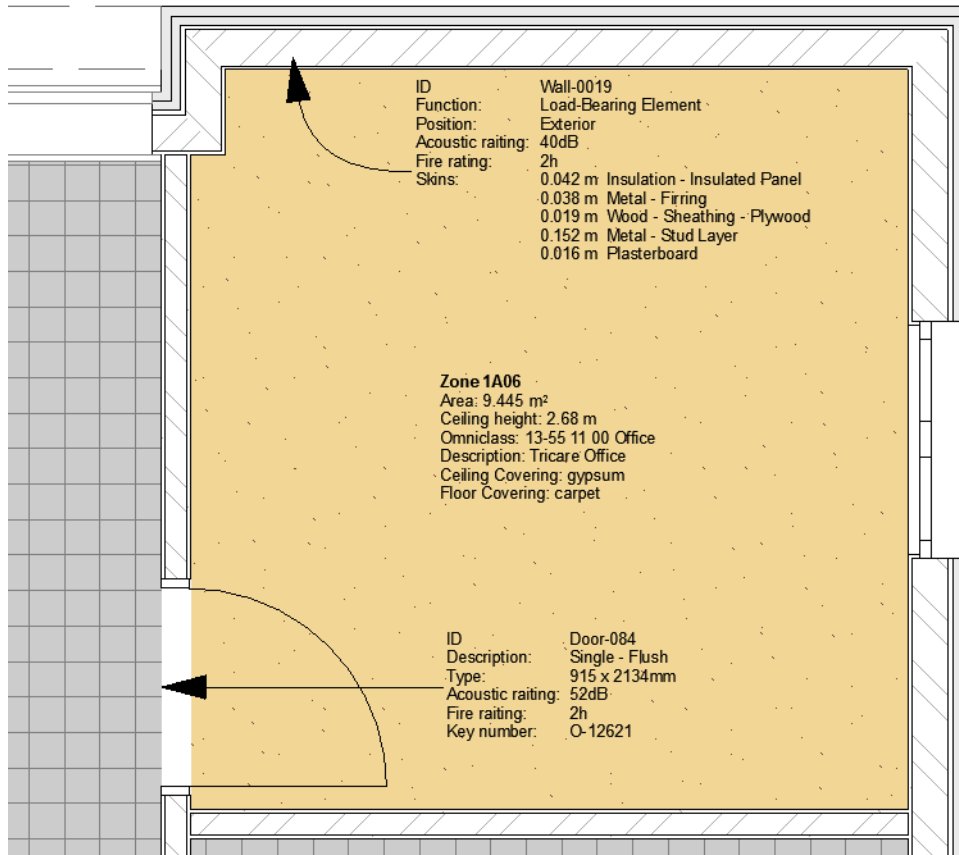
- The IFC content of Hotlink Modules can be queried and listed.
- In Teamwork, IFC data can be modified for elements that you have reserved.
- The IFC data of elements are accessible through the ODBC driver and the ARCHICAD API (Add-Ons that can be developed for ARCHICAD). Use the IFC Project Manager to manage all IFC data related to the project (including that of Hotlinked Modules). You can navigate easily between the model elements and the data listed in the Manager, both from the Floor Plan and from 3D views.
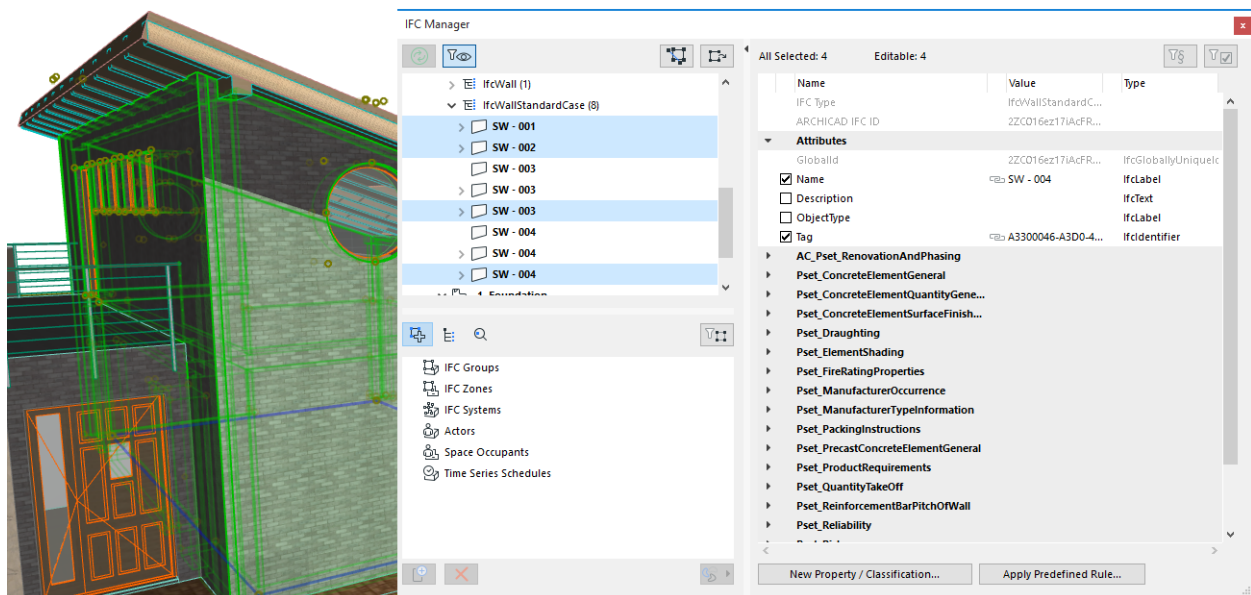
- All ARCHICAD tool parameters (element properties, Interactive Element Schedule (IES) data, Library Part parameters, etc.) can be mapped to IFC standard or custom properties based on conversion rules, defined in the IFC Translator for Export.

- When assigning IFC properties to elements, you should naturally choose the parameters that the receiving application is capable of reading, displaying or querying. Thus it is worthwhile to consult with the engineer or other professional to whom you plan to send the data.

Using Standard Profiles with Structural Applications

If you exchange data with structural applications, it can be helpful to use standard elements as your steel profiled Columns or Beams. During the data exchange process, numerous structural engineering programs are able to recognize and identify such standard elements accurately and completely.

In ARCHICAD, the **Options > Complex Profiles > Import Standard Steel Profile** command brings up the Profile Database, from which you can import profile shapes and sizes, which are listed by their country-specific code numbers.

> **Hint:** Standard profiles can serve as the basis for creating additional, standard-shaped (e.g. I-shaped) profiles that have a custom name or additional details (such as a fillet radius) - use the Profile Manager to duplicate and edit a standard profile.
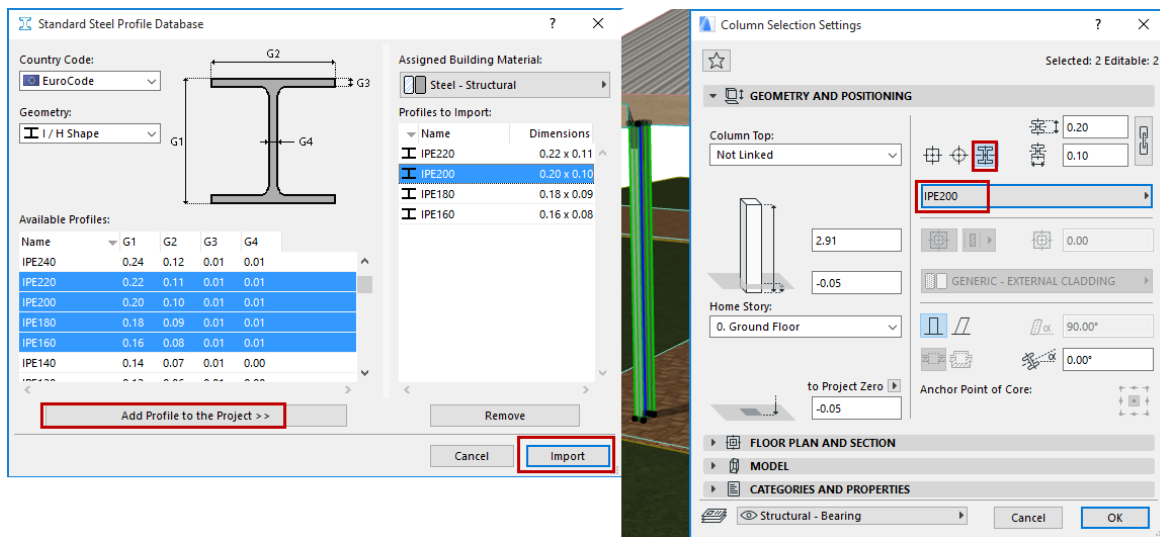
Layer System

ARCHICAD's layer system (Layers and Layer Combinations) can help in narrowing down the parts of the model to be exported. Use layers to group elements conceptually (e.g. structural elements) and to separate them from elements not needed in the exported model (e.g. furniture). For example, you can choose filters that will export only elements located on layers set to "visible", while you hide the layers of the elements you do not need to export.
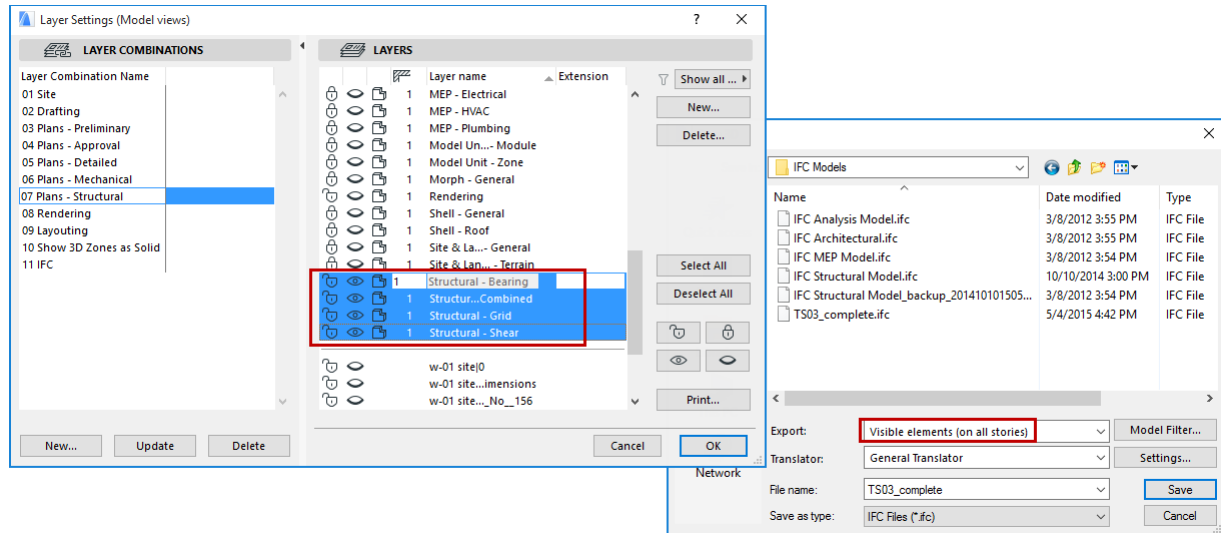
Note: Naturally, layers are also exported as standard IFC entities assigned to elements. The receiving application may display this data or perhaps use it to filter elements; this depends on the particular application. For example, Tekla Structures can filter reference model elements based on layers exported from ARCHICAD.

Filtering by Element Representation

Since the export always considers the display settings of the current exported view, you can further filter the model according to the elements' display status:

Note: The following display options can vary depending on the view. Keep in mind that IFC export will consider the display options that were in effect for the particular view from which the export command was issued.

Partial Structure Display

The Partial Structure Display function allows you to display or hide the model's complex or composite components, depending on their type or classification. For example, when collaborating with other designers or engineers, you may prefer to ignore non-load-bearing walls, and to display/output only the load-bearing components of complex elements.
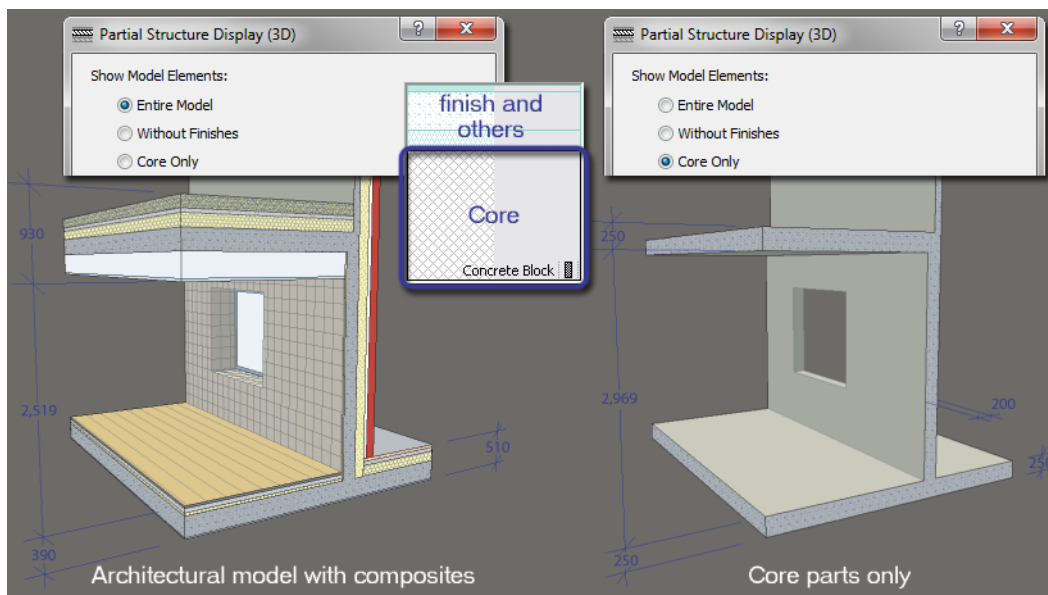
The first three options display or hide the components of composite or complex elements, depending upon how you have defined those components. For example, choosing "Core Only" displays only the load-bearing skin of the complex or composite structures.

"Core of Load-Bearing Elements Only" considers all construction elements (not just composite/complex), and enables you to hide any elements you have classified as "Non-Load-Bearing Elements" or "Undefined".

See Classification.

It displays all elements classified as "Load-Bearing Elements". Load-bearing composite and complex elements are displayed with their Core only.

The Veneer part of Columns can be displayed or hidden by Partial Structure Display according to its type: "Core", "Finish" or "Other".

Window/Door Representation

In exporting models with windows/doors/skylights, you should consider whether the recipient of the model data really needs all the detailed geometrical parameters (frames, glass) associated with the openings, or whether exporting just the openings themselves might be enough (as when
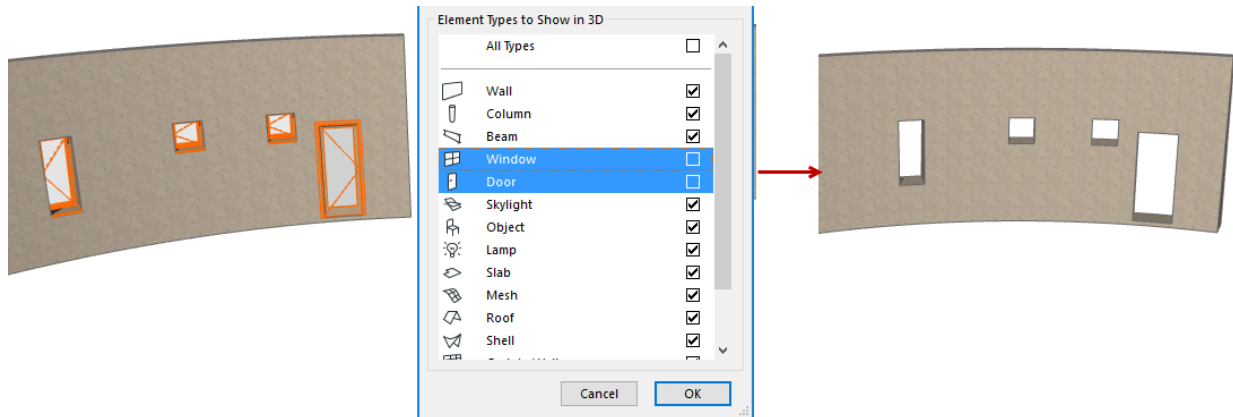
exporting for analysis programs). Element visibility can be defined using the following ARCHICAD controls:

Floor plans

Document > Model View > Model View Options: Options for Construction Elements > Door/Window/Skylight Options.

3D Views

View > Elements in 3D View > Filter and Cut Elements in 3D: Element Types to Show in 3D (Window/Door/Skylight).

Recommended Export Formats

The following pages provide an overview of the main export formats available from ARCHICAD.

IFC Model-Based Connection

The principal benefit of IFC (Industry Foundation Classes) object-oriented file format is its object description. Not only does the IFC protocol preserve the full geometric description in 3D, but it also knows object location and relationships, as well as all the properties (or parameters) of each object. With IFC input/output, ARCHICAD can communicate with a wide range of structural, mechanical and energy analysis applications.

It is important to consider what type of information should be exported to the different disciplines. For example, structural engineers will want the load-bearing parts of the building, while an HVAC consultant will need a richer model with more internal information. Besides preparation (described above), ARCHICAD's IFC interface enables you to filter the building information model before exporting it.

See [Prepare Architectural Model for Export](#).

Predefined (but customizable) Translators help you apply IFC model exchange settings as simply as possible, providing "one-click" export/import solutions.

After exporting an IFC model, it is good practice to check the IFC model in an IFC viewer. There are many free IFC viewers on the market that can be readily downloaded:

- DDS-CAD Viewer: http://www.dds-cad.net
- Solibri Model Viewer: http://www.solibri.com
- Tekla BIMsight: http://www.teklabimsight.com

IFC-based data exchange can be enhanced by using the so-called BIM Collaboration Format (BCF)-based communication. When several IFC models from various professions are combined in one project, the BCF workflow enables participants to add comments to the overlapping issues (e.g. collisions). BCF comments include the referenced IFC elements' GUIDs and an attached preview (snapshot) picture; these enable users to easily locate the "problematic" model elements in the referenced view, using the same exact camera position as the snapshot. ARCHICAD's Mark-Up tool supports BCF commenting, import and export. Many professional software programs and the many of the viewers listed above have implemented BCF.
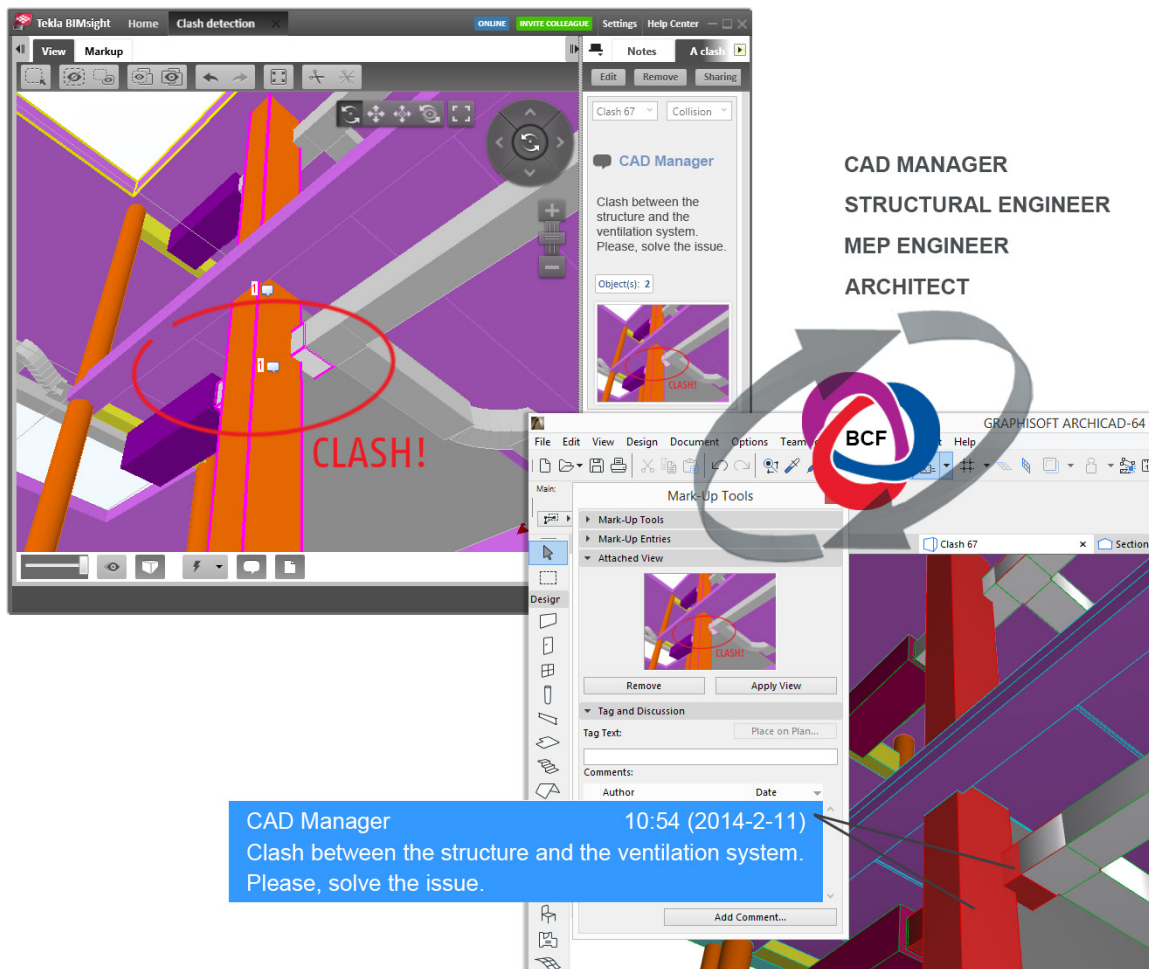
Direct Model Link

Another way to export a model is to use the direct link between ARCHICAD and another software application. This means that a specific Add-On (developed by other applications for use with ARCHICAD) converts the ARCHICAD elements (e.g. the structural elements) to the corresponding elements of the connected application. This exchange mode also ensures that only those properties needed by the target application are included in the resulting model file.

Ask your partner if his/her application has an available Add-On for ARCHICAD.

CAD Drawings

Despite their increased reliance on model-based data exchange, architects and engineers still rely on each other's CAD drawings to use as a reference in their respective models.

Because file format compatibility is crucial when working with outside consultants, or when upgrading from another CAD system, ARCHICAD provides the functionality to ensure an accurate conversion process.

ARCHICAD's DXF/DWG translator supports formats up to AutoCAD 2017 and accurately maps layers, pen colors, fonts and blocks. ARCHICAD can write out DXF/DWG data that contains both Paper Space and Model Space information in the same file. ARCHICAD's intelligent handling of AutoCAD XREFs, at input and output, not only preserves the link but allows XREF administration (including linking, unlinking and binding) within ARCHICAD.

When you provide your consultants with digital files for modification, ARCHICAD's DXF/DWG Merge Engine ensures a "clean" file. User-defined rules eliminate conflicts, giving you control over how changes are merged with the Virtual Building model.

Additionally, ARCHICAD imports and exports AutoCAD's vectorial DWF format and MicroStation's DGN.

PDF Output

Adobe's Portable Document Format (PDF) has become the most popular digital file format for publishing and archiving the architectural documentation. ARCHICAD's internal PDF engine supports both the export and import of PDF documents, including PDF/A format. Importing PDF documents as drawings is a great way to bring in a standard detail or manufacturer's specifications directly onto an ARCHICAD layout sheet or Worksheet.

Import Data to ARCHICAD

The following sections provide information on what to consider when importing data from other programs to ARCHICAD.

ARCHICAD imports all file formats - IFC models, CAD drawings and PDF files - listed in the Export section.

Merge vs. Link vs. Open

Visualization of Imported Content

Imported Properties

Merge vs. Link vs. Open

The possible ways of using the model data, CAD drawings and reports received from another application in ARCHICAD are the following:

Merge

Use Merge to add the model or drawing content (or part of it) to the currently running ARCHICAD project. Merged model data are converted into native ARCHICAD elements, which can then be used as a protected or editable reference. The imported content, used as a reference, is separated from the host project elements, and can be displayed together or independently from the original project data by choosing a visualization technique.

See Visualization of Imported Content.

Merged IFC data are converted to native ARCHICAD properties, so they can be searched, listed, and used in the model.

The **Detect IFC Model Changes** command applies the merging algorithm for the detected geometrical differences between two (old and new) states of received models (two IFC files exported from the same application).

> **Note:** Before merging a file, you should save the running ARCHICAD file.

Link

As another "reference" possibility, you can directly hotlink any IFC file to an ARCHICAD host project, managing it like other Hotlink Modules. Hotlinked IFC content is imported using an IFC Translator for Import, saved within a template file, so that you can maintain control over the attributes of the Hotlink Module file.

CAD drawings and reports (PDF) can be directly linked to the current ARCHICAD project. Depending on the file formats, use XREF and/or Drawing connection.

Open

The **Open** command launches a model or CAD drawing as a separate ARCHICAD file, independent of any other project currently open in ARCHICAD.

Visualization of Imported Content

ARCHICAD offers a number of visualization tools that make it easy to find and view the imported content within ARCHICAD, and, if needed, to differentiate it from the architectural model.

Layer Display Modes
Trace & Reference

Layer Display Modes

To differentiate elements from the original ARCHICAD elements, place them onto a separate layer.

> **Note:** You can set ARCHICAD to do this automatically as part of the merge process, using the appropriate control of the IFC Translators dialog box.
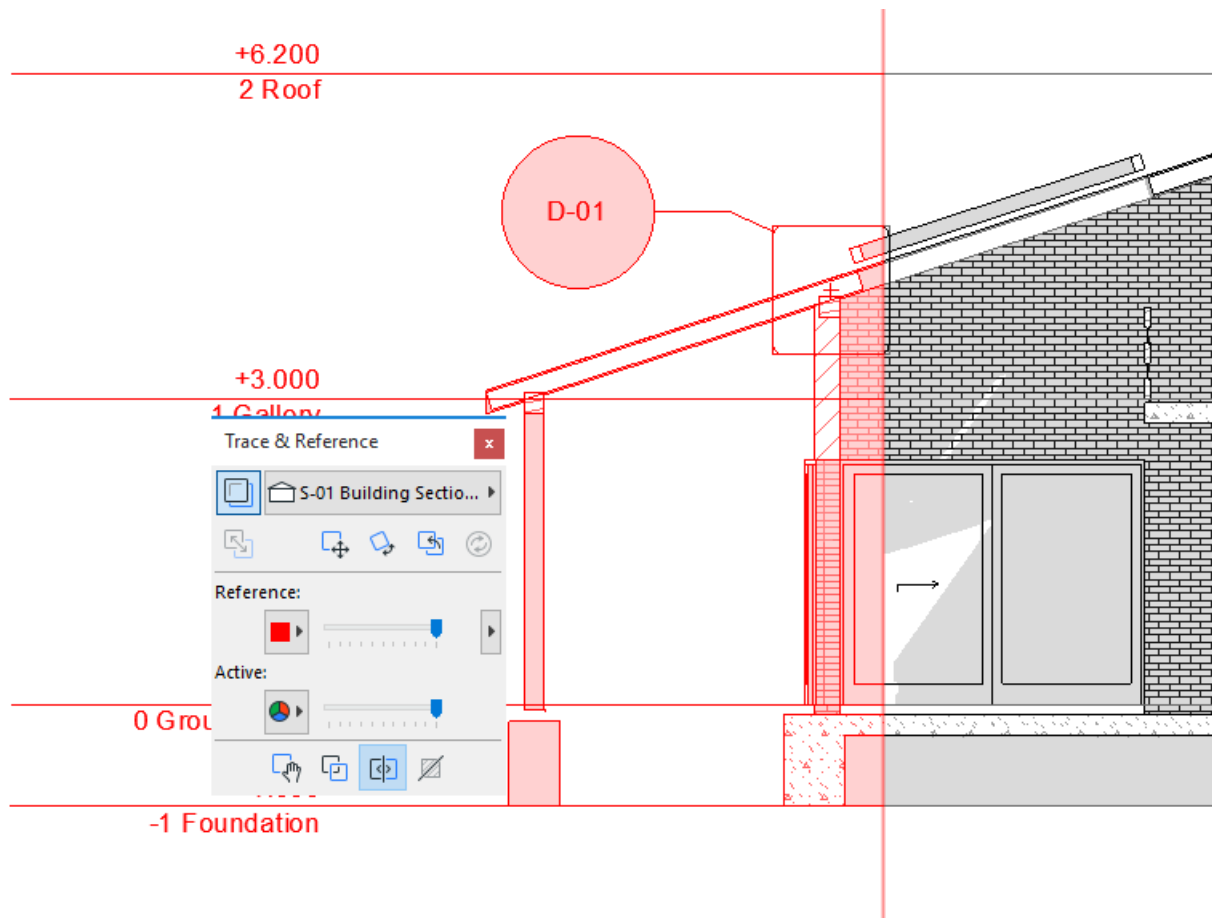
In 3D Views, you can use layer settings to display imported structural and mechanical elements differently from architectural elements. For example, set the 3D View Display mode of architectural layers to Wireframe, while applying Shading mode for all imported element layers.
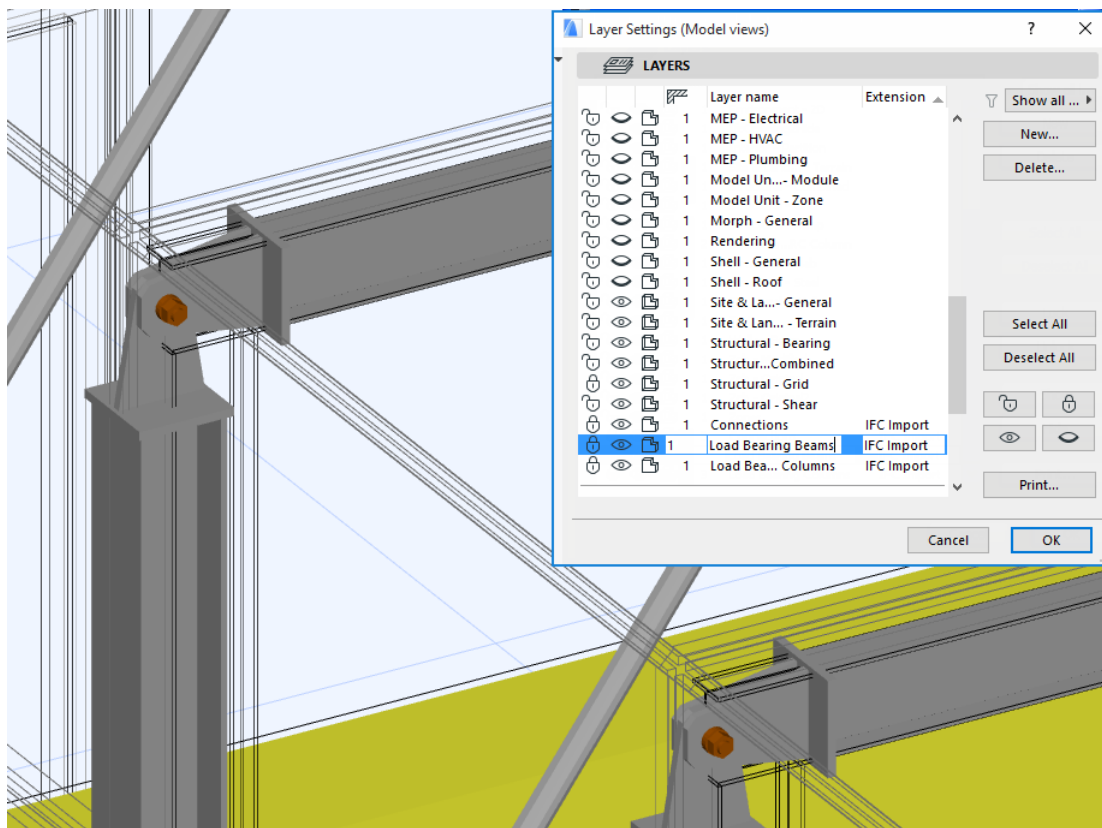
Trace & Reference

ARCHICAD views can also be used to differentiate elements of different disciplines. For example, create some views showing architectural elements, and other views that show the structural/mechanical elements only.

If you activate an architectural view, you can then use the Trace & Reference feature to view a structural/mechanical view at the same time – differentiated by highlighting or colors, or splitting the views apart on screen.

+6.200
2 Roof

D-01

+3.000
1 Gallery

Trace & Reference

S-01 Building Sectio...

Reference:

Active:

0 Grou

-1 Foundation

Imported Properties

When importing model-based data using IFC, the imported data will include not just the geometry of the elements, but also many of their parameters.

The most important general IFC properties will be interpreted as ARCHICAD attributes. These include, for example, construction materials (e.g. the steel quality of a column, represented in ARCHICAD by a Building Material), composites, profiles, presentation styles (as ARCHICAD Surface), and layers.

IFC properties imported from an IFC model become part of the running ARCHICAD project and will be considered native ARCHICAD properties. Certain of these IFC properties have exact counterparts as ARCHICAD parameters - for example, Structural Function and Position.

See Classification.

Other IFC data will appear as standard or custom IFC properties in the element's Settings dialog box and, for the model as a whole, in IFC Project Manager.

Since the IFC properties are native to ARCHICAD, the following functions are available:

• Assign, edit and view IFC properties in the Manage IFC Properties dialog, accessible from the element Settings dialogs (Classification and Properties panel).
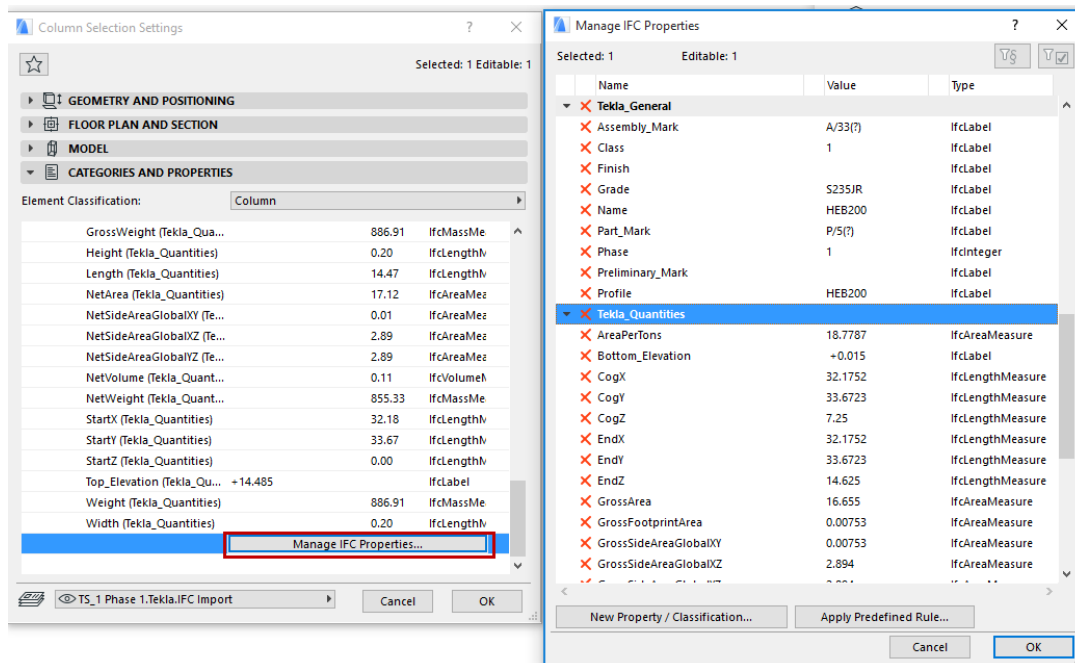
• Use the **Find & Select** command to search for the IFC properties of any element.
• Use Interactive Element Schedule to list the IFC properties of any element.
• Use the Label tool to show IFC properties of any element in the ARCHICAD window.
• You can use the Pick up/Inject Parameters shortcuts and Copy-Paste to transfer IFC properties from one element to another.
• The IFC content of Hotlinked Modules can be queried and listed.

To see all the imported IFC properties of imported IFC models (Structural, MEP, etc.), use the IFC Project Manager. There, you can further filter the displayed properties by visible layer: this way, you can show only the properties of a particular IFC model, or just part of the model. The structure of

the IFC Project Manager enables you to easily navigate among elements, which can be listed either by type or by containment structure, and selected in the Floor Plan or 3D Window.
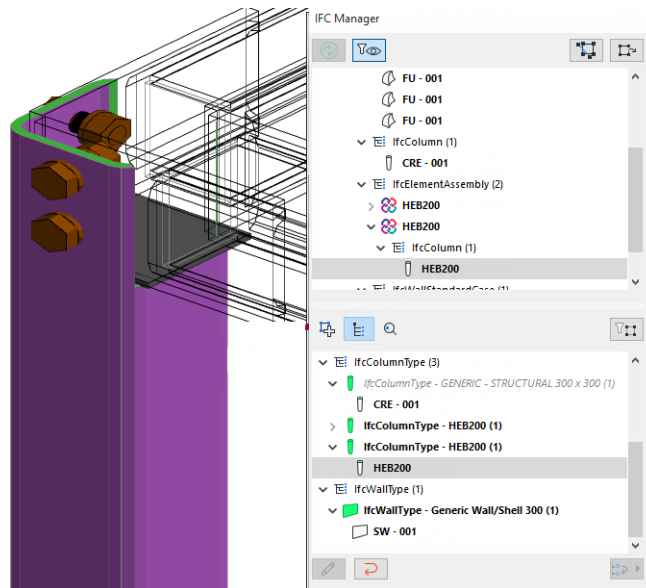
Detailed Workflows: Architectural-Structural

This section describes the recommended workflow for data exchange with selected structural applications.

Tekla Structures

Autodesk Revit (Structure)

Analysis Applications

Tekla Structures

Tekla Structures is a Building Information Modeling (BIM) software that enables the creation and management of accurately detailed, highly constructible 3D structural models regardless of material or structural complexity. Tekla models can be used throughout the entire building process from conceptual design to fabrication, building and construction management.

*Read more about Tekla Structures at* http://www.tekla.com.

In addition to IFC, BCF-based issue management (e.g. clash detection, property changes, etc.) can be carried out between Tekla Structures and ARCHICAD, as both of the applications support BCF as a native function.

Here, we describe the proposed workflow for architectural-structural model exchange between ARCHICAD and Tekla Structures. The suggested exchange data format is the model-based IFC version 2x3.

> **Note:** To see a video (narrated in English) of the recommended ARCHICAD-Tekla Structures workflow and its options, based on a real example, go to:
> http://www.graphisoft.com/archicad/open_bim/structural_workflows/
> Then scroll to: ARCHICAD-Tekla Structures Workflow.
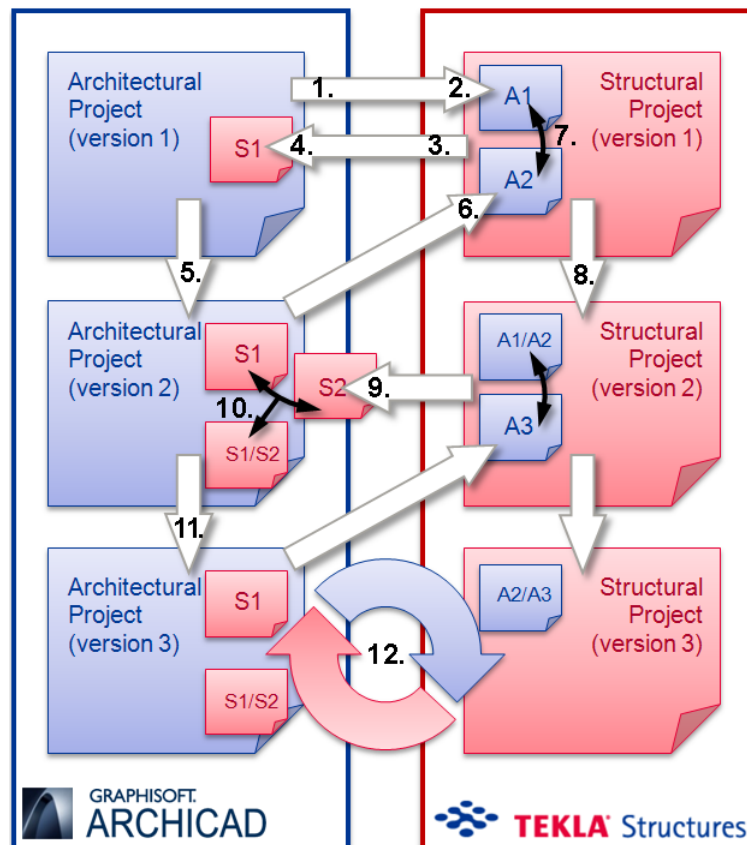

Step 1: Model Export from ARCHICAD

Let's start with the architectural model: architects create the first model according to the client's request and the given site.

When building the architectural model, you should keep in mind that you plan to share it with a structural engineer. Thus, use the classification and category options in ARCHICAD to differentiate load-bearing elements, place elements onto special layers, and/or define the initial profile and materials of the elements, such as steel bar (column and beam) elements.

If you prepare your architectural model this way, then all you have to do when exporting it to IFC is to apply certain filters. Moreover, among the export options, you can choose "Export all visible elements", which is another way to filter the elements for export: for example, use ARCHICAD's Partial Structure Display function so that only the cores of composite elements are visible, or use Model View Options to display and thereby to export the opening only, without the frame details and other unneeded data.

See *Prepare Architectural Model for Export.*

ARCHICAD offers a built-in translator whose settings are optimized to export models to Tekla Structures via IFC (the name of this translator is "Tekla Structures Export"). Of course, you may define and fine-tune your own custom translators, based on your specific needs.
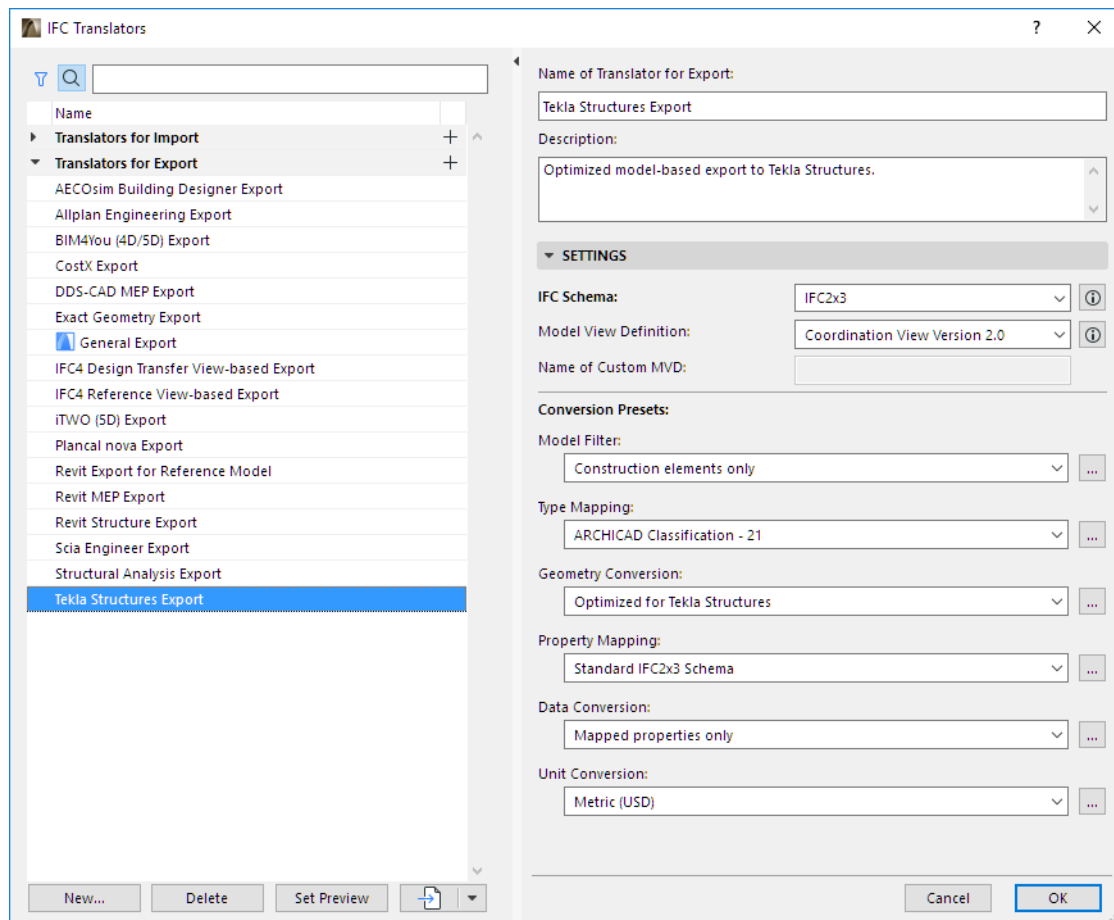
Other ways to filter elements during the export process:

- by elements' visibility in the view from which the export is launched,
- by current element selection,
- by story (e.g. ground floor only),
- by element types (e.g. columns and beams only),
- by ARCHICAD Structural Function classification (e.g. "Load-Bearing elements only"),

or you can export the whole project/building without any filtering. The default filtering rules of the translators can also be fine-tuned or modified manually as part of the export process (**File > Save as (IFC)**).

> **Note:** You should not use this filter when *importing* a model from Tekla Structures (the "All elements" setting is recommended instead), because Tekla Structures does not differentiate between load-bearing and non-load bearing elements.

You can set model views for the Tekla Structures export that contain only the important (visible) elements you would like to share with the structural engineer, and then use Publisher to export all these view sets as IFC models, with one click.

Step 2: Model import into Tekla Structures

Engineers receive the model from the architect and insert it as a protected reference into a Tekla Structures project ("Insert reference model" tool). They can choose to import the entire content of the architectural model, or only the elements on selected architectural layers. This way, the structural engineer further filters the model if required.

Engineers define the structural model and its details based on the reference model and its element properties (materials, profiles) as defined by the architect. Tekla-type elements can be converted from the referenced architectural elements using Tekla's "Convert IFC objects to native objects" tool; or they can be defined manually.

Tekla Structures can also generate analytical models from the structural model and share them with analysis applications. Based on the results of the analysis and design calculations, the structural model is finalized.

Step 3: Structural model export from Tekla Structures

The structural model or a filtered part of it can be exported back to ARCHICAD via an IFC file.

The following table, which summarizes the most essential Tekla Structures elements, shows that a highly detailed structural model can be imported into ARCHICAD.

Elements of Tekla Structures
Concrete / Steel Column
Concrete / Steel Beam
Concrete / Steel Polybeam
Concrete Slab
Concrete Panel
Steel Contour Plate
Steel Curved / Orthogonal Beam
Steel Twin Profile
Pad / Strip Footing / Concrete Foundation
Precast Found Block
Precast / Concrete Stair / Stair
Handrailing
Stiffeners / Web Stiffeners
Bolts
Connected Plate Parts
Reinforcing Bar / Reinforcement Mesh

Step 4: Structural model import into ARCHICAD

Depending on the chosen import method, you can merge or link the structural model, or a part of it, into your running ARCHICAD project.

We recommend using the default IFC translator set for Tekla Structures Import. Of course, customized translator and filtering settings can also be applied.

Note: You should not filter elements by "Structural Function" when importing a model from Tekla Structures, because Tekla Structures does not differentiate between load-bearing and non-load bearing elements in its model export; it does not support the "Load-Bearing" IFC property. Thus, the "All elements" option is the recommended and default Model Element Filter setting of the "Data Exchange with Tekla Structures" translator.

According to the default Tekla Structures Import IFC Translator, the imported elements are placed on locked layers with the extension "Tekla", in accordance with the reference model concept.

Structural elements can be displayed together with the architectural model using ARCHICAD's special visualization techniques. For example, you may visually compare the current model and the structural content as two different 2D views, using the Trace & Reference tool.

For more details, see Visualization of Imported Content

Architects can check the main structural as well as other additional properties by element (in the Settings dialog of the imported elements) or by model-hierarchy (using IFC Project Manager).

See Imported Properties.

This import process (using the Tekla Structures Import IFC Translator) also contains material conversion, which maps the default Tekla Structures materials to ARCHICAD Building Materials, while preserving the original names of the imported materials. This also means that structural elements in section windows will be displayed with the cut fills of their assigned Building Materials. Of course, the mapping rules can be easily edited and expanded at IFC Translator settings.

Any unrecognized Tekla materials are displayed with a default chosen ARCHICAD Building Material.
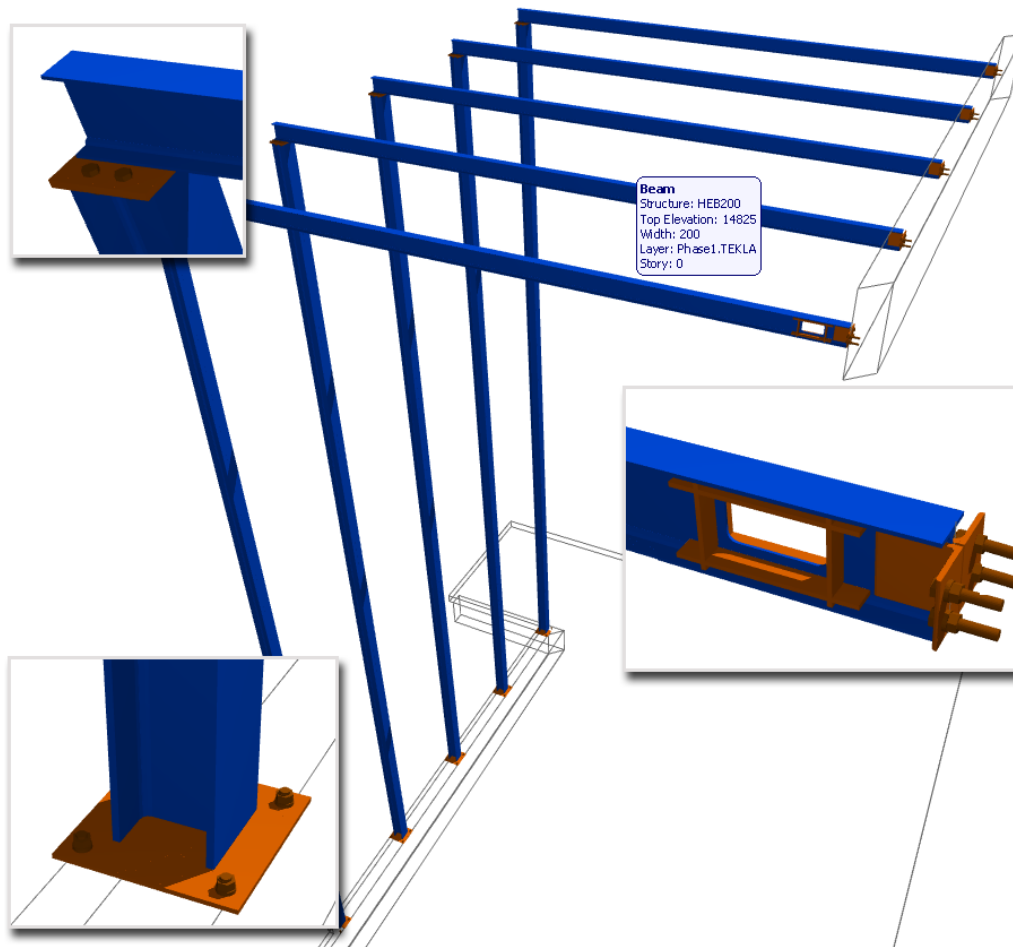
Steps 5-6: Architectural model update

In ARCHICAD, you can manually update your project according to the imported model elements by using them as reference, or by copying and using the structural elements as real ARCHICAD-type elements, since they are native ARCHICAD elements, as a result of the automatic conversion that occurs with the import process. (These imported elements are locked by default.)

A new version of the architectural project can now be exported again via IFC as described earlier.

Steps 7-9: Change detection in Tekla Structures

Tekla Structures can insert the new IFC file next to the old one in the same structural project. A change manager can compare and display the geometrical changes between the two reference models. The new, deleted, changed and unchanged elements can be displayed alongside the real structural model.

Next, engineers can make changes in the project according to the results of the comparison, and then send a new structural model version back to ARCHICAD.

Steps 10-11: Change detection in ARCHICAD

The new IFC model version received in ARCHICAD can be compared with the previous version, using the **Detect IFC Model Changes** command.

The result of the comparison is listed and displayed with the Mark-Up tool, and only the differences are merged into the current project. You can easily check the changes recommended by your structural partner, and make modifications on your current project manually, or by using structural elements as real ARCHICAD-type elements.

Step 12: Additional Data Exchange/Cycles

Both engineers and architects can repeat the previously mentioned model exchange, comparisons and updates in additional cycles. And finally, the two disciplines make their own or combined documentations.

Autodesk Revit (Structure)

Autodesk Revit provides tools specific to structural design for structural engineering firms: it integrates a physical model with an independently editable analytical model for structural analysis, design, and documentation.

In addition to IFC, BCF-based issue management (e.g. clash detection, property changes, etc.) can be carried out between Revit and ARCHICAD. Revit supports the BCF workflows via 3rd party Add-Ins such as *BCF Manager*, developed by Kubus.

Here, we describe the proposed workflow for architectural-structural model exchange between ARCHICAD and Revit (version 2010 or later). Although both softwares are able to handle CAD drawings, here we highlight the model-based data exchange via IFC (recommended version 2x3).

> **Note:** To see a video (narrated in English) of the recommended ARCHICAD-Revit (Structure) workflow and its options, based on a real example, go to:
> *http://www.graphisoft.com/archicad/open_bim/structural_workflows/*
> Then scroll to: ARCHICAD-Revit Structure Workflow.
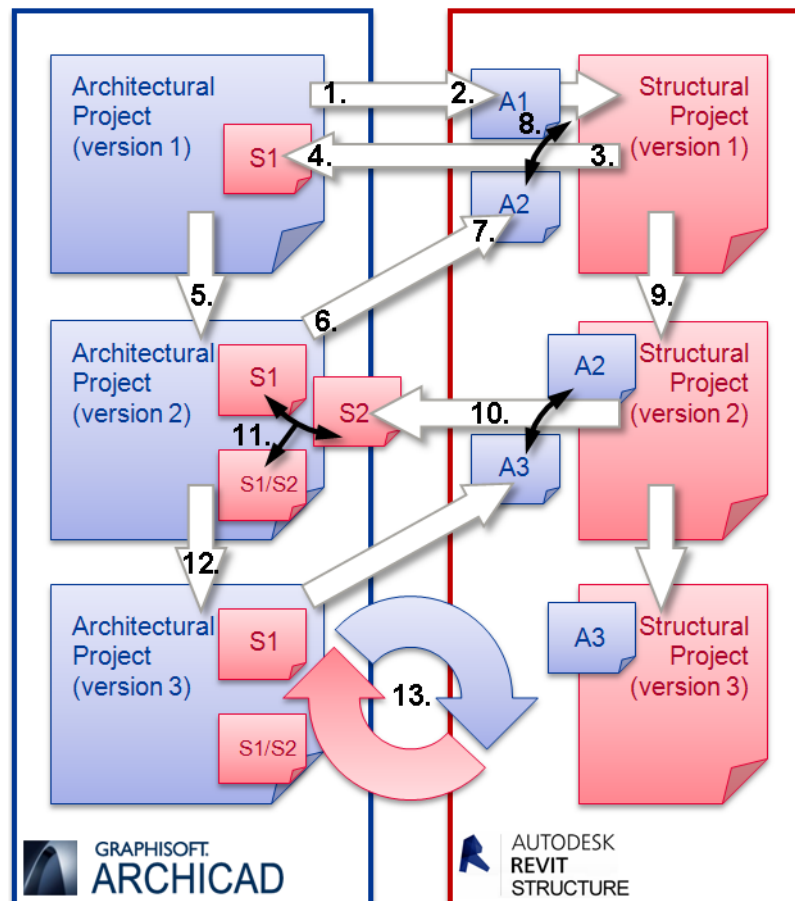
Step 1: Model export from ARCHICAD

Let's start with the architectural model: architects create the first model according to the client's request and the given site.

When building the architectural model, you should keep in mind that you plan to share it with a structural engineer. For example, you can use the classification options in ARCHICAD to differentiate load-bearing elements, place elements onto special layers, and/or define the initial profile and materials of elements, for example steel bar (column and beam) elements.

> **Note:** Revit is able to differentiate between "load-bearing" and "non-load-bearing" building elements (in element properties and by displaying disciplines). This information can be initially defined using ARCHICAD's "Structural Function" classification, whose values are translated in the IFC file and can be recognized/handled in Revit as follows:

| ArchiCAD "Structural Function" Classification	Revit Structure "Structural Usage" property
"Load-Bearing"	"Bearing"
"Non-Load-Bearing"	"Non-Bearing"

See Classification.

If you prepare your architectural model this way, then all you have to do when exporting it to IFC is to apply certain filters.

• You can use ARCHICAD's Partial Structure Display function so that only the cores of composite elements are visible, or in case of Doors/Windows, use Model View Options to display and thereby to export openings only, without the frame details and other unneeded data.

See Prepare Architectural Model for Export.

• From IFC Save Options, you can choose "Export all Visible elements (on all stories)", which is another way to filter the elements for export.

It is also advisable to include the grid-system (created by Grid Element and Grid System tools) in the IFC data, as the basis of reference for 3D element positioning.
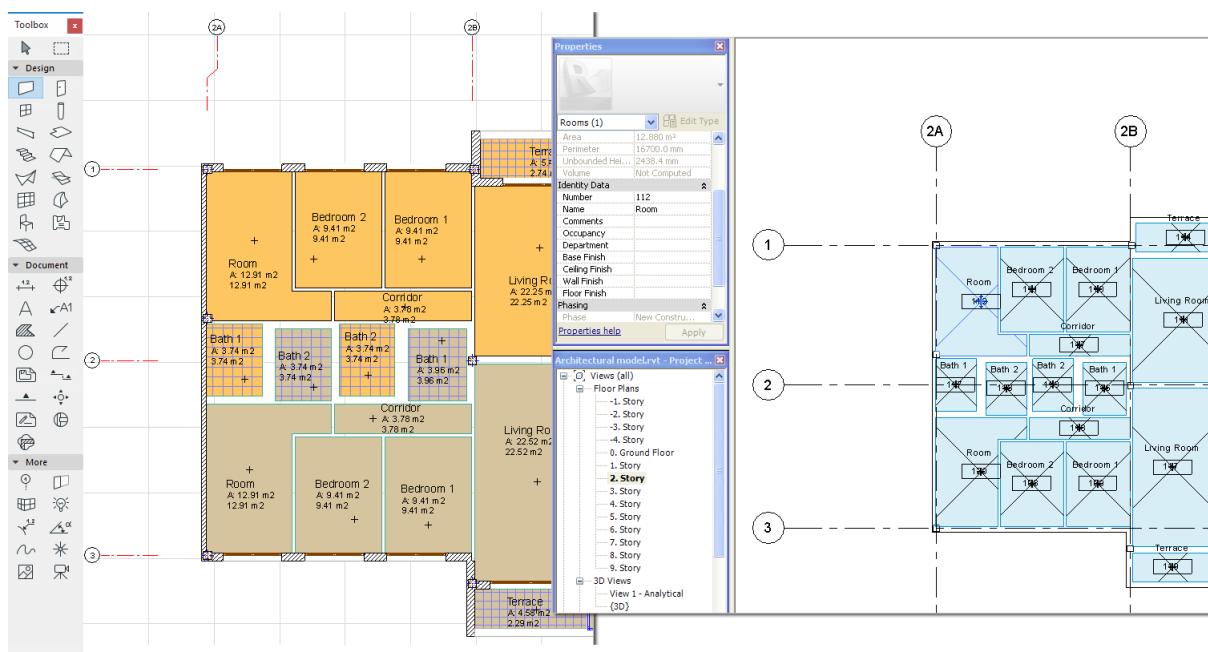
ARCHICAD offers a built-in translator ("Revit Structure Export") whose settings are optimized to export models to Revit via IFC. Of course, you may define your own custom translators, based on your specific needs.
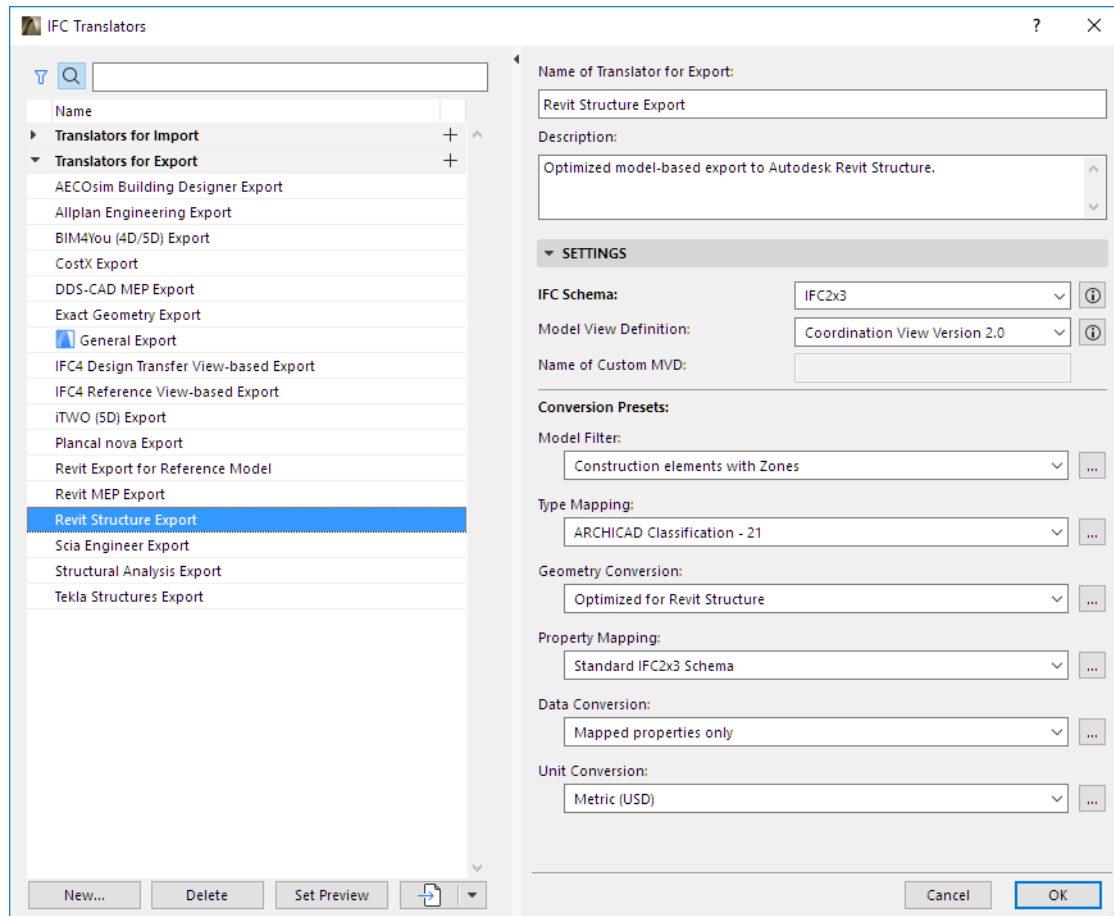
If the purpose of the exchange is merely to share a model's exact geometry (that is, as a reference model, and not to generate native elements in Revit), then we suggest using the translator named "Revit Export for Reference Model."

Other ways to filter elements during the export process:

- by elements' visibility in the view from which the export is launched,
- by current element selection,
- by story (e.g. ground floor only),
- by element types (e.g. columns and beams only),
- by ARCHICAD Structural Function (e.g. "Load-Bearing elements only"),

or you can export the whole model without any filtering. The default filtering rules of the translators can also be fine-tuned or modified manually as part of the export process (**File > Save as (IFC)**).

Notes:

- In setting up the translator for Revit (Structure), you can take into consideration the Structural Function category of ARCHICAD elements. This means that if the translator's Model Element Filter is set to "Load-Bearing elements only," then only the elements classified as "Load-Bearing" in ARCHICAD will be exported.

- ◦ Conversely, when importing from Revit, only elements categorized as "Bearing" in Revit will be imported into ARCHICAD. If there is no element-level load-bearing category assigned in ARCHICAD, or if you wish to import all elements from Revit (including non-load-bearing elements), then leave the translator's Model Element Filter setting as "All elements".
- ◦ If you would like to include 2D elements (like dimensions, texts, labels, lines, circles etc.) when exporting the 3D ARCHICAD model via IFC, you must enable this feature in the translator.
- ◦ Use the IFC format in ARCHICAD's Publisher to export the required views with just one click.

Step 2: Model import into Revit

Engineers receive the model from the architect and open its entire contents as a new Revit (Structure) project. The program converts all elements to Revit-type elements according to the applied IFC mapping table. Before importing an ARCHICAD model, the structural engineer can modify the default import settings that map IFC element types to Revit categories and subcategories.

Example: ARCHICAD Foundation-type Objects (IfcFooting) can be loaded into Revit as "Structural Foundation" elements instead of "Generic Model" elements.

Remember: Classification in ARCHICAD enables you to customize element-level conversion for the purposes of IFC export. For example, if you use the Wall tool to model a beam, you can export the (wall) element as a beam (IfcBeam) to Revit.

See Classification.

When the structural engineer imports an ARCHICAD IFC model, warning and/or error messages may appear about the limits of Revit's capacity to read IFC data accurately (for example in importing ARCHICAD Zones and Grids). To help minimize these, GRAPHISOFT has developed a Revit Add-In, called GRAPHISOFT ARCHICAD Connection, whose "Improved IFC Import" function fixes a number of these known shortcomings of the standard open process.

See GRAPHISOFT ARCHICAD Connection.

After importing from ARCHICAD to Revit, certain imported element types will be hidden by default. This is not a data loss; the engineer must simply adjust some display settings for Revit Floor Plans and 3D Views.

Examples:

- ◦ Architectural walls imported to Revit (that is, walls which were set to either "Undefined" or "Non-Load-Bearing Element" in ARCHICAD) will be hidden in Revit's "Structural" discipline view, so the structural engineer must change display settings in order to see these walls.
- ◦ Column, Stair, Roof, and Covering elements imported to Revit will be hidden by default in 3D Views. The structural engineer can easily unhide them using the Visibility/Graphic setting or tools such as the Reveal Hidden Elements command.

Engineers define the structural model and its details based on the imported model elements and their properties (materials, profiles...) assigned by the architect.

Note: When using the reference model concept, engineers can save the imported IFC model as a separate Revit file (RVT) and link it into a running Revit project as a reference to protect its content.

Revit can also generate analytical models from the structural model and share them with analysis applications, which perform analysis and design calculations. Based on the results of the analysis and design calculations, the structural model is finalized.

Step 3: Structural model export from Revit

The structural model can be exported back to ARCHICAD via IFC.

Before exporting a Revit structural model to IFC, the structural engineer can modify the default IFC export settings that map generic family instances to IFC element types. For example, Structural Stiffeners can be exported as "IfcBeam", which can then be used as real ARCHICAD Beams.

The GRAPHISOFT ARCHICAD Connection Add-In (with its Export to ARCHICAD function) is designed to fix the shortcomings of Revit's IFC model export to ARCHICAD.

See GRAPHISOFT ARCHICAD Connection.

The following table shows the elements represented by Revit's Structure basic tools, which generally make up the structural model. (This is just an indicative list of the basic Revit elements, but ARCHICAD imports all elements.)

Autodesk Revit Structure Elements
Beam
Wall
Column
Floor
Truss, Brace, Beam System
Foundation (Isolated/Wall/Slab)
Railing, Ramp, Stairs
Opening, Door, Window
Toposurface, Building Pad
Component, Model In-Place, Mass
Grid
Text
Model Text, Model Line, Dimension, Region

Step 4: Structural model import into ARCHICAD

Depending on the chosen import method, you can merge or link the structural model, or a part of it, into your running project.

We recommend using the "Revit Structure Import" IFC translator. Of course, customized translator and filtering can also be applied.

Using the "Revit Structure Import" IFC translator, the imported elements are placed on locked layers in ARCHICAD, with the extension "Revit Structure".

Structural elements can be displayed together with the architectural model using ARCHICAD's special visualization techniques. For example, you may visually compare the current model and the structural content as two different 2D views, using the Trace & Reference tool.

For more details, see [Visualization of Imported Content.](#)

Architects can check the main structural as well as other additional properties by element (in the Settings dialog of the imported elements) or by model-hierarchy (using IFC Project Manager).

Using the "Revit Structure Import" IFC translator, the import process also contains material conversion, which maps the default Revit structural materials to ARCHICAD Building Materials, while preserving the names of the original imported materials. Of course, the mapping rules can be easily edited and expanded at IFC Translator settings.

Any unrecognized Revit materials are displayed with a chosen default ARCHICAD Building Material.
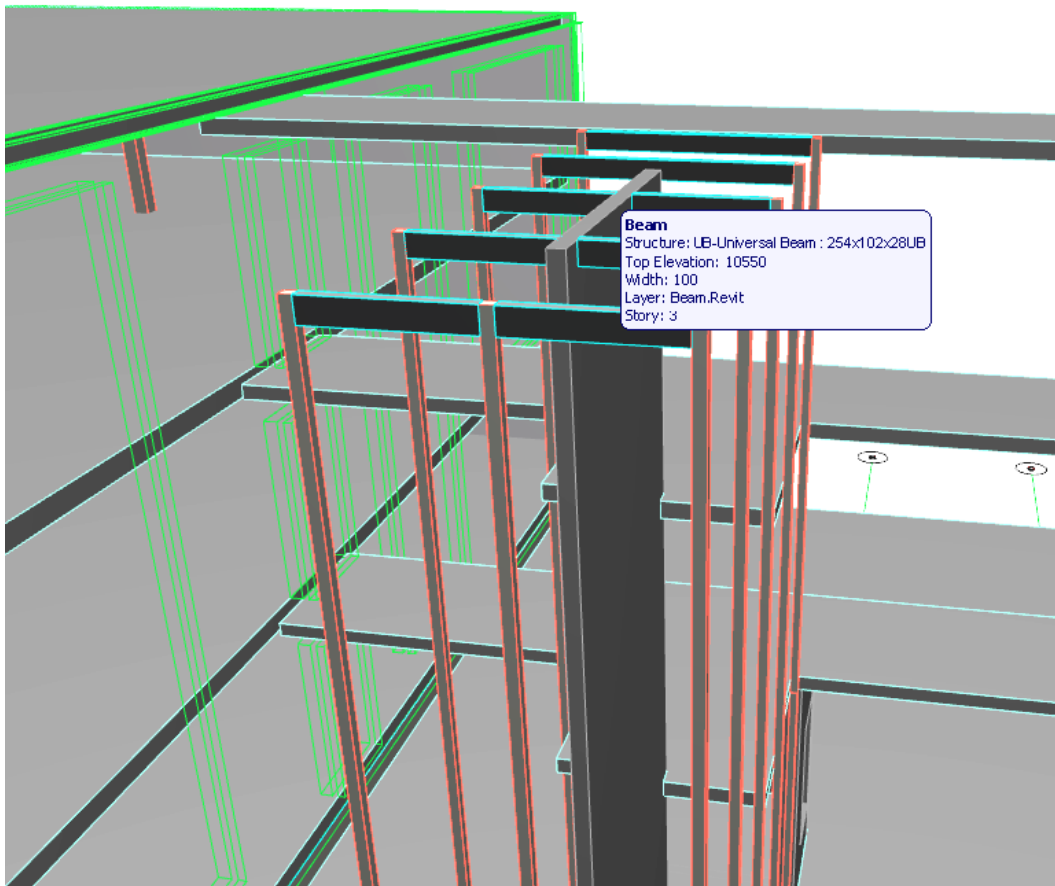
Steps 5-6: Architectural model update

In ARCHICAD, you can manually update your project according to the imported model elements by using them as reference, or by copying and using the structural elements as real ARCHICAD-type elements, since they are native ARCHICAD elements, as a result of the automatic conversion that occurs with the import process. (These imported elements are locked by default.)

A new version of the architectural project can now be exported again via IFC as described earlier.

Steps 7-10: Update models in Revit

Revit opens the new version of the architectural model as a new Revit project. If the structural engineer uses the "link concept", he/she can easily update the previously linked architectural model (an RVT file saved from IFC) to the new one. Engineers make changes in the project according to the new architectural version, and then send a new structural model version back to ARCHICAD, using IFC.

Steps 11-12: Change detection in ARCHICAD

In ARCHICAD, the received new IFC model version can be compared with the previous version by using the **Detect IFC Model Changes** command.

The result of the comparison is listed and displayed with the Mark-Up tool; only the differences are merged into the current project. You can easily check the changes recommended by your structural partner, and make modifications to your current project manually, or by using structural elements as real ARCHICAD-type elements.

Step 13: Additional Data Exchange/Cycles

Both engineers and architects can repeat this process of model exchange, comparisons and updates in additional cycles. Finally, the two disciplines make their own or combined documentations.

GRAPHISOFT ARCHICAD Connection

The GRAPHISOFT ARCHICAD Connection is a free Add-In for Revit (version 2010 or later; 32- and 64-bit). The Add-In improves the IFC model-based data exchange between Revit applications and ARCHICAD:
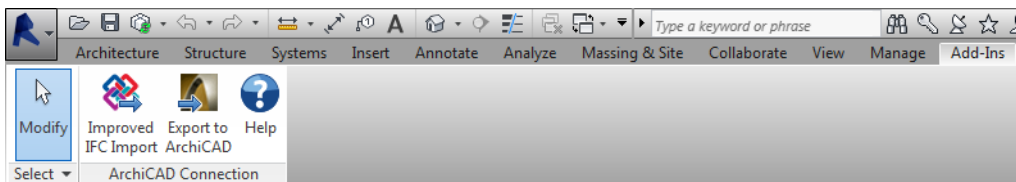
Functions

GRAPHISOFT ARCHICAD Connection has two commands. The Improved IFC Import command post-processes a previously converted (imported) IFC file in Revit and fixes a number of Revit's known shortcomings in IFC model conversion. The Export to ARCHICAD command directly exports and optimizes the IFC model data for use in ARCHICAD. ARCHICAD Connection has the following additional functions:

- Direct import and export of IFC 2x3 (*.ifc and *.ifczip) files
- Mapping of Revit Phasing to ARCHICAD Renovation Status
- Set Project Information using IFC Project data
- Correction of True North settings
- Conversion of Structural Floor elements - Improved import of IFC Spaces
- Import of all IFC parameters as schedulable Revit parameters
- Auto-Join Elements
- Export of True North data

- Export of Grid elements
- Customizable export options:
  - Phase to export
  - Export only elements visible in view
  - Export annotation elements
  - Split walls and columns by level
  - Export parts as building elements
  - Export internal IFC property sets
  - Export schedules as property sets
  - Export Family and Type name as Reference property

  Notes:

  - The installer of the GRAPHISOFT ARCHICAD Connection Add-In can be downloaded free from the following site:
    http://www.graphisoft.com/support/archicad/downloads/interoperability.
  - Although IFC4 is already supported by ARCHICAD and Revit, IFC2x3 is the recommended version.

Analysis Applications

A wide variety of analysis applications are used in different countries, which handle architectural models from ARCHICAD in different ways:

1. Some applications can open the IFC model from ARCHICAD, and then use it either as a reference model (placed on a protected layer), or convert it into a 2D or 3D Analysis model consisting of calculable lines and planes.

2. Other applications import the architectural floor plans, sections and elevations as reference drawings in formats such as DWG, then manually create an Analysis model.

3. Yet other applications import the architectural model via a third program - for example, they use Tekla Structures or Revit Structure to convert the architectural/structural model into an analysis model, and then import this analysis model, rather than importing the architectural model.

Whether using IFC or DWG format to exchange data with analysis applications, it is recommended to narrow the architectural model to just the data needed by the engineer, and to use the translators, either predefined or custom. In the case of IFC, ARCHICAD includes predefined IFC Translators for importing and exporting to analysis programs, but naturally that can also be customized as needed, or new translators created.

See [Prepare Architectural Model for Export](#).

For example, depending on the capabilities of the host structural application, you may wish to adjust the IFC Translator to enable support for grid-system export, which you may want to include in the IFC data to serve as a reference for 3D element positioning.

Most analysis applications support IFC, DWG and PDF formats for export, so you can import or place the engineer's structural recommendations into the current ARCHICAD project. ARCHICAD contains functions that enable you to view the architectural and structural models separately or in integrated form.

See [Visualization of Imported Content](#).

For structural models imported in IFC format, ARCHICAD enables you to utilize and check the profiles, materials and other properties suggested by the engineer.

See [Imported Properties](#).

Also, ARCHICAD's Detect IFC Model Changes feature can display the geometric modifications between two versions of a structural project.

(Some structural applications, in turn, can display changes between two versions of an architectural model.)

Ask your partner which of these data exchange solutions is supported by his/her analysis application, and which of the modeling options and settings will best support your workflow with your structural engineer partner.