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Building & Infrastructure User Conference

Technical Masterclass:

BIM Level 2 - Designing high performance buildings

Presented by: Simon Brown, BIM Consultant



BIM Level 2 - Designing high performance buildings

Digital building models allows us to go much further in understanding energy performance in new buildings before they are built. In this session we'll take you through design-test-refine workflow that allows building designers to deliver high performance, sustainable buildings.



Simon Brown
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Meet the Presenter

Simon has been in the Construction Industry since graduating from the University of Southbank in 1988 as part of a 4-year engineering apprenticeship.

Having qualified he became involved in fast track design build projects in the retail sector assisting in and eventually managing projects.

After that Simon moved to a national consultancy involved in design in the NHS and private sector projects.

Following redundancy Simon joined Graphisoft as an application engineer supporting the then named Cadlink (later Cymap) product. Several years later Cadline acquired Cymap and Simon joined the team to help develop the product and service delivery offering.

Simon has been instrumental in shaping the Cymap product with its associated BIM links into other products.



Objective of the session:

After this introduction to the BIM process, the information and examples will equip you with the knowledge of what to look for when linking performance analysis and design products as part of the BIM level 2 process.

Guidance Notes

This guide explains how to create a Revit model in such a way that it will create a good gbXML file. Many geometry issues with gbXML files can be fixed within Tas but in general the best solution is to fix the issue within the Revit file, as this saves on extra work if the gbXML file is used again or if the Revit file is edited and a new gbXML is exported.

The Revit term “room” will be used throughout, but the rules apply equally to “spaces” in Revit MEP.

The guide also explains how to identify gbXML issues within the Tas 3D modeller, which helps to highlight areas of the Revit file which need work.

1 Resolving Geometry Issues within Revit

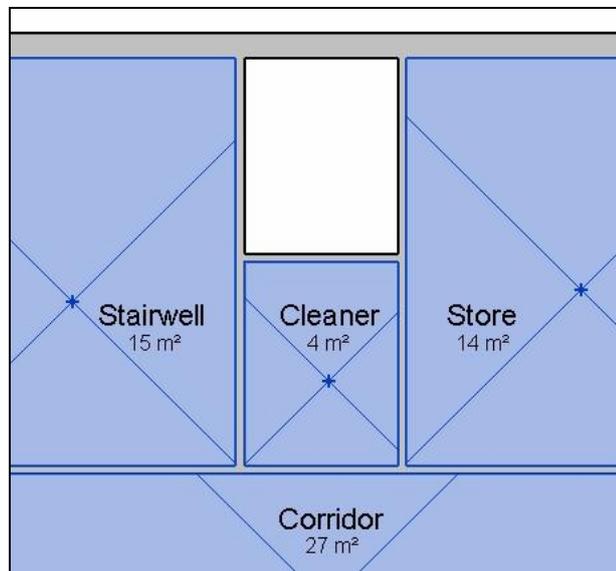
This section explains the most commonly encountered issues with Revit models which lead to incorrect geometry within the gbXML file, and gives solutions in each case. The best way to ensure a good gbXML import from Revit is to have these guidelines in mind from the beginning of the project – fixing an existing Revit model is much more complicated and time-consuming.

1.1 Columns

All columns must be made non-room bounding. Room bounding columns create external links within the building, meaning the column surfaces are treated as if they were exposed to the outside air. Room-bounding columns can also lead to confused geometry being output to the gbXML, such as missing areas. Where columns form part of a wall between two rooms and removing the column would cause the rooms to occupy the same area, the wall should be extended to fill the gap left by the column.



1.2 Rooms Overview



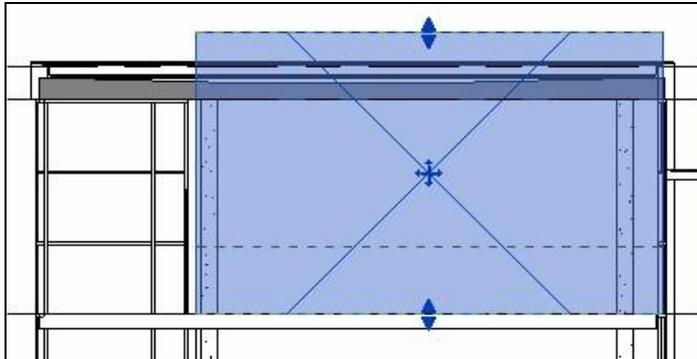
Rooms must be applied to all areas of the building. There should be no region within the shell of the building that is not filled by a room, including risers, ceiling voids, wall voids, floor voids, etc. Any areas not filled by a room will be missing from the gbXML file, and neighbouring walls will be marked as an incorrect type in the gbXML.

For example, in the picture above we see a riser which does not contain a room. This can be remedied in one of three ways:

- 1) Make a neighbouring wall non-room-bounding so the neighbouring room will fill this space.
- 2) Adjust the limits of a room above or below the vacant area to fill it.
- 3) Place a new room in the vacant area.

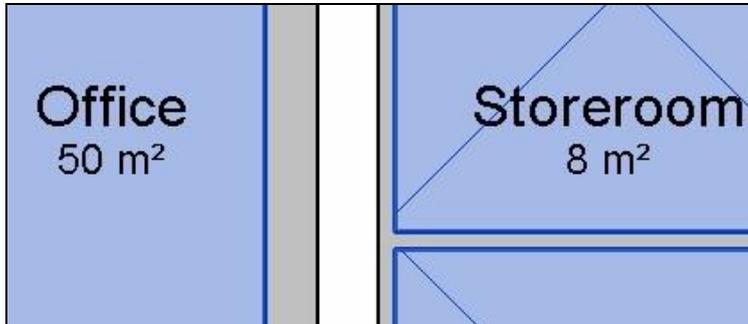
Solution 1 is often the best solution if for example, two small spaces which neighbour each other can be merged together without having a negative impact on the model. Solution 2 can be applied when one riser or lift shaft room can be extended to fill the whole shaft. Solution 3 is applicable in all cases, and the best solution when neither solution 1 or 2 can be used.

Just as the building must be filled with rooms from side to side, it must be filled with rooms from top to bottom. A good rule of thumb is to set the upper limits of rooms to the level of the storey above them, and both base and upper limit offsets to zero. Offsets should be extended, where necessary, so that the top and bottom of each room is in contact with either another room, or a room-bounding element.



In the section above a room protrudes through the roof. The two most likely causes are that the roof is not room bounding, or that the option “Areas and Volumes” has not been selected in the “Area and Volume Computations” dialog. It is a good idea to select this option before attempting to resolve any room bounding issues, to avoid confusion.

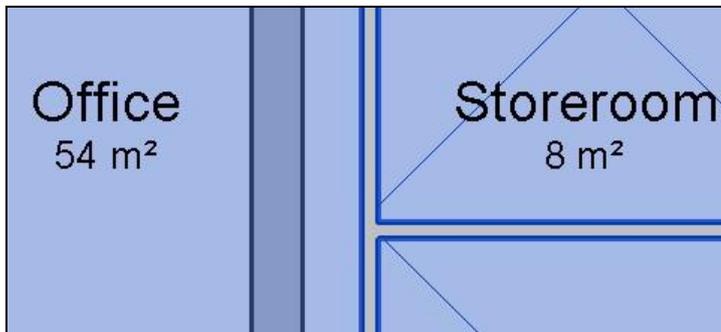
1.3 Wall Voids and Walls made of Multiple Elements



There can be no wall voids that do not contain rooms. As an example, see the picture above – two existing rooms are separated by two walls with a void between them. The geometry would be incorrect if a gbXML was made from this model; the two rooms would have no link and their walls would be marked as the wrong type.

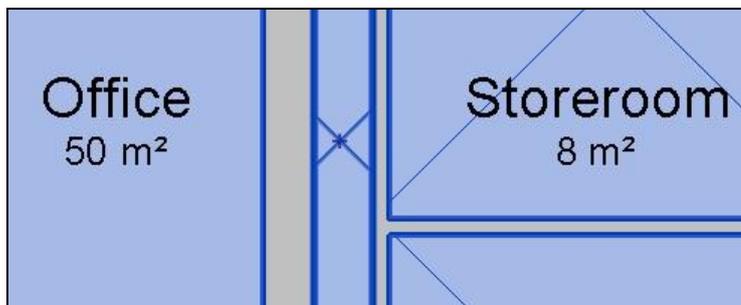


Possible solutions:



1. Make one of the walls non-room-bounding.

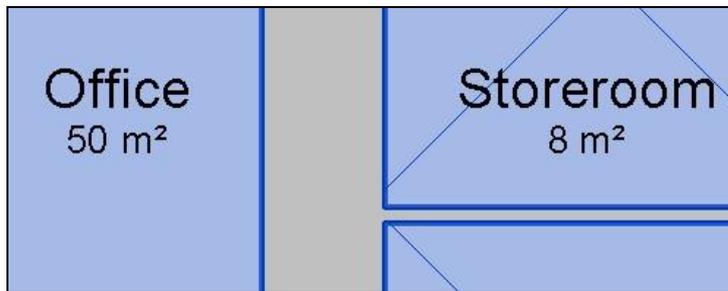
This is one of the quickest solutions, and is best applied in cases where the wall void is very small or the wall separates off an area which logically belongs to the larger room (eg. a small storage area or a thin wall hiding toilet cisterns). In the case above it wouldn't be a very good solution as the wall void is thick, as is the wall itself, and making the wall non-room-bounding has increased the floor area of the left-hand room significantly.



2. Place a new room between the two walls.

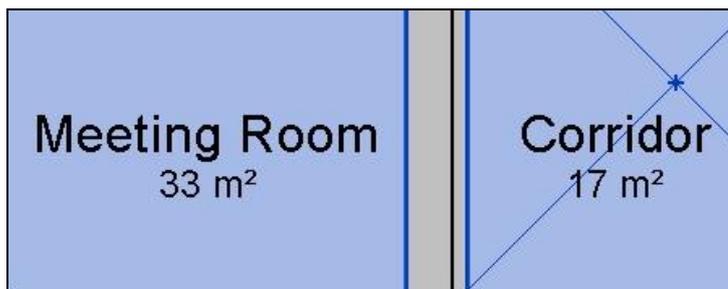
This is another quick solution and is best applied in cases when the wall void is wide. For thinner voids (less than about 300mm) it should be avoided. In this case the wall void is quite wide and this solution would be reasonable.





3. Replace the two walls with a single wall element.

A new wall type is made whose total thickness is equal to the thickness of the two walls plus their void. This is then applied in place of the two walls that existed here previously. In most cases this is the best solution as it keeps floor areas correct and avoids complicating the model with unwanted void rooms.

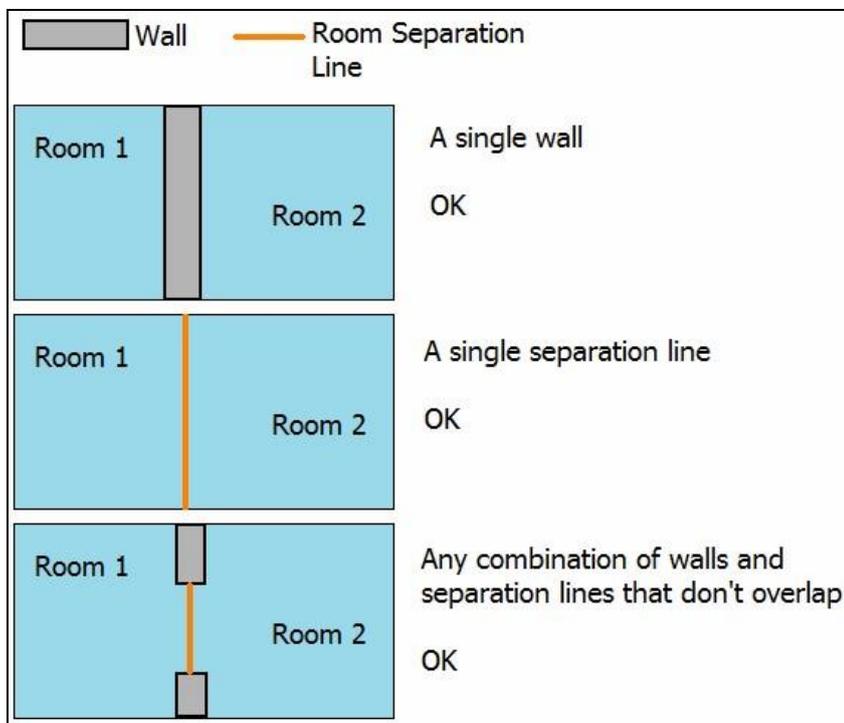
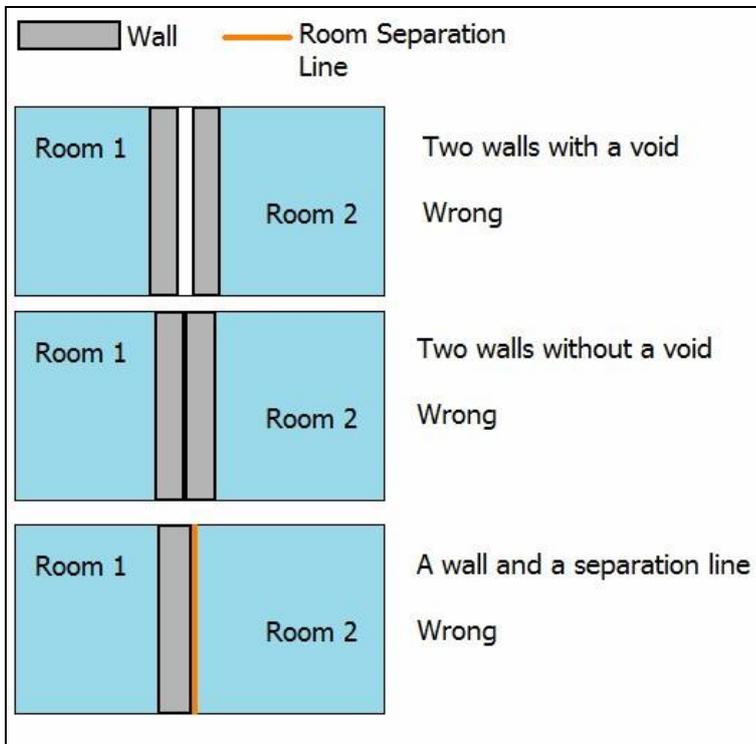


A common variant of this issue is the case where two parallel walls are in contact with each other without an intervening void (see example above). Each room borders a wall but nothing will link the two walls in the gbXML, so although the rooms may look joined, they are in fact not. The best solution is to replace the two walls with a new element with a thickness equal to the combined thickness of the two walls. Making one of the walls non-room-bounding is a quicker fix but not always as good.

Another common variant is when a room separation line has been placed parallel and in contact with a room-bounding wall. In effect this line stops the room from touching the wall, and it should be removed.



Walls Summary:

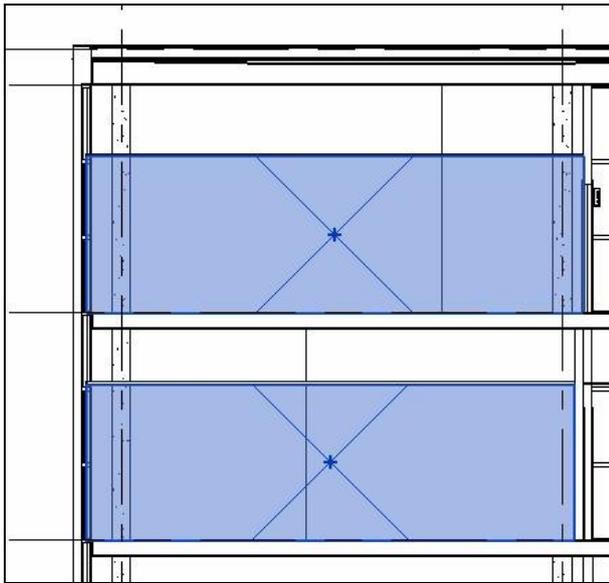


Note that these rules apply equally to links between a room and the outside air, as they do to links between two rooms.



1.4 Floor and Ceiling Voids, Floors and Ceilings made of Multiple Elements

The same principles that apply to walls between two spaces apply to floors and ceilings between spaces.

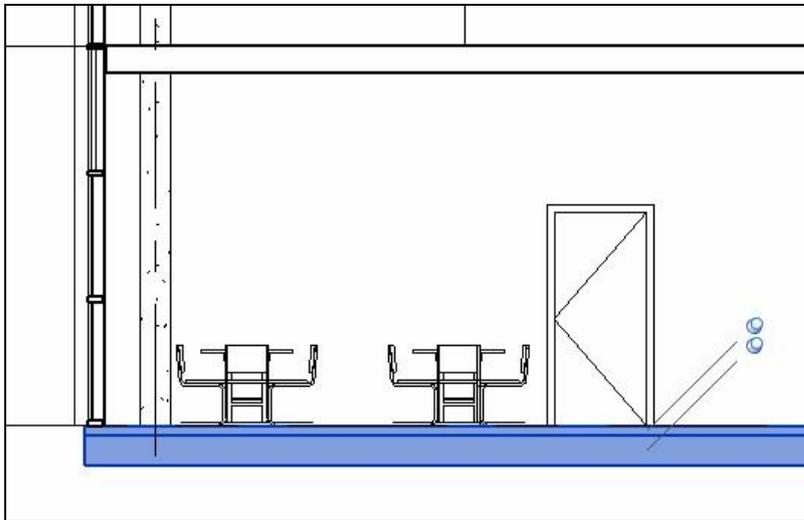


In the section above, two rooms, one directly on top of the other, are separated by a ceiling and a floor with a void between these two elements. If a gbXML was created with the model as it is, the two rooms would not have a link to each other. The solutions are the same as the wall void case:

1. Make one of the elements non-room-bounding. This is a quick solution which is the best option if one of the elements does not completely separate off a sealed region, for example a suspended ceiling which only partially covers the room. In most cases this solution should be avoided as it will give incorrect room volumes.
2. Add a new room in the void. In this case a new level has to be created which runs between the ceiling and floor. The new room would then be assigned on this level. This solution is best for large floor and ceiling voids (more than about 500mm).
3. Replace the floor and the ceiling with a single element. The new element's thickness should equal the combined thickness of the two elements plus the thickness of the void. In most cases this is the best solution.



In all cases, ensure the offsets of the rooms in question (including the void room if this option has been used) are correct; their tops and bottoms must reach a room bounding element.



As with walls, there should be no instances where floors and/or ceilings are placed directly in contact with each other. In the case shown by the section above, the room is only considered to be in contact with the uppermost floor element, and the lowest floor element is disregarded. The best solution here is to replace the two floors with a single, thicker element. The quickest fix is to make the top layer non-room bounding.

1.5 Exterior Elements

All floor surfaces which are intended to be in contact with the ground must have the function “Exterior”. If the same floor type is to be used elsewhere in the building, duplicate the floor type before changing its function.

Similarly, all walls intended to be in contact with the outside air should have function “Exterior”. If the same wall type is used for internal purposes, duplicate it before changing its function.



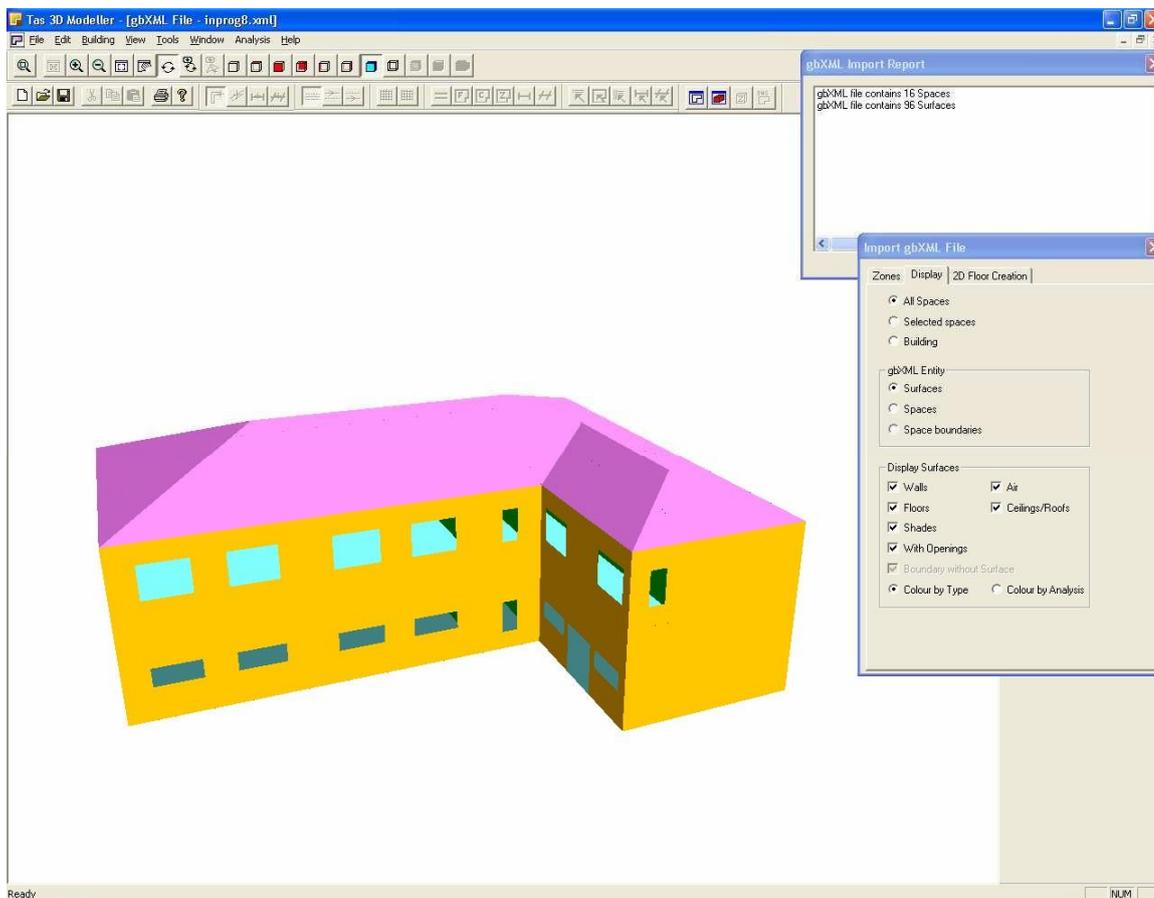
1.6 Checklist

- Turn on the “Areas and Volumes” option.
- Make columns non-room-bounding.
- Assign rooms to all areas including lifts, risers, and voids.
- Ensure room limits are sufficient for each room to have a bounding element or another room at the top and bottom. (In general, set upper limit to floor above.)
- Remove all room separation lines that do not separate two spaces.
- Ensure that two or more room-bounding walls have not been placed in parallel and in contact with each other. Do the same for floors and roofs.
- Resolve any issues with overlapping rooms.
- Change function of external walls and ground floors to “exterior”.
- Ensure all areas have a floor.
- Where possible, replace bay windows with windows directly in the main wall.



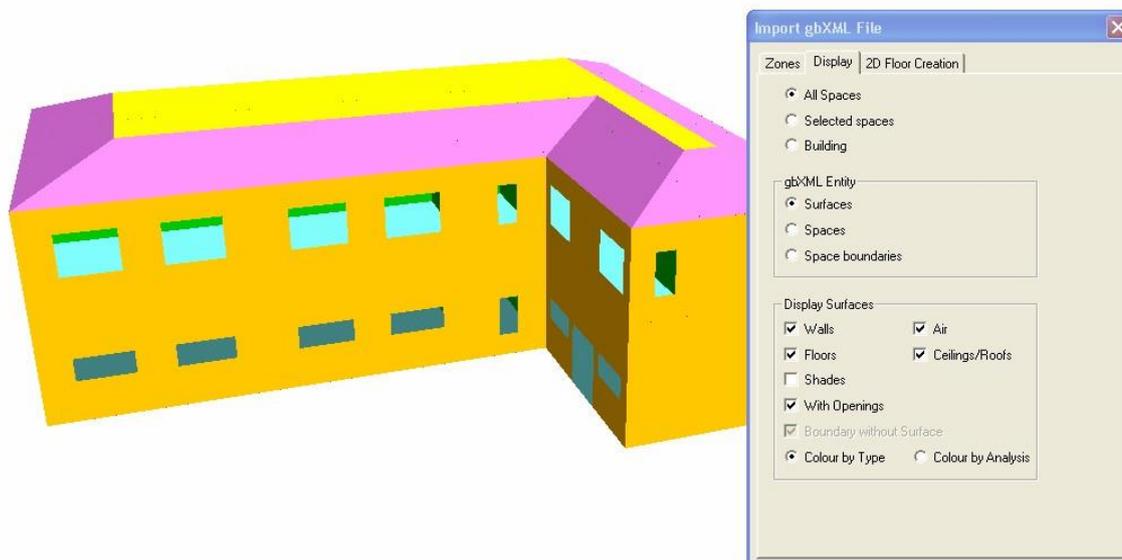
2 Identifying gbXML Issues using Tas3D

The image below shows a simple gbXML which has been imported into Tas3D, prior to turning the gbXML into a Tas model. At this stage checks can be carried out on the model to ensure that the geometry has been exported as required into the gbXML – the gbXML does not need to be converted into a T3D before analysing for geometry issues.



2.1 Checking Shade Surfaces

On the “Import gbXML File” dialog box, go to the “Display” tab and disable the “Shades” checkbox in the “Display Surfaces” section (see below). This will hide any surfaces which are not in contact with a room. If any surfaces disappear which are supposed to be in contact with rooms (e.g. walls, floors, or roofs), then the gbXML file is incorrect. Shades should only appear for surfaces that are not directly part of the analysed area but which will be taken into account for the shading calculations, for example roof overhangs, external shading devices, or neighbouring buildings.



In the image above, hiding the shade surfaces has caused part of the roof to disappear – in this case the issue was that the room limits were set too low and they didn’t reach the top of the roof. In general, if anything disappears which shouldn’t when the shades checkbox is disabled, the solution is to ensure that a room was applied to the area and that the room isn’t prevented from reaching the building surfaces by e.g. a room separation line or badly defined room limit.

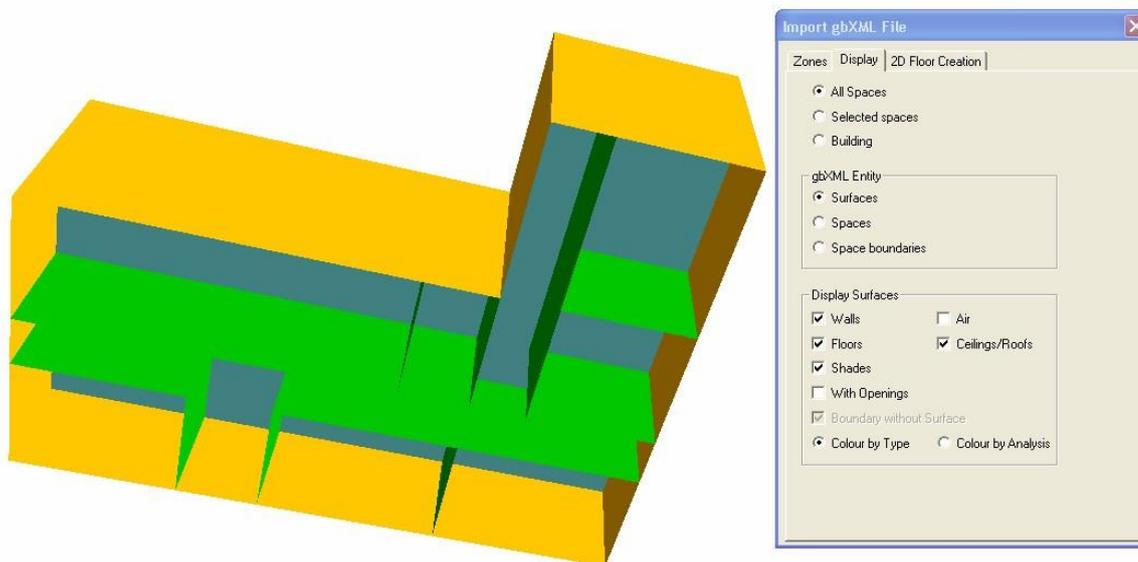
Be sure to look underneath the model to inspect the floor surfaces.



2.2 Air Surfaces

The “Air” checkbox (also in the “Display Surfaces” section of the “Display” tab) is used to toggle the display of surfaces which do not have a solid building element applied to them. The only cases for which this would be correct are room separation lines between neighbouring rooms and for the interface between two rooms, one on top of the other, without a floor between them.

In the image below, disabling the “Air” checkbox has made the floor vanish – in this case the issue is that there isn’t a room-bounding floor on the bottom of the building.



Note that the “With Openings” checkbox is disabled. This option toggles the display of openings on the surfaces (windows, doors and rooflights). The reason for disabling this option is to distinguish between air surfaces that are not displayed and surfaces that are not displayed due to the fact that they are windows and doors.

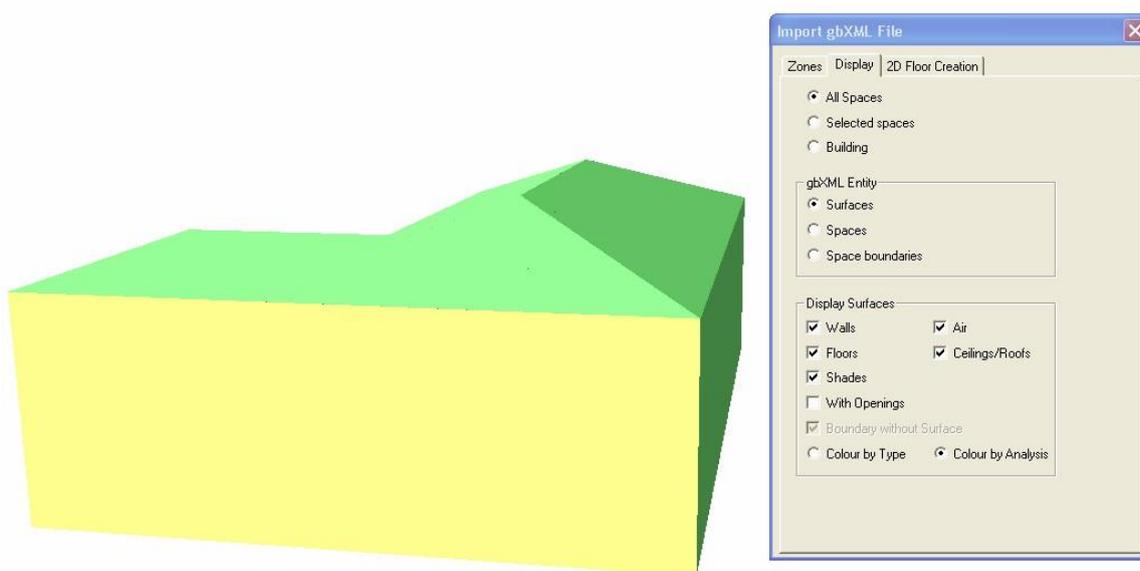
Air surface issues often occur at the same time as shade surface issues, the reason being that if a room doesn’t reach its wall, for example, the wall will become a shade surface and the room will end with an air surface instead of a wall.

Air surfaces can be reassigned to a different building element after the Tas model has been created, using the Set Wall / Floor / Ceiling Element tool. It is not uncommon, even with a good Revit model, to end up with small air surfaces in the gbXML, usually at the corners of walls. These cannot always be helped, but exposed air surfaces will be marked as the building element “Airexposed” in Tas3D, which can be given an appropriate construction later, e.g. external wall.



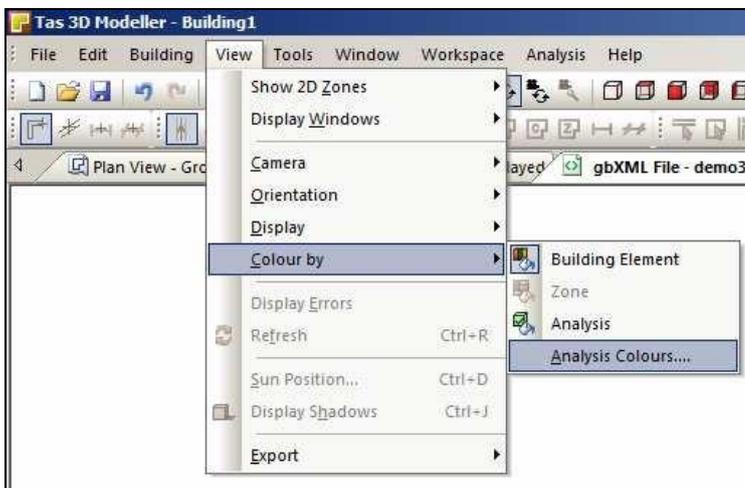
2.3 Colour by Analysis

At the bottom of the “Display” tab is a radio-button which toggles between colouring the model by the building element type, or by “analysis”. This refers to the surface specification (for example, ground, external, internal, null, or a link to another zone). This option is used to see if the surface is correctly specified.



The most common issues related to surface analysis types are ground floors which do not link to the ground and external walls marked incorrectly as “internal”. The image above shows an example of the latter issue. As before, the windows and doors are removed from the graphic for clarity. The surfaces exposed to the outside climate are represented by the colour green but the wall facing out of the page is coloured yellow. This indicates that it is incorrectly specified as an internal building component. This can be corrected in Revit by changing the wall function to “External”.

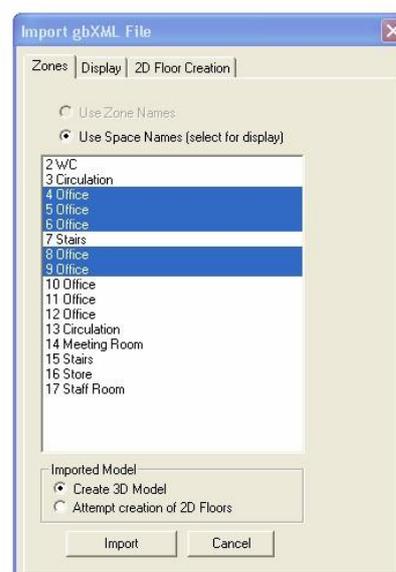
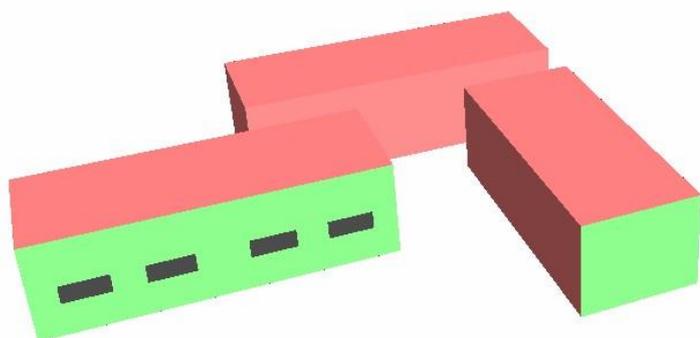
The surface type represented by each colour may be seen by clicking “Analysis Colours” in the “View” menu of Tas3D (see below). The user has the option to change the colours used.



2.4 Looking inside the Model

As not all issues are related to the building envelope, it may be necessary to investigate the internal surfaces of the gbXML file. There are two ways to do this. The first method is to use the checkboxes in the “Display Surfaces” section to hide certain surface types. For example, the roofs can be hidden to take a look at the surfaces below.

The second method is to view only a selection of rooms. On the “Zones” tab, click the spaces to investigate (hold down the Ctrl key to enable multi-select). After this, click the “Display” tab and enable the “Selected spaces” radio-button. In the image below, the “Selected spaces” and “Colour by analysis” options are used to check surface types for the ground floor offices. In this case the rooms are free of problems.



2.5 Creating a Tas 3D Model from the gbXML

There are two import options available on the import gbXML file dialog box. The “attempt creation of 2D Floors” option will attempt to split the model into floors and create a model with all the options normally available within the Tas 3D modeller. It is strongly recommended that this option is only attempted if no major issues were encountered when using the “create 3D model” option.

The “create 3D model” option creates a model where the geometry is taken directly from the gbXML file rather than being converted into a normal Tas 3D file. Some of the modelling options of 3D Tas are unavailable (for example new windows cannot be placed and the geometry of imported rooms cannot be changed), but building element types, zone assignments, and window types, dimensions, and frames can be edited. In most cases, “create 3D model” is the best option to use, and it is the option which will be discussed in more detail below.

In either case an import should only be attempted after all issues identified using the methods explained above have been resolved.

2.6 Understanding the gbXML Import Report

After pressing the import button, it is worth checking the “gbXML Import Report” window. In most cases the errors and warnings shown here indicate that a problem needs resolving within the Revit model. Note that following the guidelines in section 1 of this document can greatly reduce the number of messages here. The meanings of the errors and warnings are discussed below:

“ERROR Surface <name> has inconsistent polygon and angles. Polygon has been reversed”

This message appears when incorrect geometry data has been found in the gbXML file. In the large majority of cases, reversing the surface resolves the issue, so the 3D modeller automatically reverses them. Note that this message may appear in the import report even with well-made Revit models. The problem occurs during the export from Revit to gbXML, but as it is corrected automatically in the Tas import it should be no cause for concern.

“ERROR Space <name> - unable to create closed volume”

This message appears when it seems the gbXML geometry cannot be put together to create a sensible room. This happens either because the model was badly drawn or because the geometry has become confused during the export from Revit. A common cause is that the model contains room-bounding columns. Note



that the named room may still be present in the imported model, but it may have incorrect surfaces, for example two floors instead of a floor and a ceiling.

This can also appear if there are thin gaps between surfaces. The user can check whether this is the case by using the analysis model errors and warnings dialog (see section 2.7). In general, when these gaps are small they will not have a significant effect on the simulation of the Tas model.

“ERROR Space <name> has no shell geometry”

This message appears if a room has not been placed in a properly enclosed region in the Revit file. This may be because there is a gap in the building geometry or because the room was placed outside the building.

“WARNING Surface <name> is adjacent to space <name> on both sides”

This message appears when instead of linking to another room, the ground, or the outside air, a surface has a link to the same room on both sides. Tas 3D will automatically attempt to correct these surfaces, which usually means marking them as being exposed to the outside air. The most common causes of the message are:

- The surface is an internal wall without another room on the other side, either because not all areas have rooms assigned, or because the wall has a void or touches another parallel wall.
- The surface is supposed to be an external wall but has the function “interior”.
- The room has bad limits and this message refers to an air surface at the top or bottom of the space.
- The surface is supposed to be a ground floor but has the function “interior”.
- A room separation line is preventing the room from reaching a wall.

The best course of action if this message appears is to go back to the Revit model and correct the underlying issue. The issue may be obvious by simply inspecting the room in question, but if needed the surface can be identified in Revit from its code name in the “Export gbXML” dialog with the “Analytical Surfaces” option selected.

This message can also appear in relation to small additional surfaces which sometimes appear at the corners of walls. These surfaces, defined within the gbXML from Revit, can appear even in well-drawn models and cannot always be fixed. In general, when these surfaces are small they will not have a significant effect on the simulation of the Tas model.



“WARNING Space <name> has no surfaces”

This message appears if a room has not been placed in a properly enclosed region in the Revit file. This may be because there is a gap in the building geometry or because the room was placed outside the building.

If there appear to be no changes needed to the Revit model but messages still appear in the import report, it may be worth attempting an import using the “attempt creation of 2D floors” option. This is only recommended for advanced Tas users as it may involve locating, identifying, and fixing complicated geometry issues. Remember that some messages may still appear for good models, for example in cases where Tas has automatically corrected surface orientations.

2.7 Analysis Model Errors and Warnings

After importing a gbXML using the “create 3D model option”, warnings specific to gbXML files may appear in the “analysis model errors and warnings” dialog box in the 3D view. The meanings of the messages are explained below:

“WARNING – Imported Space has gaps between surfaces”

This message usually occurs in spaces which have the message “unable to create closed volume” in the import report. The best course of action is to return to the Revit model and find the gaps which are preventing the space from being properly enclosed.

In some cases it may not be possible to correct these gaps, but if they are small then they will not have a significant effect on the simulation of the Tas model.

“WARNING – Imported Space has surfaces that may have incorrect orientations”

If this message appears then it indicates that some surface edges do not match with the edges of another surface, and as a result it has not been possible to create an enclosed space with no gaps in its geometry. This is a result of confused geometry in the gbXML file. The best course of action is to return to the Revit model and investigate the affected room. Room-bounding columns are a common cause of this error.

“WARNING – Imported surface has unknown adjacency – exported as Exposed”

This message is related to the message “Surface <name> is adjacent to space <name> on both sides”. If this message appears, then as this surface has no other surfaces coincident with it, Tas has marked it as an exposed surface.



“WARNING – Imported surface has unknown adjacency – exported as Null Link”

This message is related to the message “Surface <name> is adjacent to space <name> on both sides”. If this message appears, then this surface coincides with another surface, indicating that it is internal to the building. Tas has marked the surface as a null link (adiabatic).

