48-749 Parametric Modeling Lecture 3

Carnegie Mellon University School of Architecture

Lecture 3

Part 1

- Different bims
- Interoperability

Part 2

- Sun studies using Revit
- Material Takeoff- Recycled materials
- Massing
- Adding parameters

BIM and AECM tools

AECM Tools

- Revit
- Bentley Systems
- ArchiCAD
- Digital Project

Revit

- Revit is the market leader in the US, introduced by Autodesk in 2002
- It was acquired from a start up company
- It is a separate platform from AutoCAD (different code base and file structure)

Revit

It offers a family of products-

- Revit Architecture
- Revit Structure
- Revit MEP

It offers interfaces to

- It includes gbXML interfaces for energy simulation
- It includes direct interfaces to ROBOT and RISA (for structural analysis)
- It imports from Schetchup, a conceptual design tool

- Revit (Strengths)
- It is easy to learn and friendly user interface
- It has a broad set of object libraries created by third parties
- It is bi-directional-information generation and management based on updates
- Its object library supports multi-user interface

- Revit (Weakness)
- It is an in-memory system that slows down for projects larger than 330MB
- It does not support complex curved surfaces

Trapelo Road Project - Revit



- Bentley Systems
- Bentley offers a wide range of related products for architecture, engineering and construction
- Their Architectural bim tool, Bentley Architecture was released in 2004, it descended from Triforma

Bentley Systems

Family of products integrated with Bentley Architecture

- Bentley Structural
- Bentley Building Mechanical Systems
- Bentley Building Electrical Systems
- Bentley Facilities
- Bentley PowerCivil(for site planning)
- Bentley Generative Components
- > All applications are written to a file so it lessens the loads on memory

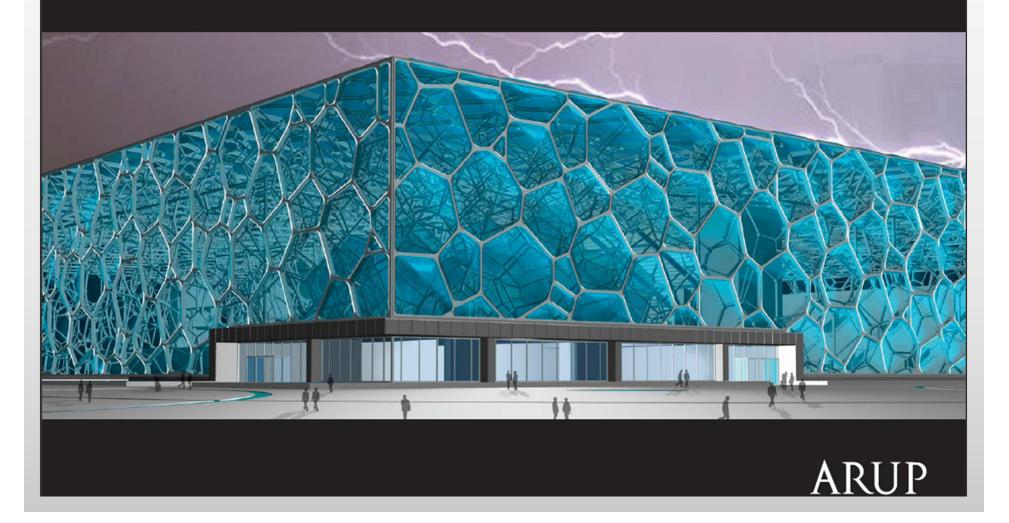
Interfaces to other applications

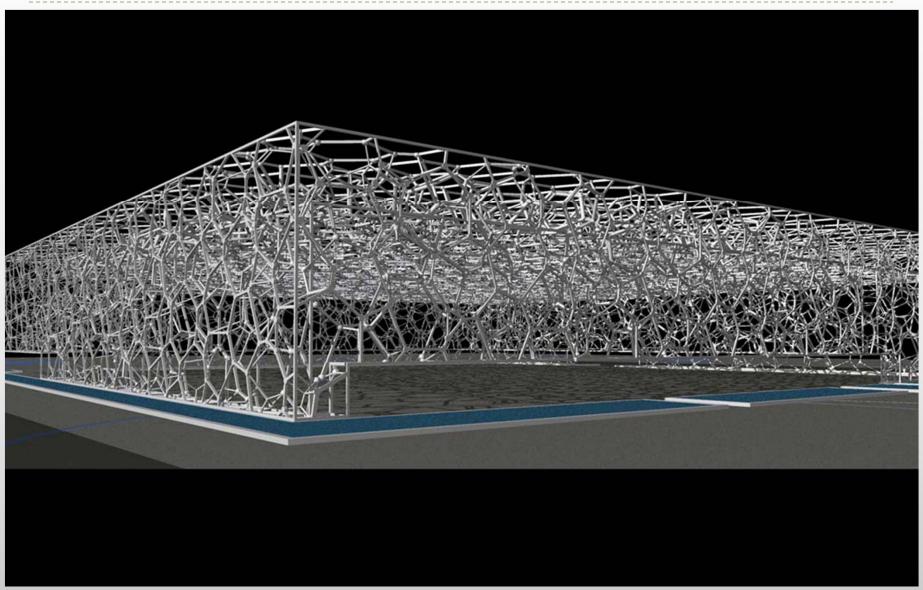
- Primavera and other scheduling software
- STAAD and RAM for structural analyses
- Offers multi-project multi-user project repository called Bentley Project Wise

- Bentley Systems (Strength)
- Bentley offers a wide range of tools in almost all aspects of the AEC industry
- Bentley supports modeling curved surfaces, including Bezier and NURBS
- It includes multiple level support for developing custom parametric objects-Parametric Cell Studio and Generative Components

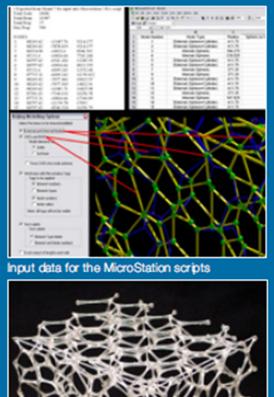
- Bentley Systems (Weakness)
- Large non integrated user interface which is hard to learn and navigate
- It has less extensive object libraries than similar products

Beijing National Swimming Centre, China American Institute of Architects Building Information Model (BIM) Awards Competition 2004 (TAP) Knowledge Community



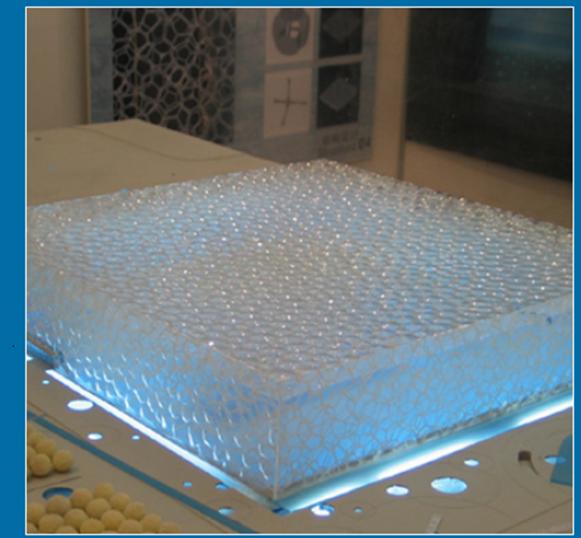


- Interoperability was solved using Bentley products
- Import 3D max 3D model that won the competition
- Create STL file for rapid prototyping
- Continual import and export of CAD models
- Continual visualizations from Bentley structural
- Full documentation of entire steel structure





Rapid prototype resin model



Completed prototype model with ETFE pillows

ArchiCAD

- ArchiCAD is the oldest architectural bim tool since 80's marketed by Graphisoft
- It was recently acquired by the German company Nemetschek
- It currently serves the MAC platform in addition to Windows

Family of Products

 Construction oriented software that is based on the ArchiCAD platform, now marketed by Vico Software

Interfaces

- Mason for curved surface modeling and animation
- ArchiFM for facilities management
- gbXML, Ecotect, Energy+, ARCHiPHISIK and RIUSKA for energy simulation
- Custom parametric objects use GDL(Geometric Description Language) scripting language
- It contains extensive libraries for users and also has an ODBC interface

- ArchiCAD (strength)
- Has an intuitive interface and easy to learn
- Has large object libraries
- Currently the strongest bim product for Macs

BIM and AECM (Architectural design)

ArchiCAD (weakness)

- It has limitations in its parametric modeling capabilitiesdoes not support updating between objects in assembly or automatic application of Boolean operations between objects
- It is an in-memory system and can encounter scaling problems with large projects; it can module large projects into modules to manage them

BIM and AECM (ArchiCAD)- e Lab at LBNL



- Building was first drawn in AutoCAD.
- ArchiCAD used information from AutoCAD files, and was saved as a BIM in IFC 2.0 format
- Directly interoperable tools included ArchiCAD, Solibri Model Checker (SMC), EnergyPlus (E+), COMIS, and PrecisionEstimating (PEWin).
- Indirectly interoperable tools (i.e. tools that can exchange data with an interoperable tools and thus import geometry data from a BIM via that interoperable tool) included Artlantis, DOE-2 and Radiance.

- Digital Project
- Developed by Gehry Technologies
- It is a customization of Dassault's CATIA (Computer Aided Three-dimensional Interactive Application) for architecture and building
- It is able to model any type of surface and support elaborate customization of parametric objects
- DP supports VBA scripting and a strong API to allow add ons
- CATIA involves modules called Workbenches

Family of Products

- Architecture and Structures workbench
- Knowledge Expert- supports rule based checking
- Project Engineering Optimizer allows for easy optimization of parametric designs
- Project Managers for tracking parts of model and managing their release

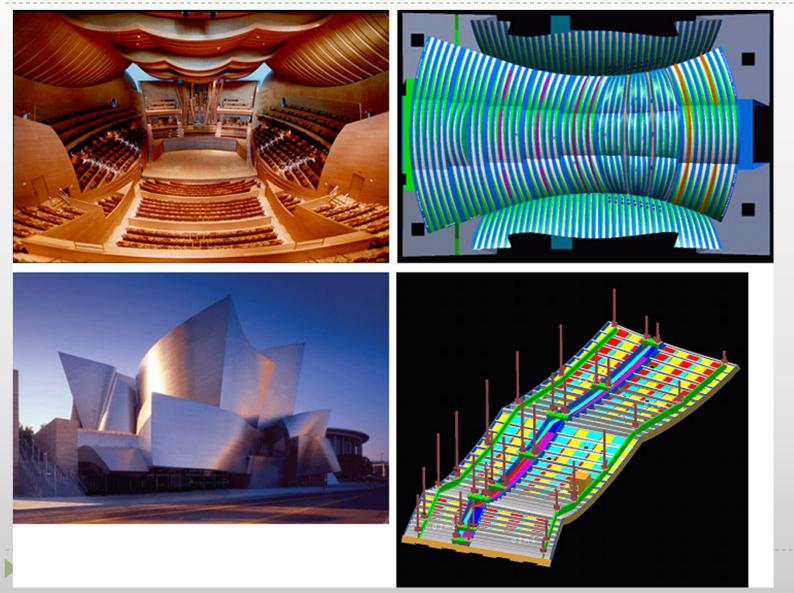
Interfaces

- Interfaces with Ecotect for energy studies
- It has Uniformat[®] and Masterformat[®] classification embedded for specifications and cost estimations

- CATIA Digital Project (Strength)
- Powerful and complete parametric modeling capabilities
- Able to model large and complex projects
- Able to control surfaces and assemblies

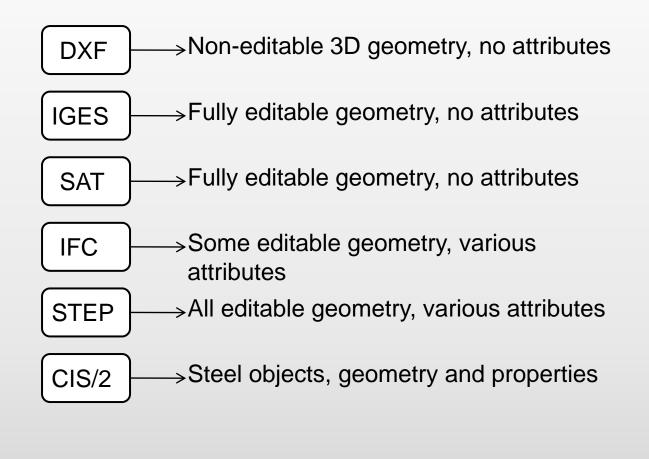
- Digital Project (Weakness)
- Requires a steep learning curve
- Complex user interface and high initial cost
- External third party libraries are limited

BIM and AECM (Digital Project)(Disney Opera House)



BIM and AECM (Architectural design)

- Mortenson construction company was forced to create 3D models as they received 3D models from the designers as construction documents
- 3D CATIA surface model was provided and Mortenson had to use this for designing the actual ceiling panels in 3D using CATIA
- These 3D models also functioned as shop drawings for construction. The same was true for the ductwork above the ceiling, and other components of the building.



- Data Exchange is carried out in the following ways:
- Direct, Proprietary links between specific BIM tools
- Proprietary file exchange formats, primarily dealing with geometry
- Public product data exchange formats
- XML- based exchange formats

Direct, Proprietary links

- Direct links rely on middleware software interfacing capabilities such as ODBC or proprietary interfaces such as ArchiCADs GDL or Bentley's MDL.
- These are all programming level interfaces relying on C, C++, or now C# languages

Proprietary file exchange formats

 These are developed by a commercial organization for interfacing with that company's application such as DXF(Data eXchange Format) from Autodesk

STL for stereo lithography and 3DS for 3D Studio

Public product data exchange formats

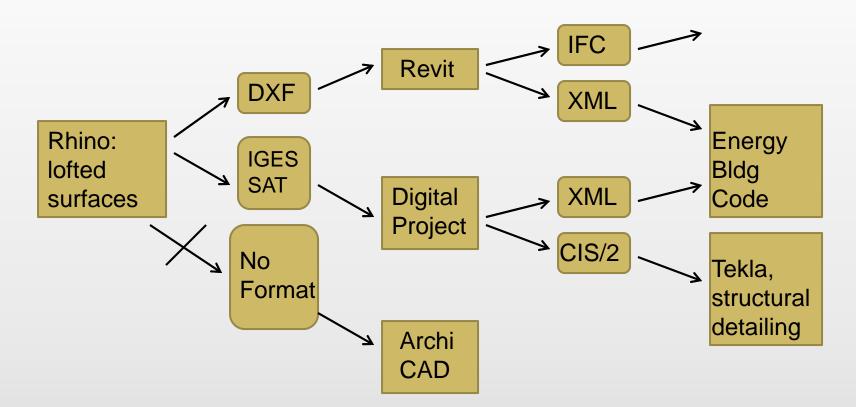
- These are based on an open standard building model, IFC(Industry Foundation Class)or CIS/2 for Steel are the principle options
- This format carries object, material properties and also relations between objects as well as geometry
- These are essential to interface between analysis and construction management applications

XML is extensible Markup Language

- This is an extension to HTML
- It allows the definition of the structure and meaning of some data of interest
- The structure is called a schema
- Different XML schemas support exchange of many types of data between applications

Format Types		
Image Raster	JPG, GIF. TIF, BMP, PIC, PNG, RAW, TGA, RLE	Raster images vary in compactness, some compress with data loss
2D Vector	DXF, DWG, CGM, IGS, DGN	Vary regarding compactness, line width, pattern, layering
3D Surface and Shape	3DS, WRL, STL, IGS, SAT, DXF, DWG, OBJ, DGN, XGL (3D)	These vary according to type of surfaces and edges represented and or material properties- shape , color, texture

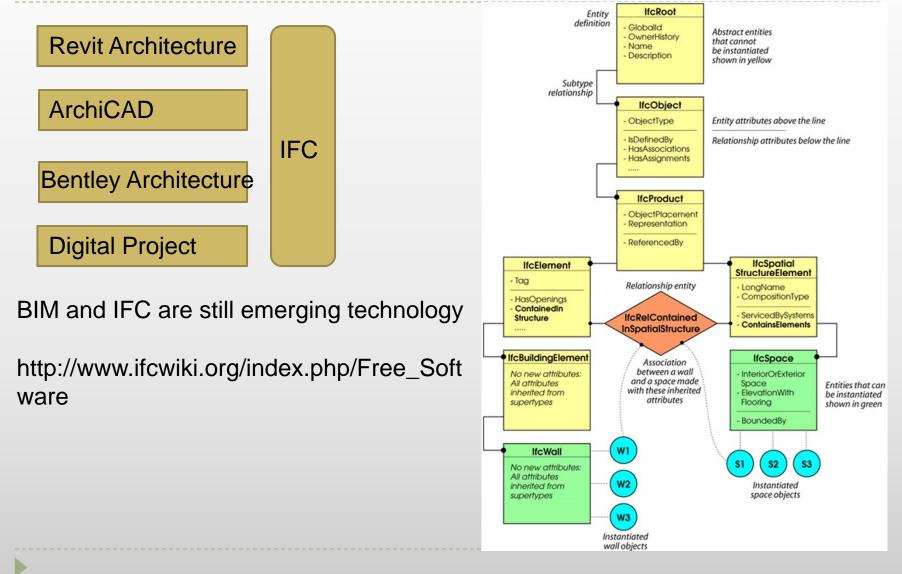
Format Types		
3D Object exchange	STP, EXP, CIS/2	Product data model formats represent 2D or 3D geometry. They also carry relations and properties of objects
GIS	SHP, SHX, DBF, DEM, NED	Geographical information formats
XML	AecXML, AEX, Obix, bcXML, AGCXML	XML schemas developed for exchange of building data. They vary according to the information exchanged and workflows supported

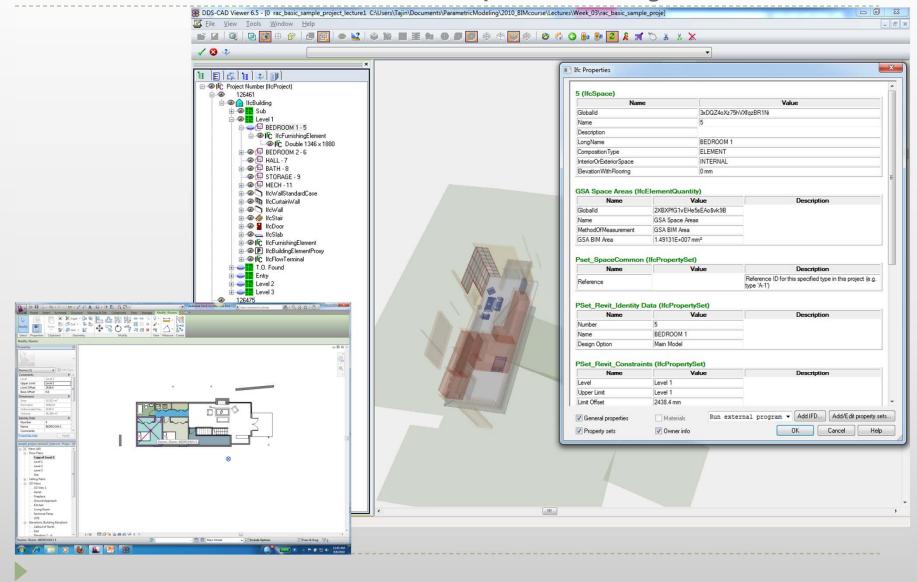


Object classification, needed object properties, model abstraction, mapping to needed shapes and properties

- Industry Foundation Classes (IFC)
 - 1985-1990 > CAD era
 - DXF IGES > (geometry based formats)
 - 1990-1995 > STEP-Exchange(-G)
 - ▶ 1995-Today > IFC
- Based on ISO-STEP technology
- EXPRESS language
- STEP toolkits
- STEP base structure libraries: geometry, measurements, units, etc.
- Has base entity definitions for building projects, some forms of analysis, some systems, at design stage (not fabrication)

- AR Architecture
- BS Building Services
- CM Construction
 - CM1 Procurement Logistics
 - CM2 Temporary Construction
- CS Codes and Standards
- ES Cost Estimating
- PM Project Management
- FM Facilities Management
- SI Simulation
- ST Structural Engineering
- XM Cross Domain





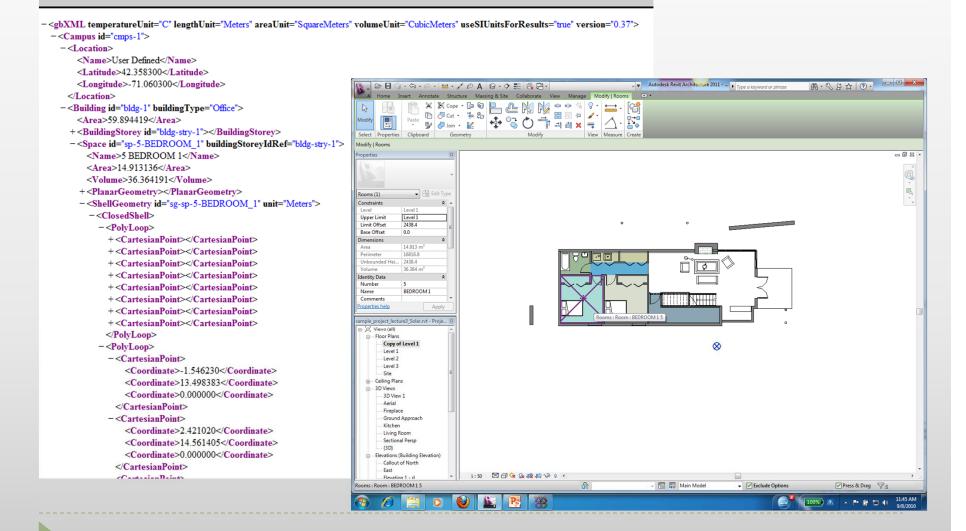
- Example Worldwide Projects
- CORENET (by the Singaporean Building and Construction Authority) – supports electronic submission and recording, checking and approval process.
- Australia is undertaking a similar effort as Singapore called DesignCheck
- BuildingSmart (by the Norwegian government and construction industry) also for automatic code checking, planning and integration in design, procure, build and facilities management
- The General Services Administration (in US) relying on exchanges based on IFC for various projects

XML schema areas

- OGC (Open Geospatial Consortium)has developed the OpenGIS Geographic Objects (GO) Implementation Specification. It defines a common set of abstractions for describing, managing, rendering geometric and geographic objects.
- gbXML -(Green Building XML) is a schema developed to transfer information needed for preliminary energy analysis of building envelope, zones and mechanical equipment

BIM and AECM (Interoperability-gbXML)

This XML file does not appear to have any style information associated with it. The document tree is shown below.



- aecXML administered by FIATECH, a major construction industry consortium supporting AEC research and the IAI. It can represent specifications, change orders, contracts, materials. Though it carries descriptions of buildings and components it does not geometrically or analytically model them.
- IFCXML- It is a subset of IFC schema that is mapped to XML. It supports the following use cases: Material Catalogs, Bill of Quantities.

Lecture 3 part 2

Using BIM in design

- From a building design perspective there are five steps:
- Optimize the building mass
- Create good site orientation to maximize north south exposure and limit east west exposure
- Optimize the use of day lighting and sun shading
- Optimize the building envelope assembly
- Optimize the use of carbon free resources such as sun, wind, and rain

Using BIM in design

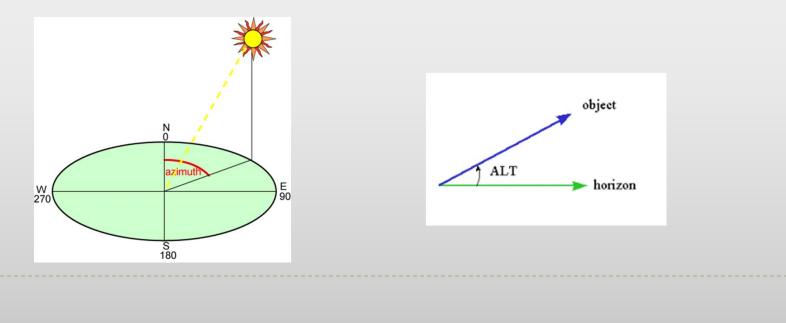
Solar Studies

- Project North and True North
- Exporting sun study animations
- Material Quantity Takeoff
 - Filtering materials
 - Calculating for recycled material
- Creating Mass
 - in place mass
 - conceptual mass

Solar Studies

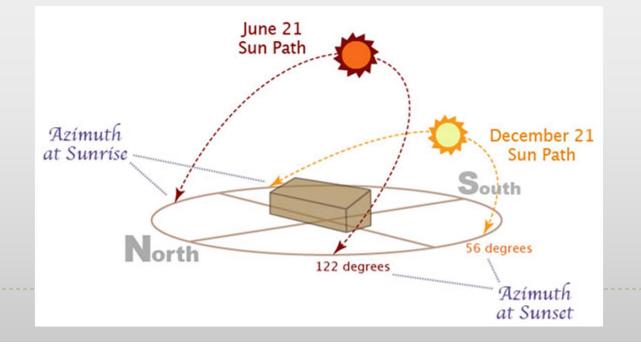
Suns position measured by

- Azimuth of an object is the angular distance along the horizon to the location of the object. By convention, azimuth is measured from north towards the east along the horizon (this may vary)
- Altitude is the suns elevation measured in angles from the horizontal plane



Solar Studies

- At solar noon, the sun is always directly south in the northern hemisphere and directly north in the southern hemisphere.
- At the equinoxes, the sun rises directly east and sets directly west regardless of the latitude, thus making the azimuth angles 90° at sunrise and 270° at sunset.



Solar Studies

Sheet 'South' and 'Magnetic South'

Find degree of declination to True North/South

Two things

- Set project location in the settings> Manage place> location
- Website: of National Geophysical data Center
- http://www.ngdc.noaa.gov/geomagmodels/Declination.jsp

Solar Studies (without changing orientation)

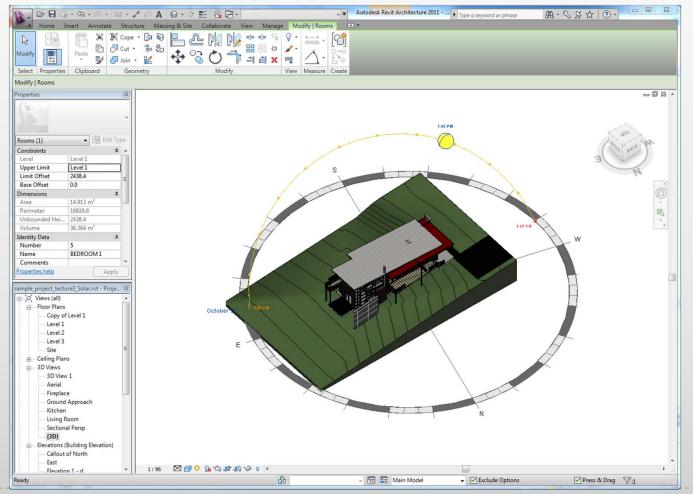
Summer solstice 21
 June

Winter solstice 21
 December



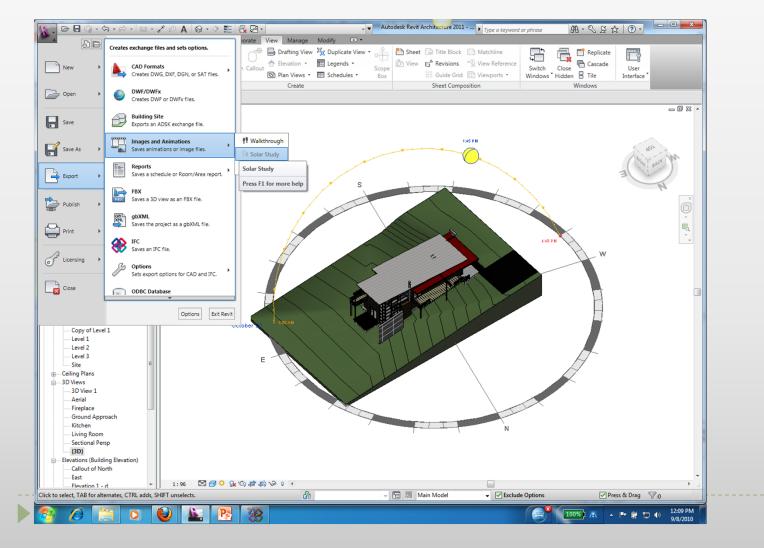
Solar Studies (using solar path tool)

Turn sun path on



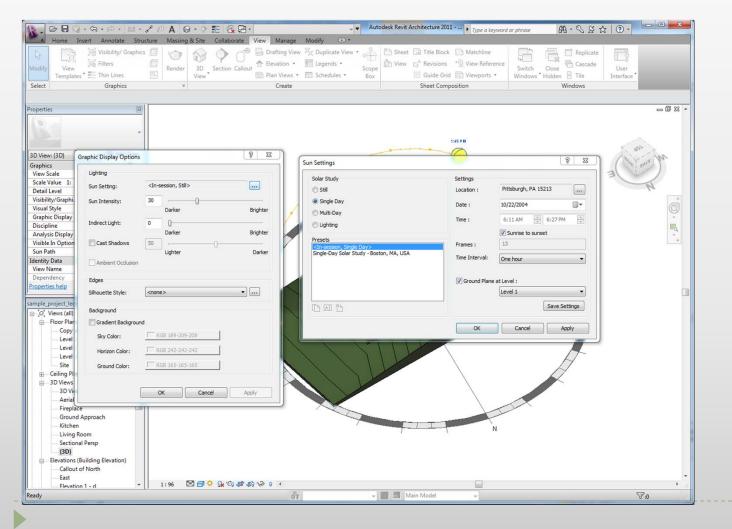
Solar Studies (export solar study)

By default solar study export is grayed out



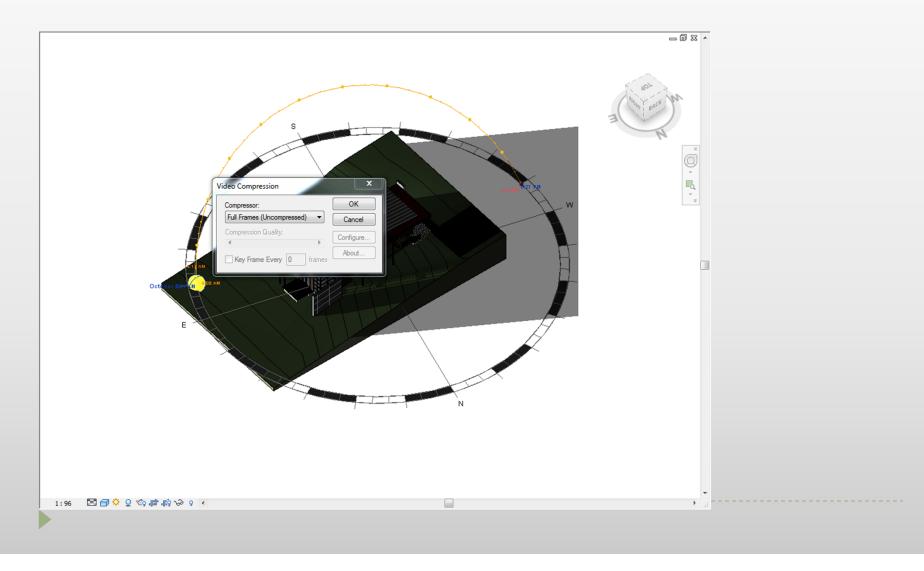
Solar Studies (export solar study)

Graphic display options to pick Single day, location and time

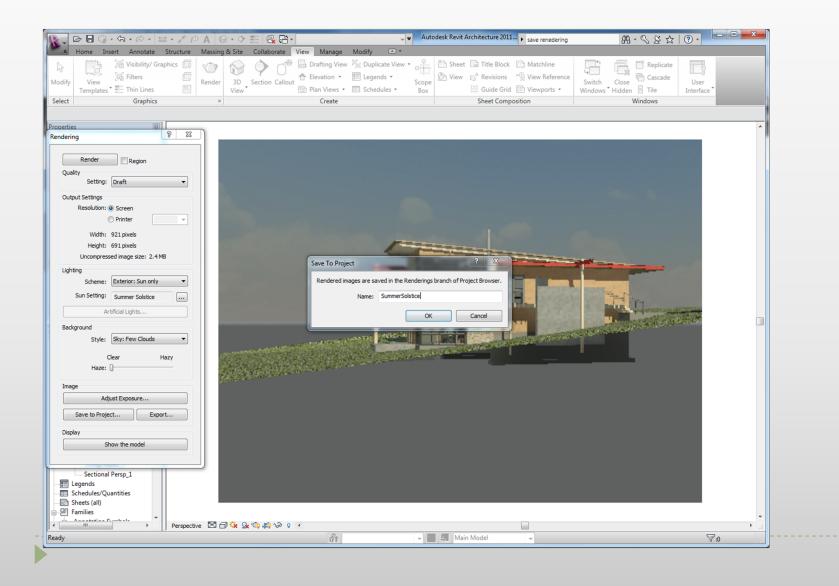


Solar Studies (export solar study)

Make sure cast shadows is selected and then export



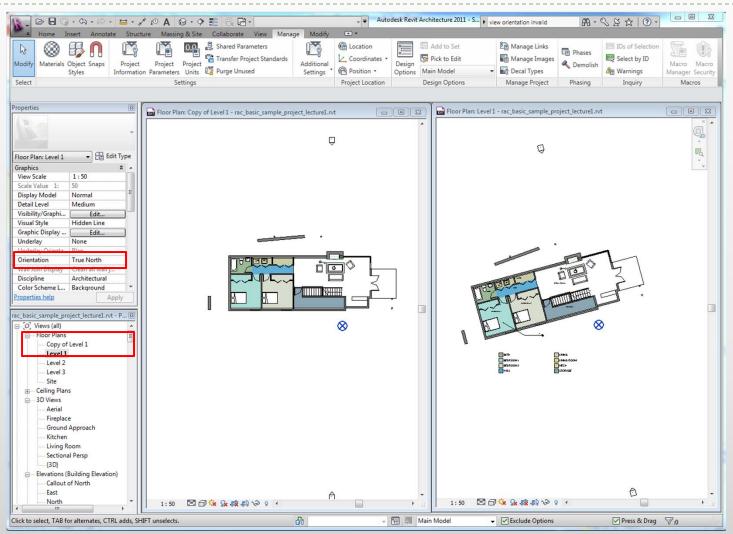
Solar study (Rendering a solar study)



Solar Study (Find declination)

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Declination = 15° 1' W changing by 0° 3 For more information, visit: Answers to some <u>frequently asked question</u>		<u>Today's Space Weather</u>				
For more information, visit:	ns Instructions for use		C Map Satellife Hyb Map a constant Beaver, Brook Map a constant Beaver, Brook Beaver, Beaver, Beav	id os St		

Solar Study (Copy level and change to True North)



Solar Study (Compare lighting for in same situations)

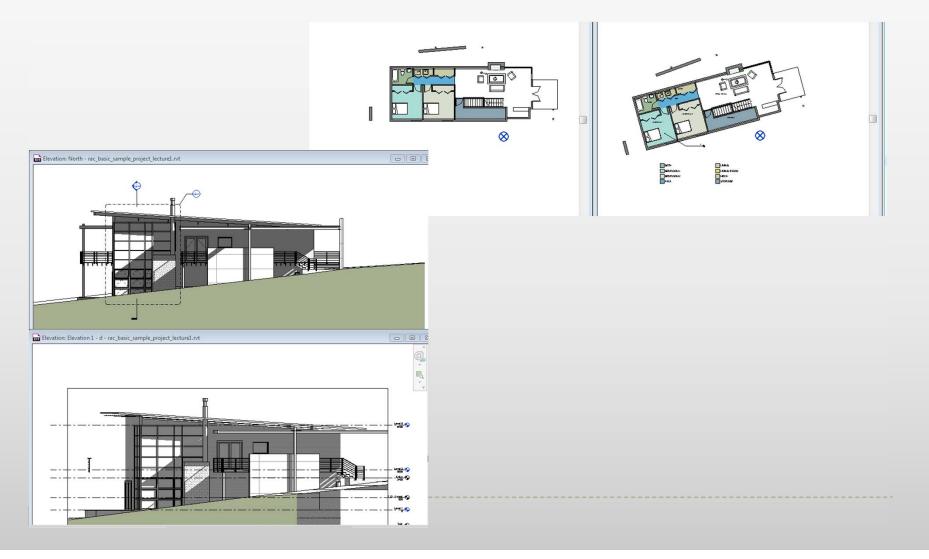


Solar Study (Project base point) Model Cat>Site>

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Solar Study (Exercise: 01)

Find True North for your project and switch between project north and true north



Revit Schedules (Material takeoff)

- In the New Material Takeoff dialog, choose multi-category
- In the Material Takeoff Properties dialog, for Available Fields, select the material name and volume

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- In the New Material Takeoff dialog, choose multi-category
- In the Material Takeoff Properties dialog, for Available Fields, select the material name and volume, Use filter and choose Material: Name, contains and type Concrete (this is case sensitive)

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Calculating Recycled material

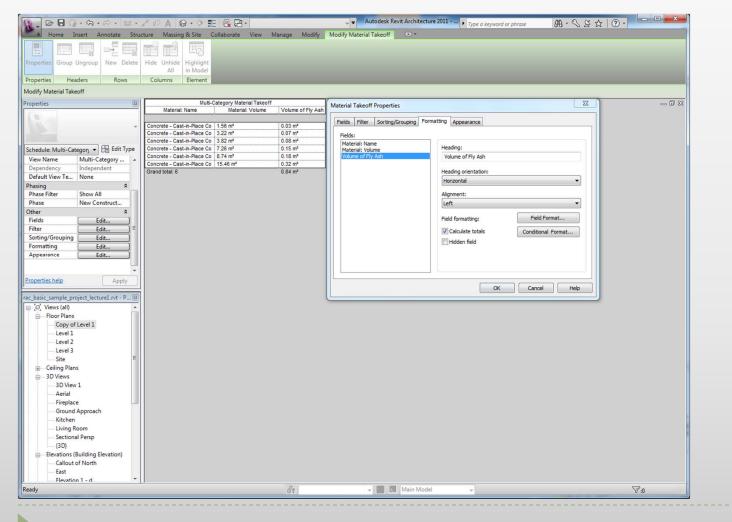
- Click the Calculated Value button. Name the field Volume of Fly Ash.
- Change Type to Volume and enter the following formula: Material: Volume * 0.21. In the Material Takeoff Properties dialog,

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Select grand totals in the sorting tab

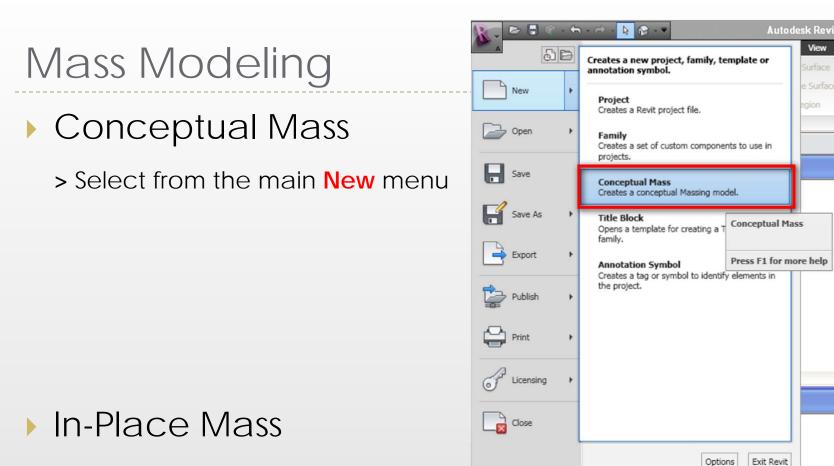


Summary of the schedule

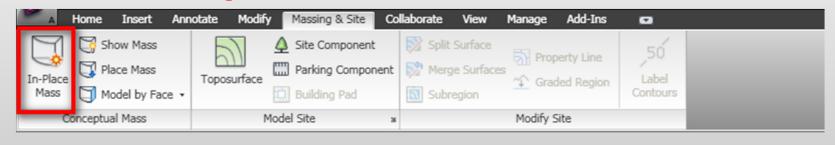
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Revit and Recycled material (Ex-02)

- Calculate for reused brick from the model. The percentage should be 30% of the Material Volume of a brick wall.
 - Select Material:Name
 - Select Material:Volume
 - Calculated Value= Used Brick
 - Calculate Total Volume of Used Brick

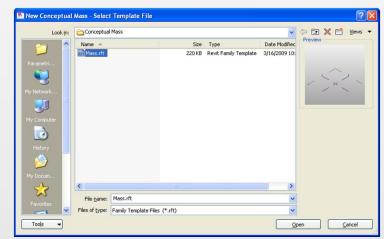


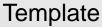
> start from Massing & Site

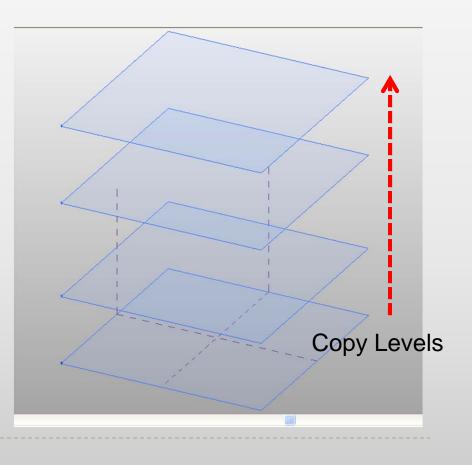


View

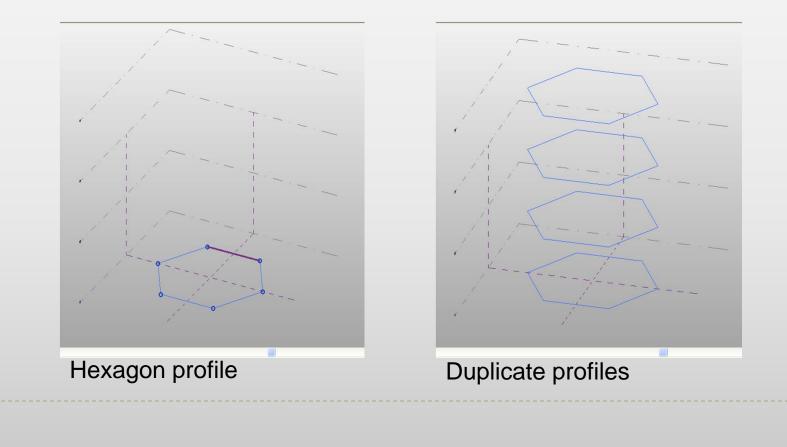
Step 01: Start from the mass template.
 01.1: Copy the reference level





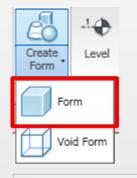


 Step 02: Draw the profile (hexagon) & copy profile to each level (Copy to clipboard & Paste Aligned)



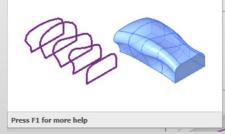
Step 03: Create the mass from the selected lines.

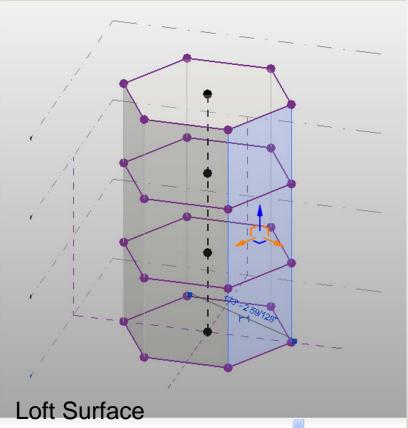
Create \rightarrow Create Form



Form Creates a form from selected lines.

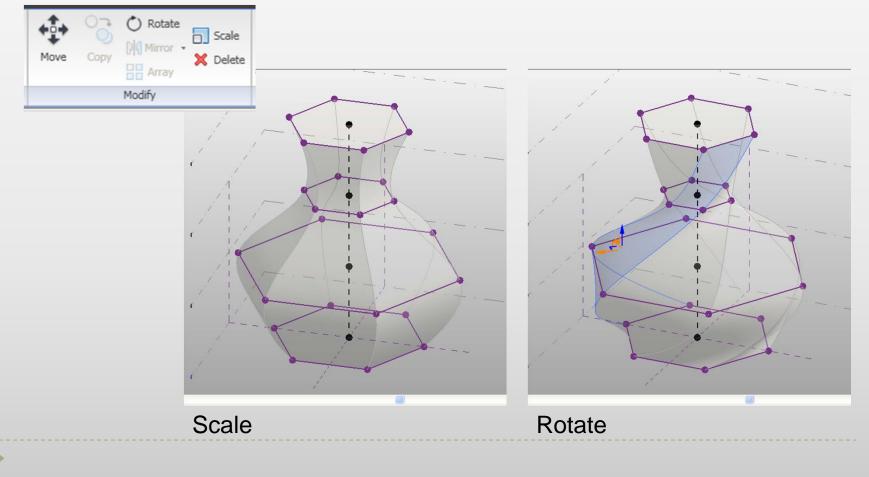
To create a form, first select lines (or edges from existing geometry), and then click Create Form. Use this tool to create a wide range of forms, including lofts, extrusions, revolves, and sweeps.



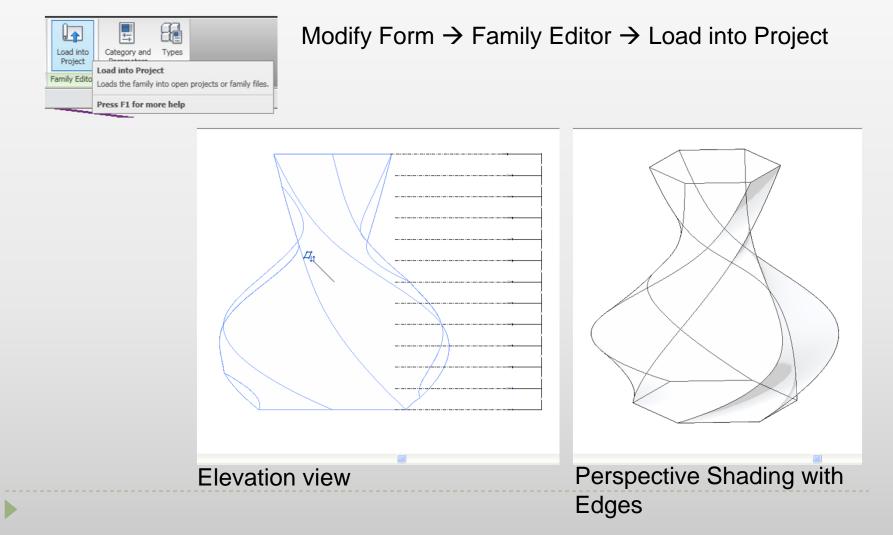


Step 04: Modify mass by changing profiles.

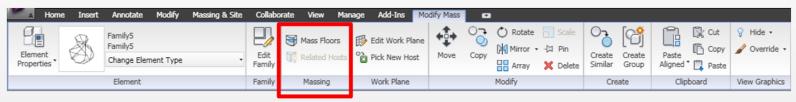
Modify Form \rightarrow Modify



> Step 05: Load the Mass to the project.

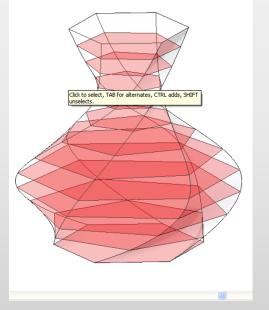


Step 06: Create Mass Floors.



Modify Mass \rightarrow Massing \rightarrow Mass Floors

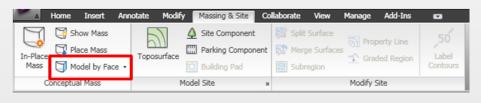
Mass Floors
 Level 1 Level 2 Level 3 Level 4 Level 5 Level 6 Level 7 Level 8 Level 9 Level 10 Level 11 Level 12 Level 13
OK Cancel Help



Select levels for mass floors creations.

Step 07: Create floor and wall elements.

Massing & Site \rightarrow Conceptual Mass \rightarrow Model by Face



→ Floor	→ Wall
Floor	Floopreates walls
Wall	Wall
Curtain System	Curtain System
Roof	Roof



Conceptual Mass (Excersice:03)

Create a mass as a conceptual mass

- Load it into a project
- Create levels and assign it to the mass
- Create floor and wall by face
- Make levels into views



Add parameters to existing (new) Family

- For Existing Family -> Edit Family
- Step 01: Choose Types from Family Properties
- Step 02: Add new parameter to the property table..

Pro

Parameter	Value	Formula	A Far	nily Types
Construction			× L	New.
Function	Interior	=		Departu
Wall Closure	By host	=		Rename
Construction Type		=		Delet
Materials and Finis	hes		× L	Deloc
Door Material	Door - Panel	=		
Frame Material	Door - Frame	=		
Dimensions			A Par	ameters
Thickness	0' 2"	=		A <u>d</u> d
Height	7'0"	=		
Trim Projection Ext	0' 1"	=		Modify
Trim Projection Int	0' 1"	=		
Trim Width	0' 3"	-		Remoy
Width	3'0"	=		
Rough Width		=		
Rough Height		=		
Identity Data			*	
Assembly Code	C1020	=		
Keynote		-		
Model		-		
Manufacturer		=		
Type Comments		=		
URL		=	~	

Add parameters to existing (new) Family

- Step 03: Choose parameter type and Group where this parameter belongs to.
- Step 04: Assign the value to the value by insert Formula, if applicable.

For example,

-			Family Type
Parameter	Value	Formula	<u>^</u>
Construction		*	
Function	Interio	=	Renan
Wall Closure	By hos	-	
Construction Type			Dele
Materials and Fi	nishes	۵.	
Certified (default)	 Image: A start of the start of	=	-
Door Material	Door -	-	
Frame Material	Door -		Parameters
Dimensions		۵.	Add
Volume (default)	3.50	= Thickness * Height * Width	
Inickness	02		Modif
Height	7' 0"		
Trim Projection Ext			Rem
Trim Projection Int	0' 1"	=	
Trim Width	0'3" 3'0"	=	
Width Rough Width	3.0.	=	
Rough Height		<u> </u>	
Identity Data		*	
Assembly Code	C1020	=	~

Volume = Thickness* Height*Width