Utilizing gbXML with AECOsim Building Designer and speedikon

Building Performance Analysis Using Bentley Products

A Bentley White Paper

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Sustaining Infrastructure

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Introduction

In the rapidly changing environment of today's architecture, engineering, and construction (AEC) industry, demand for more intelligent and coordinated ways to design and construct projects continues to grow. As a result, it is becoming more commonplace to see building projects delivered ahead of schedule and under budget – often through the use of building information modeling (BIM).

Unlike computer-aided drafting (CAD), BIM offers intelligent components that constitute the building design. These components can carry embedded information to describe the geometry, function, interrelationships, and dependencies within a system, performance characteristics, and other properties. The "intelligence" contained in these components allows the transfer of information from the building design application to applications capable of analyzing acoustics, costing, energy consumption, and more.

Increasingly, due to issues such as today's high energy costs, sustainable design is being demanded or legislated. It has become extremely important to understand, at an early stage and throughout a project, the impact that the building design itself will have on the energy requirements needed to maintain building performance targets as well as to meet occupant comfort. To understand and calculate these demands and allow systems to be designed to accommodate the requirements, many energy analysis tools are now available, including Bentley's Hevacomp products, AECOsim Energy Simulator, and Bentley Tas Simulator. These analysis applications share data with design applications, enabling model reuse, and eliminating redundant data entry.

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There are currently several efforts specifically focused on creating an open schema so that applications from disparate vendors can share data. Green Building Extensible Mark-up Language (gbXML) is one schema that is widely used in building industry software, including in Bentley's AECOsim Building Designer and Bentley speedikon building products.

gbXML development was started by Green Building Studio (GBS) in 1999 with funding from the California Energy Commission and Pacific Gas and Electric. The gbXML schema was released in 2000, quickly became the standard schema for building information exchange, and was soon adopted by major BIM authoring and analysis software vendors. In 2008, GBS was acquired by Autodesk, and gbXML was spun-off into a non-profit called the Open Green Building XML Schema, Inc. (http://www.gbxml.org). This non-profit now includes a board of directors whose members come from 11 software companies, including Bentley Systems.

Because gbXML is an open XML schema, it is freely available for use by both individuals and vendors as a data transfer mechanism within their products. The goal of gbXML is to provide a universally accepted schema to enhance interoperability among software tools that handle building information.

The gbXML schema contains a hierarchy of data placeholders. With nearly 400 elements and attributes, there are more placeholders than will probably ever be used. To successfully transfer an element, the source software must export to gbXML and the destination software must import from gbXML. Some examples of the types of data that can be incorporated into a gbXML file include information related to building geometry (planar or rectangular geometry), envelope properties such as wall u-values and window emissivity values, building and equipment schedules, weather data, shading properties, point-by-point lighting data, hydronic loop equipment properties, air loop equipment properties, surface adjacency info, and zone and HVAC system-related data.

Currently, most software tools do not take advantage of the full capabilities available in the gbXML schema; instead, they use it primarily for the transfer of geometry. As both the schema and software tools mature, more in-depth use of the schema can be realized to further save time by reducing redundant data entry and ensure greater fidelity between the design and analysis aspects required for today's building projects. It is also important to realize that the use of this or any schema is not error proof. The adage "garbage in, garbage out" applies here, as it is important to model a building design accurately and understand the capabilities of gbXML export functionality to achieve a successful transfer of information from design to analysis applications.

The gbXML export function within Bentley building products creates an analytical model for performance analysis based on the existing building information model.

This paper will provide basic knowledge of the gbXML data model and then review building elements in a building design from the perspective of space boundaries to illustrate how to best prepare a model for gbXML export. It will explain the process of exporting building information using gbXML, focusing on the creation of an analytical space model from BIM data, as well as the capabilities of Bentley software tools that support gbXML, and areas to help streamline data transfer via gbXML Setup of energy parameters is outside the scope of this paper.

Process Workflow

The gbXML export function within Bentley building products creates an analytical model for performance analysis based on the existing building information model. Building elements are analyzed and all space geometry and topology is used to create the input data required for performance analysis. After the analytical model is created, the user can reassign spaces to thermal zones and set up additional energy parameters. Finally, the data can be transmitted via gbXML to applications such as Bentley Hevacomp products, AECOsim Energy Simulator, Bentley Tas Simulator, and other gbXML-compliant analytical applications.

Analytical Spaces and the gbXML Data Model

This section provides a conceptual understanding of data stored in a gbXML file for performance analysis. The knowledge imparted can help in developing models for easier transfer to analytical applications or for troubleshooting existing models. The information covers only aspects of gbXML that deal with geometry and topology.

Analytical Space

Analytical space is the most important concept for energy analysis. It is often the equivalent to an architectural space (or room) in a building, but there can be differences. As defined in the documentation for the gbXML schema, "a space represents a volume enclosed by surfaces" (Open Green Building XML Schema, 2009).

These volumes are not intersected and fill the entire internal volume of the building.

Analytical space needs to be completely enclosed from all sides by surfaces of building elements. Imagine that all openings (widows, doors, and simple holes) have been removed or visualize the elements before openings were perforated, leaving only surfaces that enclose the space. These elements are called bounding elements of the analytical space.

Every closed volume in a building is an analytical space, including plenums, attics, elevators (lifts), stairwells, and more. Because some of these are not typically considered room spaces by architects, they may not have related BIM space objects. Bentley building applications, however, will automatically detect these analytical spaces from geometry defined by the building elements.

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Note that some architectural spaces – for example, an open balcony – are not considered analytical spaces for performance analysis.

Space Representations

There are three different types of analytical space representations used in gbXML:

- Shell geometry
- Space boundaries
- Analytical surfaces

Shell Geometry

The shell geometry of an analytical space is a collection of faces (planar shapes) that make up a closed shell. There is no intersection of any two of the given shells. The shapes lay on physical surfaces of building elements, or approximate the surfaces of curved elements. The shell geometry is very close to the real physical space volume. Imagine an enclosed space without any opening in the walls; the shapes of building elements are the shell geometry of the space. Shell geometry can be used for computations that do not take into account space adjacency – for example, a lighting calculation.

In the data hierarchy of the gbXML data model, a space is a parent of its shell faces (see “Data Object Model” on page 8). Each face, however, belongs to exactly one building element, although this relationship is not presented in the gbXML space shell model. If an analysis application needs this data – for example to get element material properties – the space boundary or analytical surface model should be used (see below).

All bounding elements are required to connect to each other without gaps or slivers. A space should have building elements on the top and bottom in addition to the walls. These slab type surfaces often are not placed in simple designs (shown in Figure 1) to simplify the drawing; however, Bentley’s gbXML export function can modeled these slabs automatically, as shown in Figure 2 (also see “Create Storey’s Overlap Slabs” on page 13).

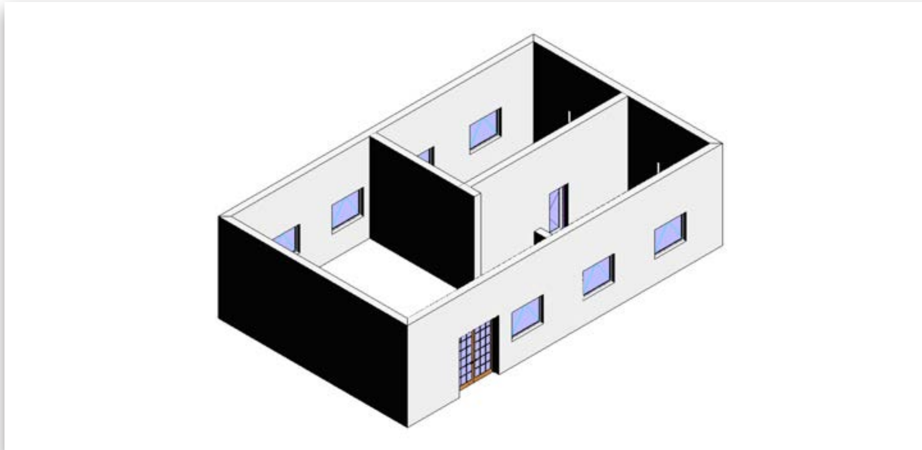

Figure 1 - Simple design model example

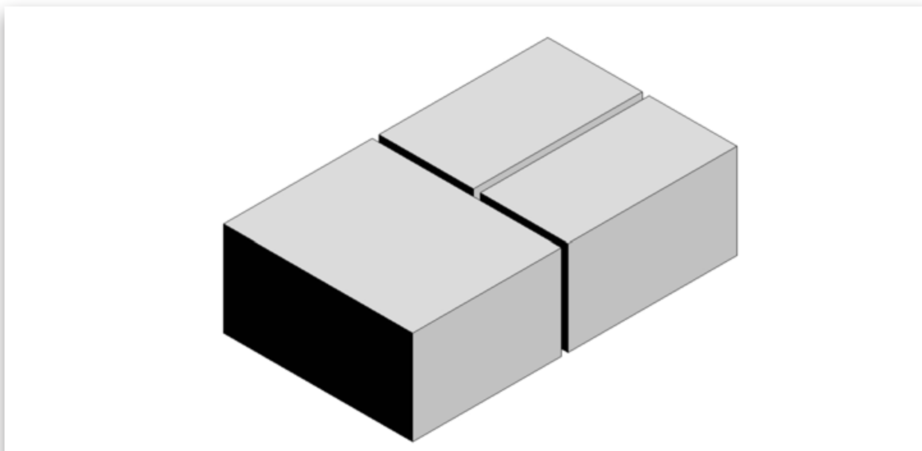

Figure 2 - Space shapes representation

Space Boundaries

For any particular face component of the shell geometry there may be one or more spaces on another side of the bounding element. Additionally, some parts of the face may be adjacent to the outdoor environment or a solid representation of another building element (for example, a T-joined wall).

By subdividing each face into such parts, we represent the relationship that the boundary has with the adjacent spaces or environment and the thermal impact these may have. Therefore, each new face has on the other side of the bounding element, either:

- an analytical space,
- an external environment, or
- a solid representation of another building element.

These faces are referred to as space boundaries (also known as secondary boundaries). To understand this concept, consider how an external building façade is modeled. Each wall would most likely be modeled as one linear form. Through the process of creating the analytical space model, the building design model is interrogated for these spaces and the external wall is divided, accordingly, to each separate space in which it acts as a bounding element. The process of segregating this form is referred to as creating the secondary boundary conditions. Thus, the space boundary geometry is a subdivision of the space shell. Similar to space shells, it is also a closed and complete shell for analytical spaces, but also in addition it takes into account the space adjacencies.

By creating space boundaries for all spaces within a building, aligning pairs of adjacent shapes are created to use for analyzing heat transmission between adjacent spaces. In the case of a wing wall, both adjacent space boundaries will belong to one analytical space. Some shapes, however, will not have adjoining surfaces, as they are adjacent to the outside environment or to another building element.

The space boundary establishes the logical relation of a given part of the space geometry to the building construction. Contained within these shapes are material properties that allow for the calculation of heat flow between adjacent spaces or to the outdoor environment. Space boundaries are used for some thermal and energy calculations.

In the gbXML data model each space boundary is a child of a space (see "Data Object Model" on page 8). Although gbXML data does not provide this adjacency information directly, it does contain enough information to determine the counterpart space boundary and the adjoining shape, or that it is an external building surface or surface such as a T-joined building element. The gbXML schema also allows to obtain from a space boundary information about the building element, such as thermal characteristics or construction.

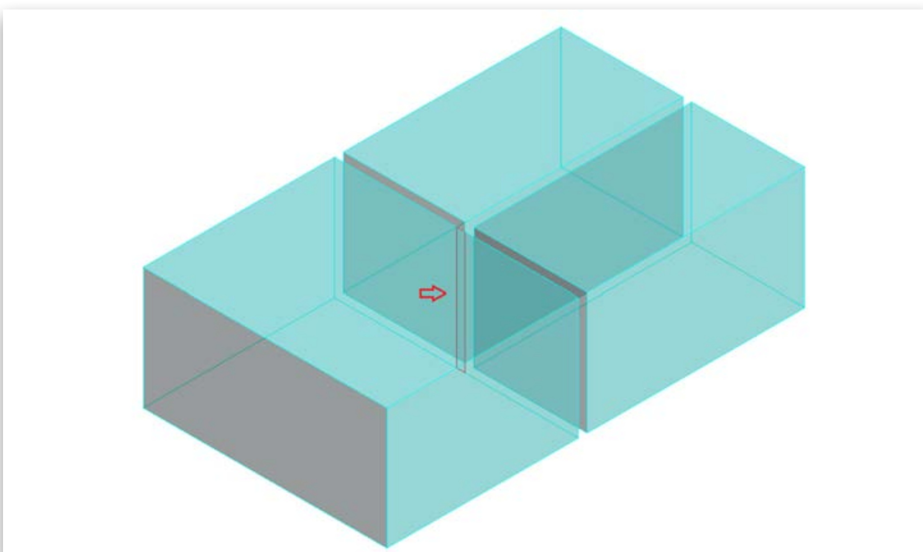

Figure 3 - Space boundaries representation

Analytical Surfaces

Analytical surfaces are abstractions of bounding elements; when we define the elements thickness to zero this prevents the surface from occupying the same plane as adjacent spaces. Analytical surface geometry is a planar shape. Curved bounding elements are approximated by faceting this surface into a connected series of planar shapes.

Analytical surfaces represent the heat transmission units within a certain area. Each surface can have two, one, or zero adjacent analytical spaces. Where the surface represents an internal bounding element (or a part of an element), the surface separates two spaces and there is a heat transmission between them. Usually the spaces are from one building but they also may belong to different buildings. An external surface that has an adjacent space on its internal side and connects with the outdoor environment on the other side would have one analytical space. There is an external heat flow through the surface, both to and from the space, based on climatic conditions on either side. Surfaces that have zero adjacent spaces represent a building element or its part that does not bound any space volume. These surfaces can impact energy consumption, however, as they can shade the building from the sun (for example, roof overhangs, window insets, or shading devices) during all or a portion of the day.

In the current version of gbXML (0.37), surfaces are “children” of the campus object – not the space object (see “Data Object Model” on page 8). In earlier versions of gbXML, surfaces were children of the building object (Green Building Studio, 2008). Adjacent spaces are pointed to as references.

Usually the spaces are from one building but they also may belong to different buildings. An external surface that has an adjacent space on its internal side and connects with the outdoor environment on the other side would have one analytical space.

Analytical surfaces and space boundaries have some similarities with heat transmission units. A pair of adjacent boundaries corresponds to a surface that is geometrically located between two adjacent spaces. Boundary of an external bounding element corresponds to a surface with one adjacent space. Shading surfaces have no analogies to space boundaries in the gbXML schema, nor do they have heat transmission. However, they are important to take into account and so have been added as external building boundaries to the Bentley Tas file format for gbXML import interpretation. On the other hand, space boundaries with a solid building element on an adjacent side have no analogies in surfaces. If a computational model uses analytical surfaces, it will ignore these parts.

Within the building industry, there are conflicting definitions for the plane location of an analytical surface. These are not well defined in the gbXML schema. The initial gbXML specification used the external plane location for external elements (with exactly one adjacent space) and the centerline plane for other cases, such as internal and shade surfaces (Green Building Studio, 2008). However, not all providers of BIM data followed this logic, which required a change in the expectations of information for analytical applications. Unfortunately, descriptions within version 0.37 of the gbXML schema do not clarify this issue. After consideration, Bentley chose to use the top plane for internal slabs and follow original requirements stated above in other cases. Figure 4 (on the next page) shows an example of the positions of analytical surfaces for walls.

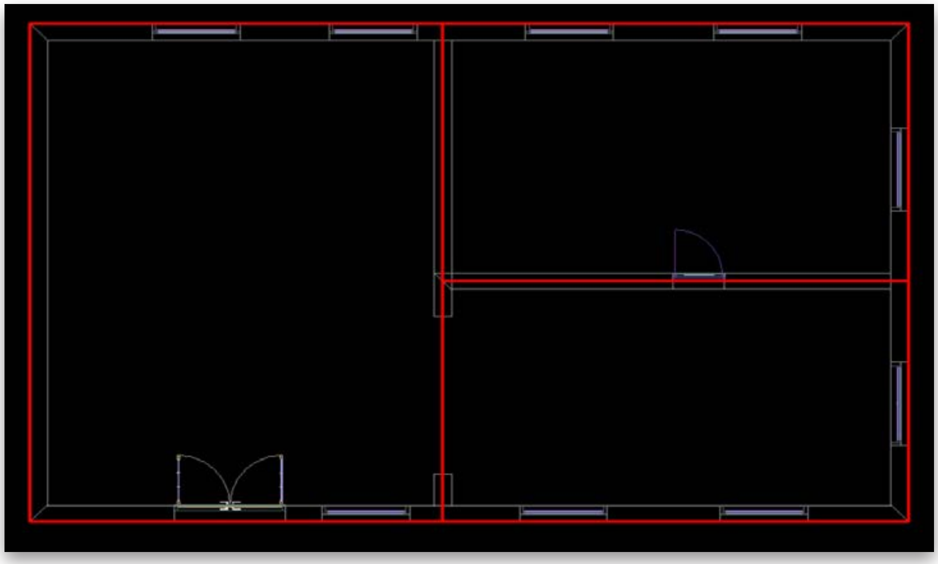

Figure 4 - Positions of analytical surfaces

gbXML documentation does not declare or define the case in which a building element contains parts both internal and external or in which it has external parts on different sides (Open Green Building XML Schema, 2009). Bentley's gbXML export treats the element as an internal element to make all surfaces from one building element coplanar. Another point of uncertainty is how to represent wing surfaces (in which both sides are in one analytical space). For these, Bentley products use two adjacent space references that are equal.

Openings

Openings are doors, windows, and open holes in bounding elements. gbXML represents openings as planar shapes. These shapes lay on their parent analytical surfaces. Openings in curved elements are approximated.

Because shapes of openings are "hosted" in the planes of analytical surfaces, they are distanced from the space shell and space boundary shapes. In other words, in the analytical model these shapes are not part of the space boundary shape, but are presented on a parallel plane.

gbXML allows navigation from a space boundary to a surface, then to openings. Openings are not accessible from the space shell.

Data Object Model

The root object in the hierarchy of gbXML data is the campus object. The campus object contains all analytical surfaces of one or more building objects. Each building object contains one or more space objects. The logical structure of gbXML data is shown below in Figure 5 (on the next page).

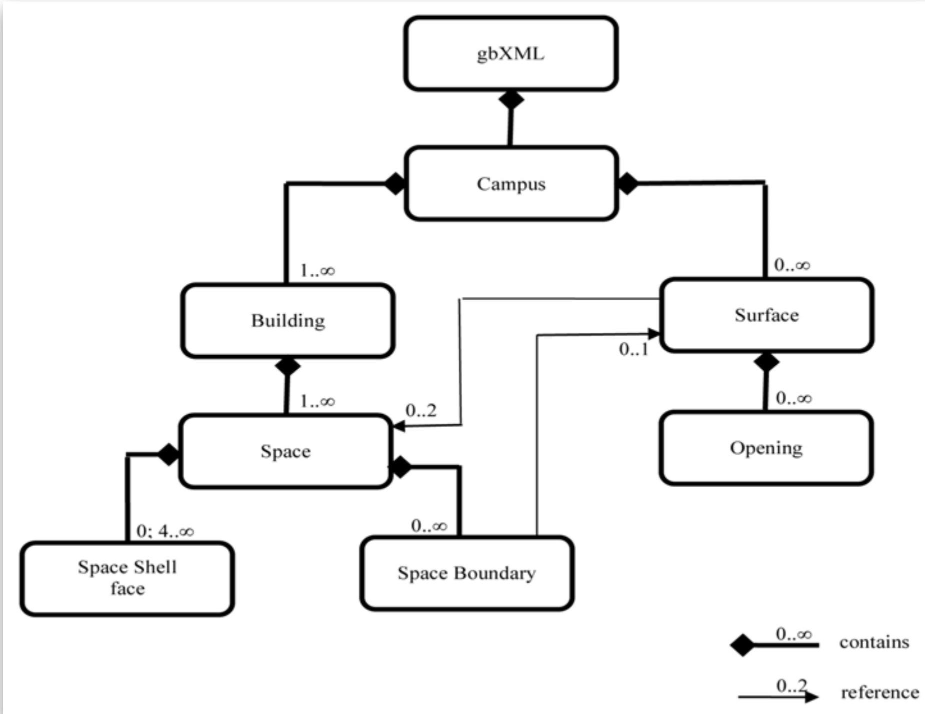

Figure 5 - gbXML data object model

All entities in the diagram are exact XML-elements except space shell face, which corresponds to a number of XML-elements that are simplified here.

Figure 6 shows the locations of geometrical entities for an internal wall.

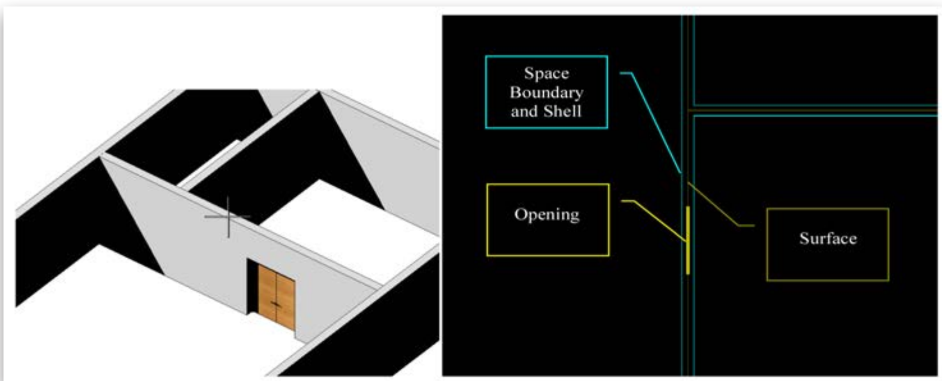

Figure 6 - Locations of geometrical entities

Preparing the Design Model

A design model must have properly created geometry for analytical spaces: that is, all spaces must be completely enclosed by bounding elements. These elements can have openings, but if openings are removed or suspended, all spaces must be closed. If there is an air transfer connection between two designed spaces and they should remain two separate analytical spaces, a building element must be used to make an opening (without placing a door or window). If there is an air connection between two spaces, where building elements are not completely touching each other, only one analytical space will be recognized. The same is true for air connection from a space to the outdoor environment.

The gbXML export function in Bentley's building products can simplify preparing the design by automatically creating an overlapping slab at a building's story level and extend the internal walls to separate spaces. These features are explained in the section "Create Analytical Space Model Dialog Box" on page 13.

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Bounding Elements Overview

Analytical space is a closed volume completely surrounded by bounding elements. Because the gbXML export functionality uses bounding elements to calculate analytical spaces, it is important to know which elements are bounding elements. In short, bounding elements are all walls and slabs. Optionally, floor overlapping slabs can be automatically placed at elevations levels (see "Create Storey's Overlap Slabs" on page 13 for more information).

AECOsim Building Designer takes bounding elements from either the active model and all displayed references, or only selected elements. Bentley speedikon uses floors and parts selected for the section or model, and all levels are used regardless of visibility.

Walls

All walls are considered vertical bounding elements. The type or attributes of a wall do not play a role in space calculation. The definition of a wall as exterior or interior in gbXML depends only on topology – whether or not there are adjacent spaces on both sides. When creating a new design for energy analysis only, creating single walls will improve performance.

AECOsim Building Designer Specific

All linear, arc, and line string forms are wall bounding elements. To be used as a bounding element, a curtain wall must be embedded in a wall.

With AECOsim Building Designer the preferred tool is the Place Wall tool. Other suitable tools are:

- Place Linear Form
- Place Compound Form
- Place Segmented Arc Form
- Place Curve Form

Bentley speedikon Specific

For Bentley speedikon, suitable wall tools are:

- Place Single Wall
- Place Cavity Wall
- Fillet Single Wall
- Fillet Cavity Wall

Virtual walls are bounding elements like any other type of wall.

Individual (free form) walls are not currently supported in the gbXML capabilities of Bentley speedikon. If these types of wall assemblies are used in an existing design, they should be recreated as a wall or slab to achieve proper gbXML export. For example, a high slab with a small base may be used to simulate this type of wall.

Slabs, Ceilings, and Roofs

Slabs, ceilings, and roof panels are interpreted as non-vertical bounding elements for spaces. Slabs and ceilings are usually horizontal but may be sloped as well. Ceilings are assumed to be internal and gbXML requires that they have exactly two adjacent spaces.

AECOsim Building Designer Specific

Slab forms, free forms, and ceiling are always bounding elements. These can be created with the following tools in AECOsim Building Designer:

- Place Floor Form
- Place Slab Form
- Place Free Form
- Ceilings
- Place Ceiling Form

A shape can be a bounding element if it has an appropriate part and family. The part and family are customizable (default options shown in Figure 7 on the next page). Tools to create these include:

- Roof Builder
- MicroStation drawing tools:
    - » Place Block
    - » Place Shape
    - » Place Orthogonal Shape
    - » Place Regular Polygon

Space shapes created with the Place Space tool are not bounding elements.

Family	Part	gbXML Surface Type
B1020	*default roof*	Roof
C3030	*default ceiling finish*	Ceiling
C3020	*default floor finish*	Floor

Figure 7 – Default options for shapes used as bounding elements

Bentley speedikon Specific

Slabs, ceilings and roof panels are bounding elements. These can be created using the following tools in Bentley speedikon Architecture:

- Define Slab
- Define Ceilings
- Roof Place Macro
- Define Roof Panel

Floor finish and space shape are not considered bounding elements.

Beams and Columns

Beams and columns are not bounding elements in AECOsim Building Designer or Bentley speedikon. If an existing design uses these elements to separate spaces, they must be redesigned using walls or slabs. High slabs with a small base shape can be used to simulate these building elements.

Space Shapes

As mentioned, space shapes placed by Create Space functions are not considered bounding elements. These shapes represent architectural spaces, which are similar but slightly different from analytical spaces.

Analytical spaces are calculated based on bounding elements only. A space shape is not required in every closed volume of a building, such as a plenum, attic space, or shaftway. In fact, space shapes do not affect the calculation of analytical spaces. However, if an analytical space contains a space shape, the analytical space inherits the name and attributes of the space shape. In this case, spaces such as a plenum or attic space share the name of the analytical space below it but are prefixed with the word "Above."

It is assumed that space shapes are placed in analytical spaces. A warning message will appear if a space shape is in an unclosed outdoor environment, or if there are two space shapes in one analytical space. These warning messages help verify the project layout.

With Bentley speedikon, a configuration file can be used to specify whether or not a window placed in a wall is operable or if a door is sliding by macro name and parameter values.

Openings

Any tools can be used to create openings and opening elements. Openings do not change space boundaries (i.e., if two spaces are separated by an element, they will remain separated after creating any kind of opening in the element).

With Bentley speedikon, a configuration file can be used to specify whether or not a window placed in a wall is operable or if a door is sliding by creating a macro with name and parameter values. All roof windows are exported as operable.

Create Analytical Space Model Dialog Box

The Create Analytical Space Model dialog box is used in both AECOsim Building Designer and Bentley speedikon to create the analytical space model for export to gbXML.

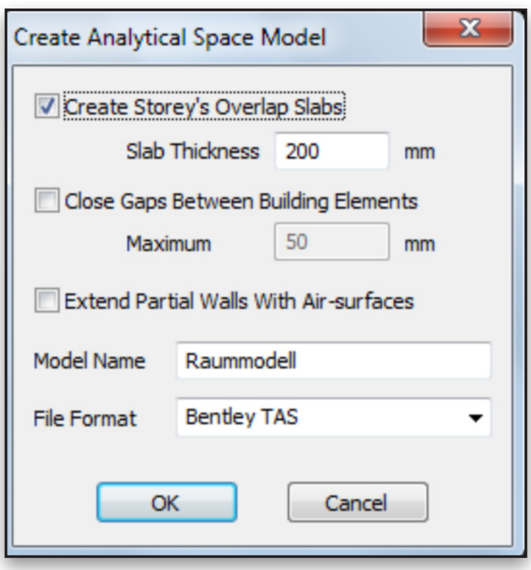

Figure 8 - Create Analytical Space Model dialog box

Create Storey's Overlap Slabs Option

The Create Storey's Overlap Slabs option enables automatic slab creation at the floors elevation levels. Some simple projects may contain walls only, without slabs (Figure 8).

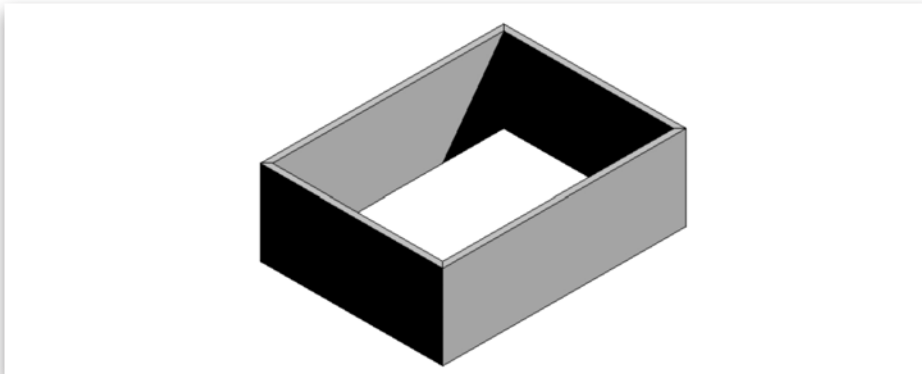

Figure 9 - Simple project with walls only

If this is project is exported to gbXML, the message “Enclosed Spaces not found” will appear in the Event Log Details and only shadow surfaces will be drawn in the analytical model, as shown in Figure 9.

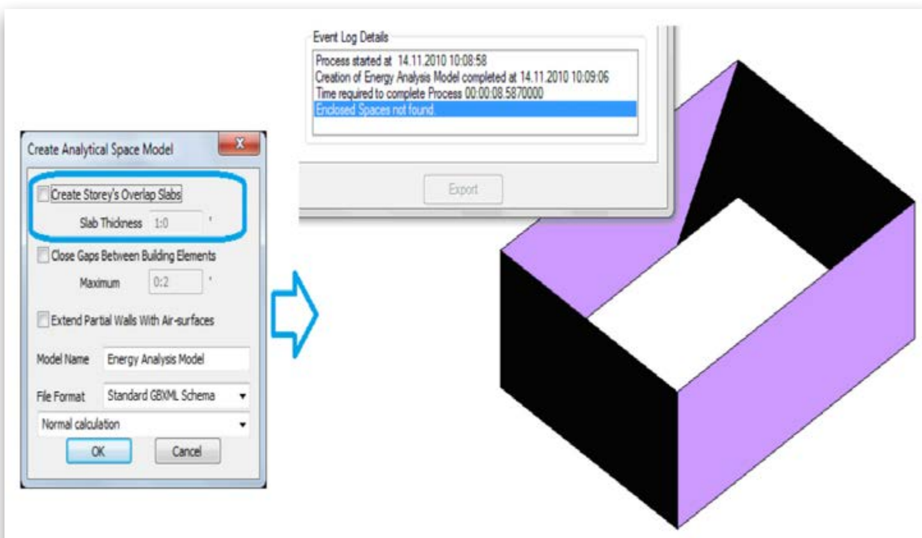

Figure 10 - Space not enclosed

This happened because the walls alone do not completely enclose the space. Boundaries at the top and bottom are necessary to form an analytical space.

There are several ways in which the design can be adjusted to alleviate the issue. One method is to place all bottom and top boundary slabs in the building design to enclose the volume. The other alternative is to use the Create Storey’s Overlap Slabs option in the Create Analytical Space Model dialog box. Selecting this option ensures that overlapped slabs will exist on each story even if they were not explicitly modeled in the design. If this option is chosen, the export function creates the slabs automatically and the space will be enclosed to create a closed volume suitable for export through gbXML, as shown in Figure 11.

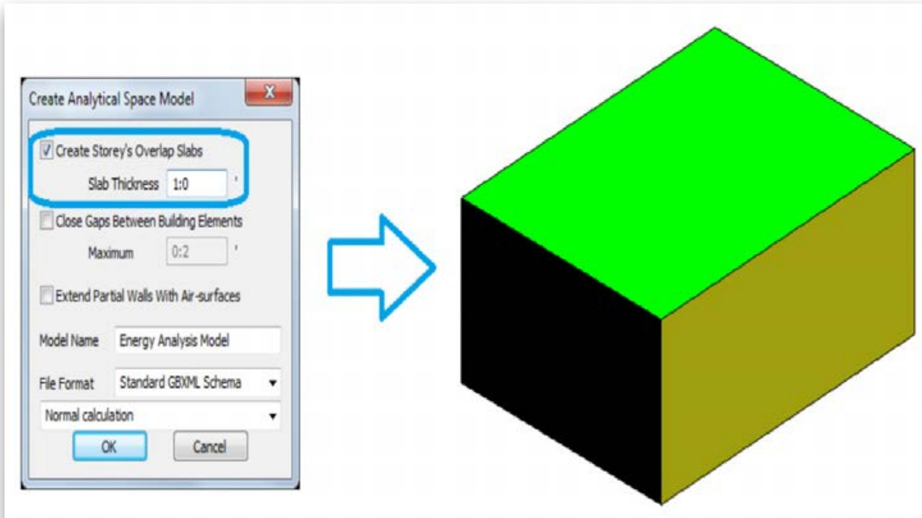

Figure 11 - Space enclosed using Create Storey's Overlap Slabs option

Overlap Slab Location

AECOsim Building Designer uses the Floor Manager to define floor levels (Figure 11). These values are taken as the top level of the slabs. The Slab Thickness option from the Create Analytical Space Model dialog box (Figure 11) allows the user to define a slab thickness.

In addition to floor level slabs defined by the Floor Manager, an overlap slab for the top floor will also be created. The elevation of this slab is the sum of the top floor elevation and last storey height, where the last storey height is the difference between the last and previous floors' elevations.

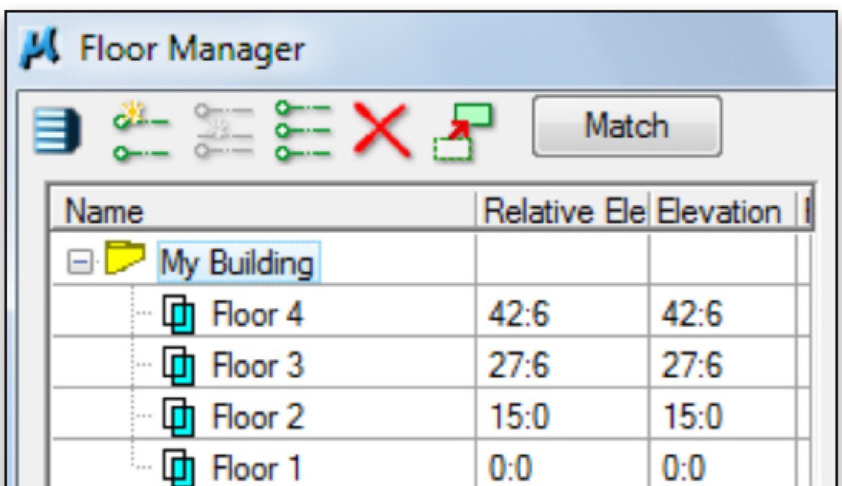

Figure 12 - AECOsim Building Designer uses floor levels from Floor Manager

In Bentley speedikon the floor levels and the thickness of the top slab come from the floor Options dialog box (Figure 12). Please note that floor level refers to bottom slab and slab thickness to top. The thickness of the bottommost (ground) slab comes from the Create Analytical Space Model dialog box (Figure 10 on previous page).

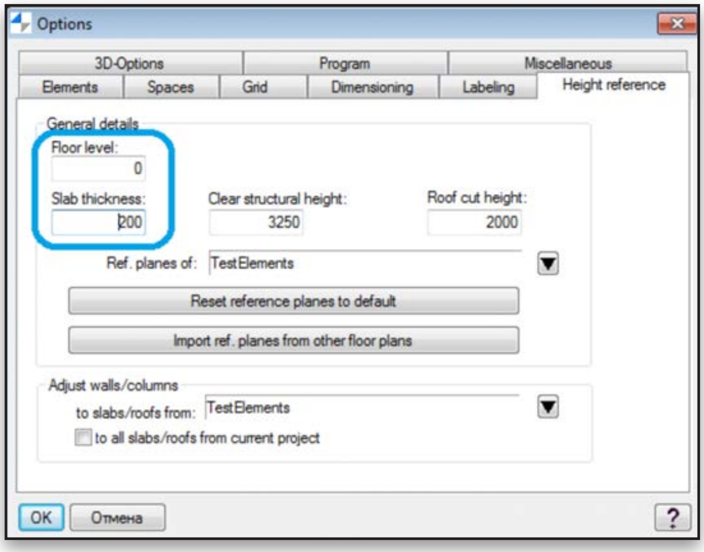

Figure 13 - Bentley speedikon Architecture uses floor levels and overlap slab thickness from the floor Options dialog box

Overlap slabs will be placed at each level where bounding elements exist. If there are no walls or designed slabs on a floor, there are no analytical spaces and no need to create overlap slabs.

In the example shown in Figure 13, slabs will be placed on the level of Floor 1 and Floor 2 but not on the upper floors. Note that the top bounding surface of the space is lower than the next floor elevation, with the difference being equal to the slab thickness.

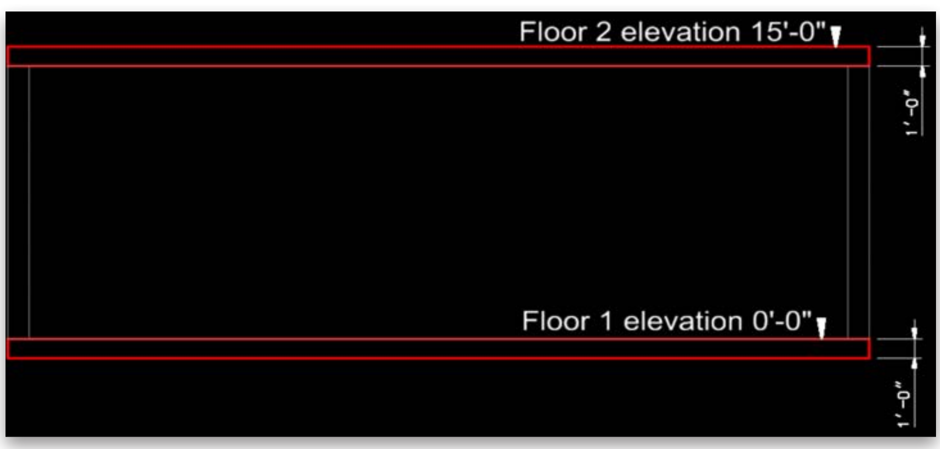

Figure 14 - Floor slab placement example

The Create Storey's Overlap Slabs option is best suited for a building model in which the floor plates are aligned and defined by the building plan. This option enables users to design suspended ceilings and other slab elements internal to the building model on the floors while avoiding slabs between floors.

In general, if the building model has complex 3D geometry, such as different thicknesses for overlap slabs, atrium spaces that span several floors, or other advanced features, it is better to explicitly model all slab elements and not use the Create Storey's Overlap Slabs option.

Close Gaps Between Building Elements Option

In some cases the existing building model may be inaccurate due to incomplete closed analytical spaces. This can occur when internal walls are slightly shorter than the defined story height, as shown in Figure 14 (on previous page).

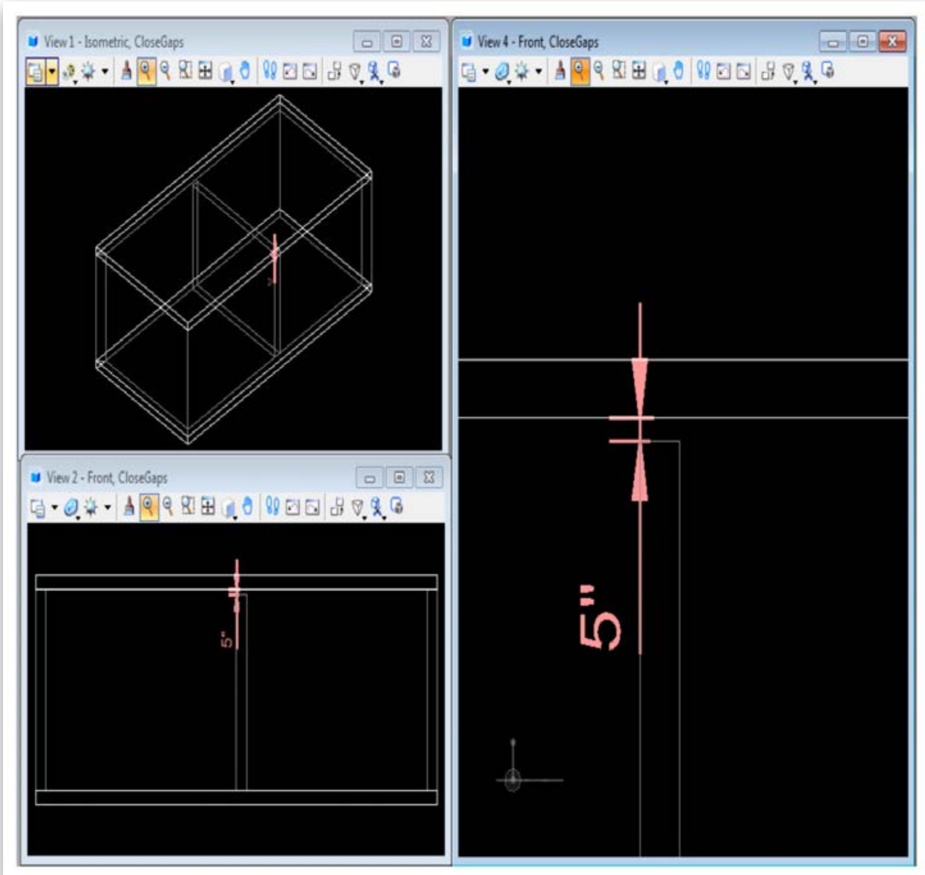

Figure 15 - Internal wall with gap

In the above example, the interior partition wall does not completely separate the two adjacent spaces. If this is exported to gbXML (with the Close Gaps Between Building Elements option off) it will result in only one analytical space due to the small opening in the partition wall (Figure 15).

If this was not intended, it can be corrected in two ways. The first is to model the partition wall so as to completely separate the two areas resulting in two analytical spaces. Alternatively, selecting the Close Gaps Between Building Elements option will result in the model spaces being automatically separated. The maximum gap should be at least 0:5 to automatically fix this situation, as shown in Figure 16 (on next page).

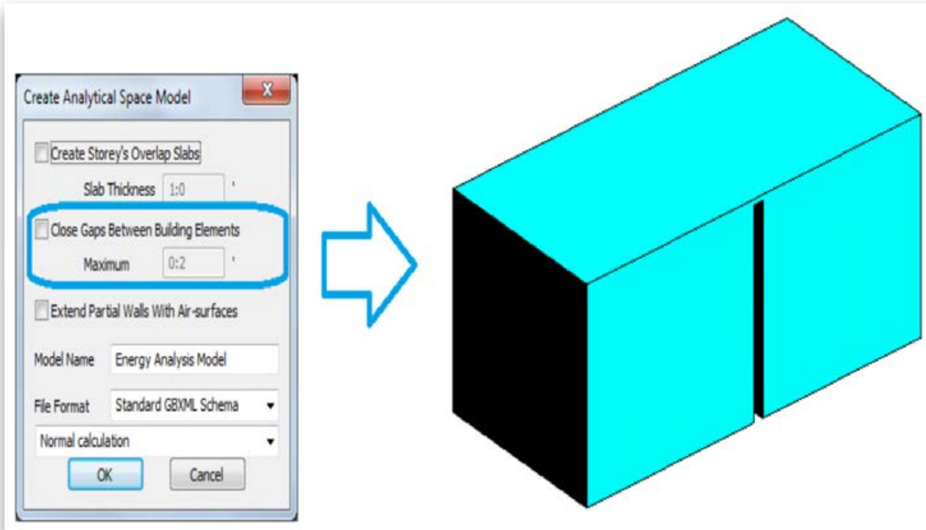

Figure 16 – Gap results in a single analytical space

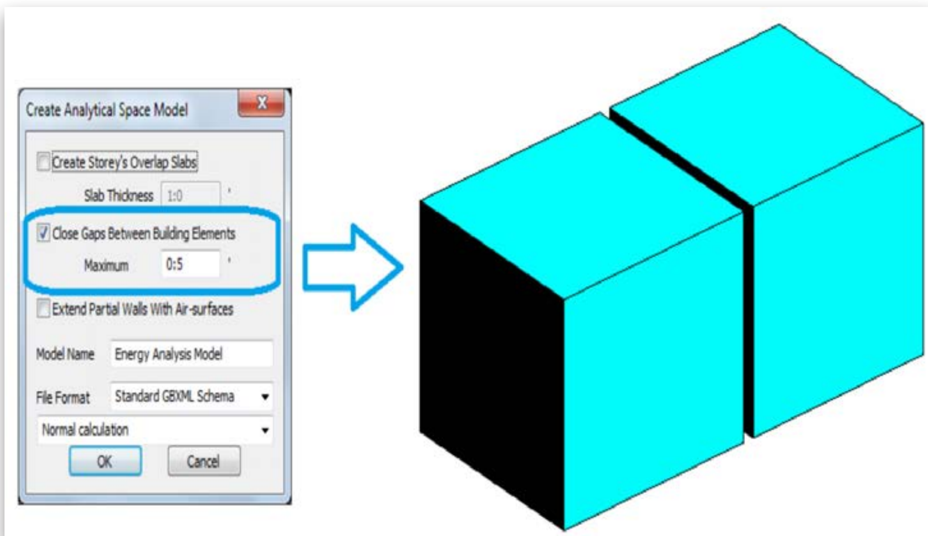

Figure 17 – Using Close Gaps Between Building Elements option results in two analytical spaces

Note that all gaps smaller than one-half inch are always closed programmatically due to the close proximity. The Close Gaps Between Building Elements option can be used to increase this limit, but decreasing this tolerance setting to less than the default half inch will have no effect. The Close Gaps Between Building Elements option only applies to internal building elements.

Extend Partial Walls With Air Surfaces

Sometimes partitions are significantly lower than the story height but it is necessary to split the physical space into logical spaces, for example, an open office space with partitions.

The Extend Partial Walls With Air-surfaces option can be used to accomplish this task. This option is similar to the Close Gaps Between Building Elements option with the following differences:

- Extend Partial Walls With Air-surfaces only checks walls to top and bottom space boundaries, while Close Gaps Between Building Elements handles all types of bounding elements and gaps.
- Extend Partial Walls With Air-surfaces creates a new "air" surface that is used by gbXML. This surface type indicates to analysis applications that this is a virtual boundary with free air, heat, light and sound transmission. Close Gaps Between Building Elements, conversely, extends boundary elements to make a physical separation between spaces.
- Extend Partial Walls With Air-surfaces has no limit. Each partial wall designated by using this option will be extended to the top of its space to create a virtual division.

Close Gaps Between Building Elements, conversely, extends boundary elements to make a physical separation between spaces.

Model Name

Entering a MicroStation model name designates how to label and draw an analytical space model. The model is used as an intermediate step in which a visual representation of the planar model is created; this allows the user to check and set attributes that may not be modeled correctly or set in the design model (see Figure 18 below). If a model already exists using the same name, it will be overwritten upon creation of the new data model.

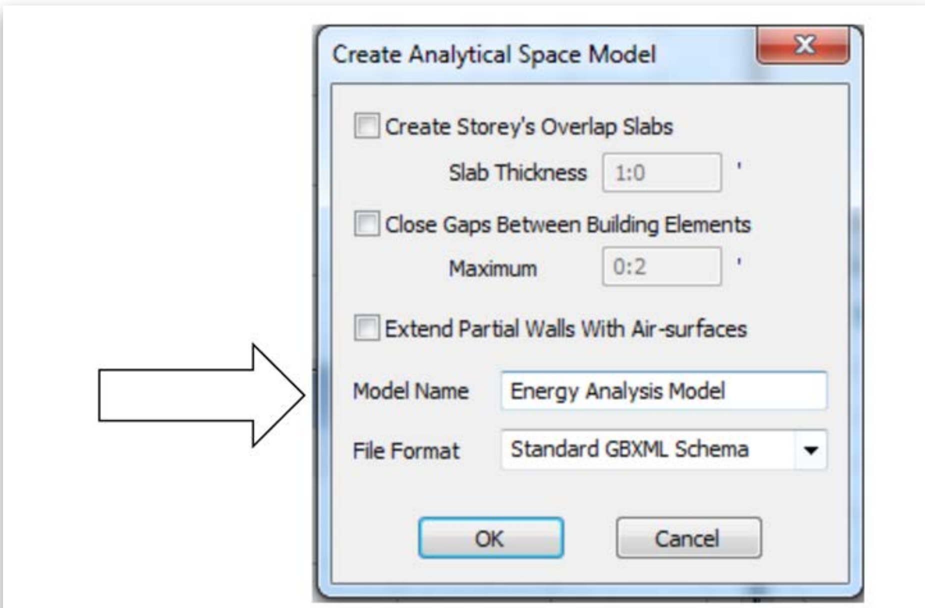

Figure 18 – Create Analytical Space Model dialog box

File Format

There are two file format options: Standard gbXML Schema and Bentley Tas. The Bentley Tas file format contains additional information and is recommended for use with Bentley Tas Simulator only, as it may be incompatible with other energy analysis applications.

Working With Analytical Space Model

After the Create Analytical Space Model dialog box options are accepted, the analytical space model is created and the GBXML EXPORT dialog box appears. This dialog box contains additional attributes that can be set, as well as the Event Log Details pane, which shows information messages and any warnings or errors. At this point, model geometry and topology can also be visually checked.

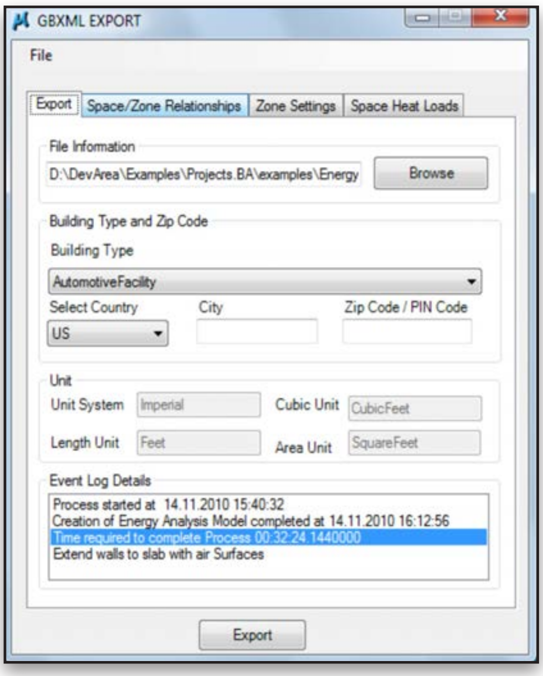

Figure 19 - GBXML EXPORT dialog box

Visual Model

The visual model shows geometry of analytical spaces as groups of MicroStation shapes. All types of gbXML representations (space shell, space boundaries, and analytical surfaces) are distributed within the drawing levels.

Drawing Levels

The model has a number of drawing levels. To review different representations and aspects of analytical spaces, these levels can be turned on and off using the Level Display tool.

- AEM_LEVEL_SHELLGEOMETRY – shell geometry representations for all spaces (By default the level is switched off)
- AEM_LEVEL_SPACEBOUNDARY – space boundary surfaces
- Analytical surfaces are in the following levels:
  - » AEM_LEVEL_WALL – wall surfaces (internal and external)
  - » AEM_LEVEL_FLOOR – floor slabs (internal and external)
  - » AEM_LEVEL_ROOF – external roofs
  - » AEM_LEVEL_CEILING – internal ceilings
- AEM_LEVEL_OPENING – shapes of openings
- AEM_LEVEL_SHADE – middle surfaces of shading elements
- AEM_LEVEL_SPACE – floor finishes of spaces

For the Bentley Tas file format there are two additional levels:

- AEM_LEVEL_EXTSHELLGEOMETRY – building shell geometry (external surfaces of the building)
- AEM_LEVEL_EXTSPACEBOUNDARY – building space boundaries (external surfaces of the building sub-divided by Spaces on internal sides of the building element)

See the sections "Space Representations" and "Building Shell" for more information.

Review Spaces

To review a particular analytical space, select the space from the list on the Space/Zone Relationships tab and it will be highlighted within the analytical model. Use the context menu to activate Displayset and see the space isolated (Figure 20 below and Figure 21 on the next page).

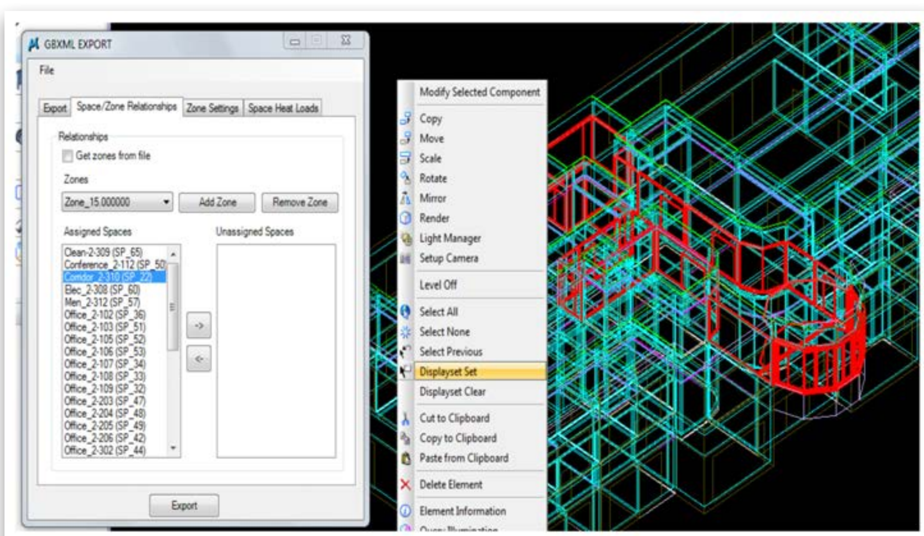

Figure 20 – Select the analytical space in the Space/Zone Relationship tab to highlight it in the model

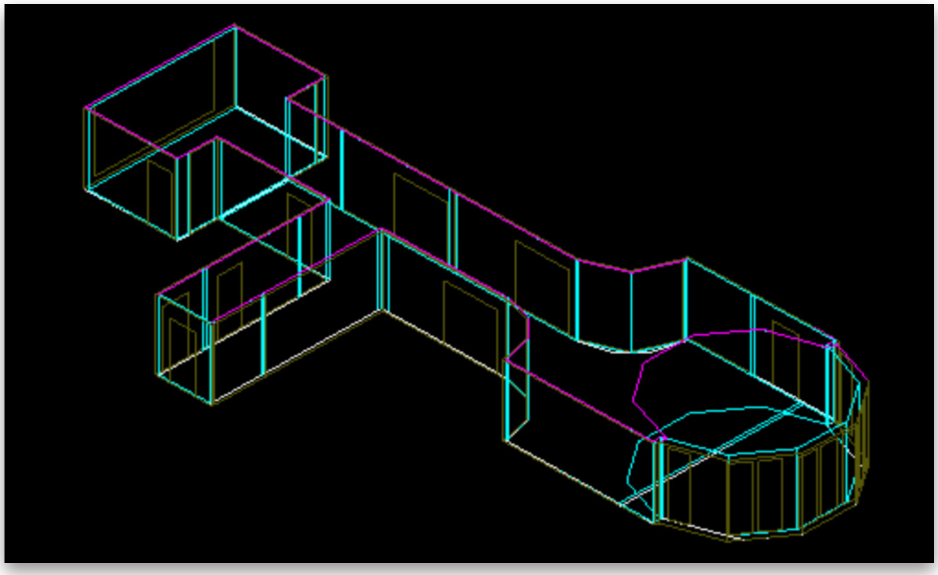

Figure 21 - Use the Displayset command to isolate the view of the analytical space

If something unexpected is found with a space, you can compare the space with the original design elements to see what elements are missing or displaying in the wrong form.

Named Groups

The Named Groups tool helps to explore the model topology in relation to the gbXML data model (Figure 20 on the previous page). The hierarchy shows spaces and all the elements comprising the space with gbXML identifiers. In this window, the context menu can be used to select spaces to view in the model or Displaysets to view selected items.

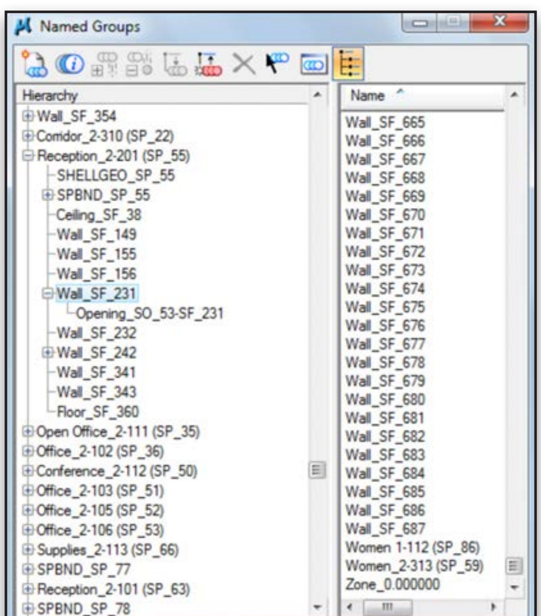

Figure 22 - Named Groups

Tags

Tags attached to shapes of the analytical model contain data about the element that is saved in gbXML. One tag that can be useful for troubleshooting is SCADObjectID. This value includes an identification of the original building element.

In the example below shown in Figure 23 (for AECOsim Building Designer), the first part of the value (WL_8903) identifies where the element came from, followed by the IDs of the building elements (4076, 4067, and 4085). The Select By Attribute tool can be used to locate the element in the original design model (Figure 24). This example is for a multi-layer wall and the string consists of IDs for all layers; for single walls and slabs there will only be one ID number.

For Bentley speedikon, this value contains the element type abbreviation, element ID, and then floor and part numbers, which allows the user to load the floor plan design and use the display element function.

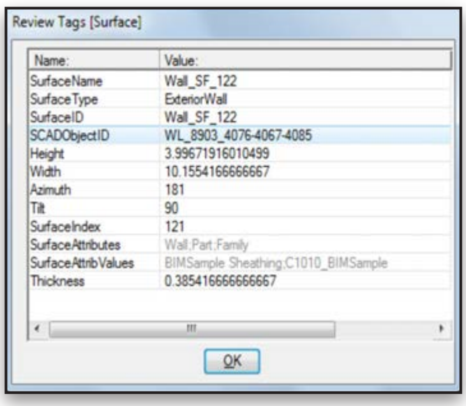

Figure 23 - Review Tags dialog box

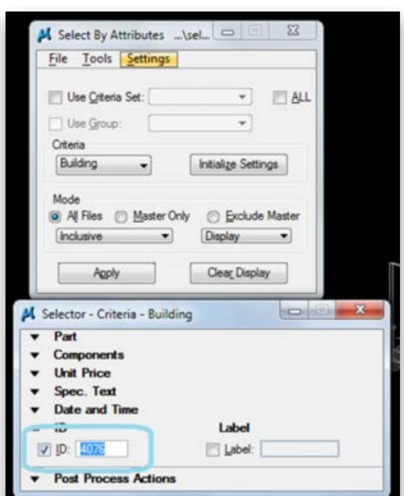

Figure 24 - Select By Attributes dialog box

Building Shell

The Bentley Tas file format also includes the external surfaces of the building. Viewing these shapes can help determine why there may be no space where one is expected. This can happen when part of a space boundary has been missed and the volume is connected to the outdoor environment. The ability to investigate the view of the building shell aids in locating the gap. To view the building shell, display the AEM_LEVEL_EXTSHELLGEOMETRY layer with all other layers off and look for any errors in the expected space.

The Bentley Tas file format also includes the external surfaces of the building. Viewing these shapes can help determine why there may be no space where one is expected.

Warnings and Error Messages

The Event Log Details in the lower pane of the GBXML EXPORT dialog box (Figure 18 shown on page 19) contains warning messages that can help identify and fix problems in the original design. These messages are also located in the aemlog.log file is located in the same folder as the gbXML file. What follows are the most common messages and how to resolve them.

Two space shapes are found in one volume

An example of full text of the warning: "Warning: Two space shapes are found in one volume: Dining (RM_0_107473) and Kitchen (RM_0_107471); smaller was ignored."

This warning indicates that there are two or more architectural space shapes placed in the design, but they are in one physical volume of an analytical space. The names and identifiers in the message indicate which spaces are involved (see above). In many cases, an architectural space is an analytical space and the warning indicates elements that may have been missed or that there is an incomplete form to separate the volumes.

If it cannot easily be determined why the volumes are not separated, the following steps are recommended:

1. The shell geometry representation of the second space should be isolated (see the section "Visual Model") as it contains a minimum amount of detail; therefore, it is typically the easiest place to isolate issues. If the second space cannot be found, the Event Log should be searched. There may be another space shape in the same volume and a third space name was used to name this analytical space.
2. Locations in which separations between volumes are expected should be examined. This can help determine if a building element has an incomplete form or if it is necessary to add a new element.
3. The Illustration and Transparent display styles may help with investigations, as may rotating views from different points, or using the Clip Volume tool.

4. The following corrections can be used to resolve this issue:

- Modify an incomplete building element
- Add a new building element
- Use the Close Gaps Between Building Elements option
- Use the Extend Partial Walls with Air Surfaces option

5. Once the issue is resolved, the model must be regenerated.

Can not find closed volume for space

An example of the full text of the warning: "Warning: Can not find closed volume for space Kitchen (RM_0_107815). Add slab or roof to close the volume. The space was ignored."

This warning occurs when an architectural space is not completely bounded from the outdoor environment. The name of the architectural space is listed in the message, along with the identifier (see above). If there are difficulties finding a sliver or disconnect, the analytical model should be regenerated using the Bentley Tas file format, and the gap found in the building shell. Once the problem has been identified, a new building element can be added or the existing element modified to eliminate the gap.

Big part of element is in another element

An example of the full text of the warning: "ERROR! Big part of element side (61%) is in another element. It may lead to incorrect results of calculations. Element ID WL_0_108455."

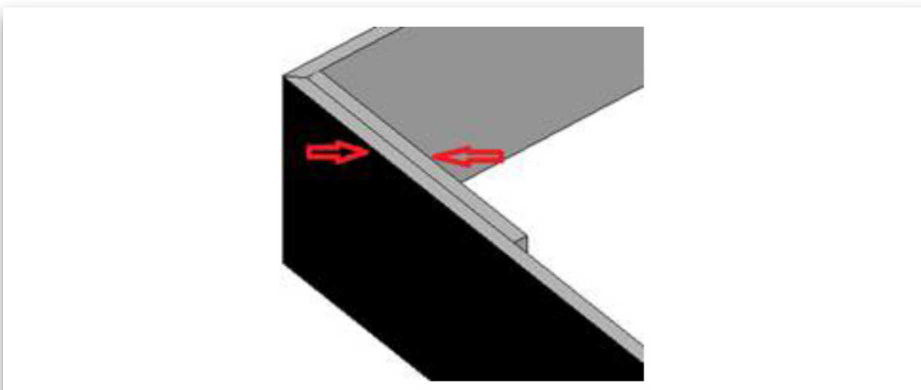

Figure 25 - This message appears when two elements have a large area of side-to-side connection or even a physical intersection.

Sides of bounding elements are heat transferring surfaces, and it is assumed the main part of the element sides are to be within a space or exposed to the outdoor environment. In this type of situation, a heat transfer calculation will lose heat by transmission flow from the side of one element to the opposite side of another element, which may result in an inaccurate calculation of energy consumption. To address this, replace the common part with one building element.

The warning message contains the element identifiers that can be used to locate them in design model (see above).

Graphic is not saved for a floor

This message is specific to Bentley speedikon.

An example of the full text of the warning: "Warning: Graphics is not saved for floor 1.Fl (01 02). Save the graphic to improve the results."

The message indicates that there is not enough geometrical information in the floor file and the data in the gbXML export is incomplete.

To fix the issue, specify the following parameter in either the user.ini or speedi.ini files:

```
[REGISTRY]

…

/apps/design/repository_vdf=2:standard
```

By default, this parameter is commented out in the speedi.ini file. The comment delimiter can be removed to activate this parameter. Once this parameter has been added, the floor design must be re-saved, and then exported again.

Bibliography

Green Building Studio, Inc. "Appendix C – GBS Software Development Kit Documentation." Conceptual Design Energy Analysis Tool (CDEAT) Phase III. October 2008. http://www.energy.ca.gov/2008publications/CEC-500-2008-075/CEC-500-2008-075.PDF

Open Green Building XML Schema, Inc. "Schema GreenBuildingXML-v.37.xsd." January 6, 2009. http://www.gbxml.org/schema/0-37/GreenBuildingXMLv.0.37.Ref.zip

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