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

BIM and AECM (Revit)

- **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)

BIM and AECM (Revit)

- **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

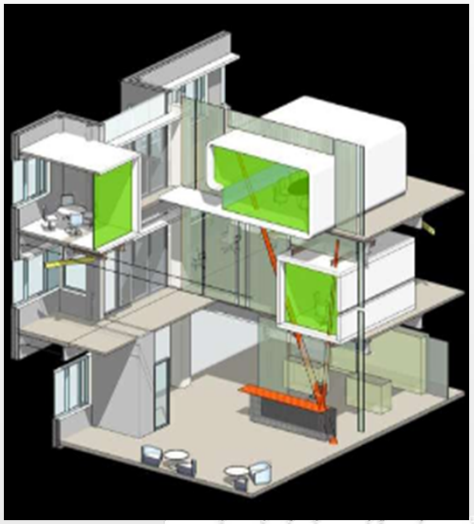
BIM and AECM (Revit)

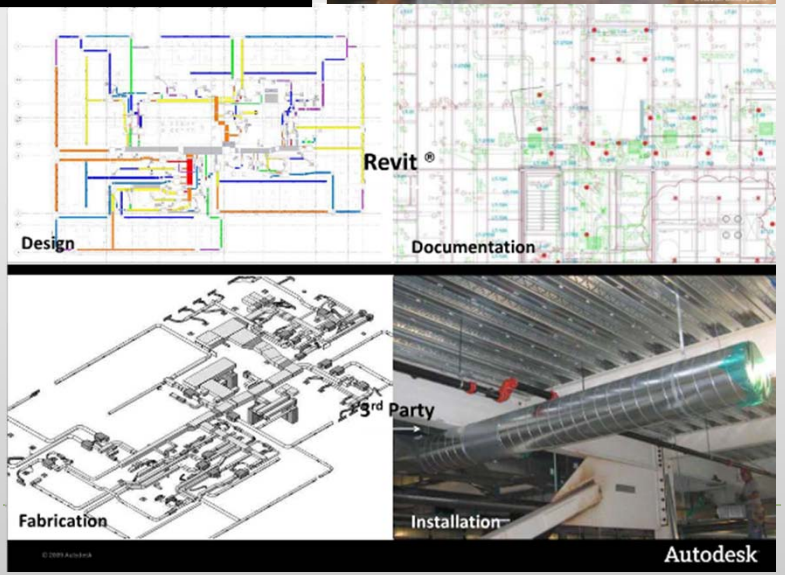
- **Revit (Strengths)**
- It is easy to learn and friendly user interface
- It has a broad set of object libraries created by third parties
- It is bi-directional-information generation and management based on updates
- Its object library supports multi-user interface

BIM and AECM (Revit)

- **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





BIM and AECM (Bentley Systems)

- **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

BIM and AECM (Bentley Systems)

- **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

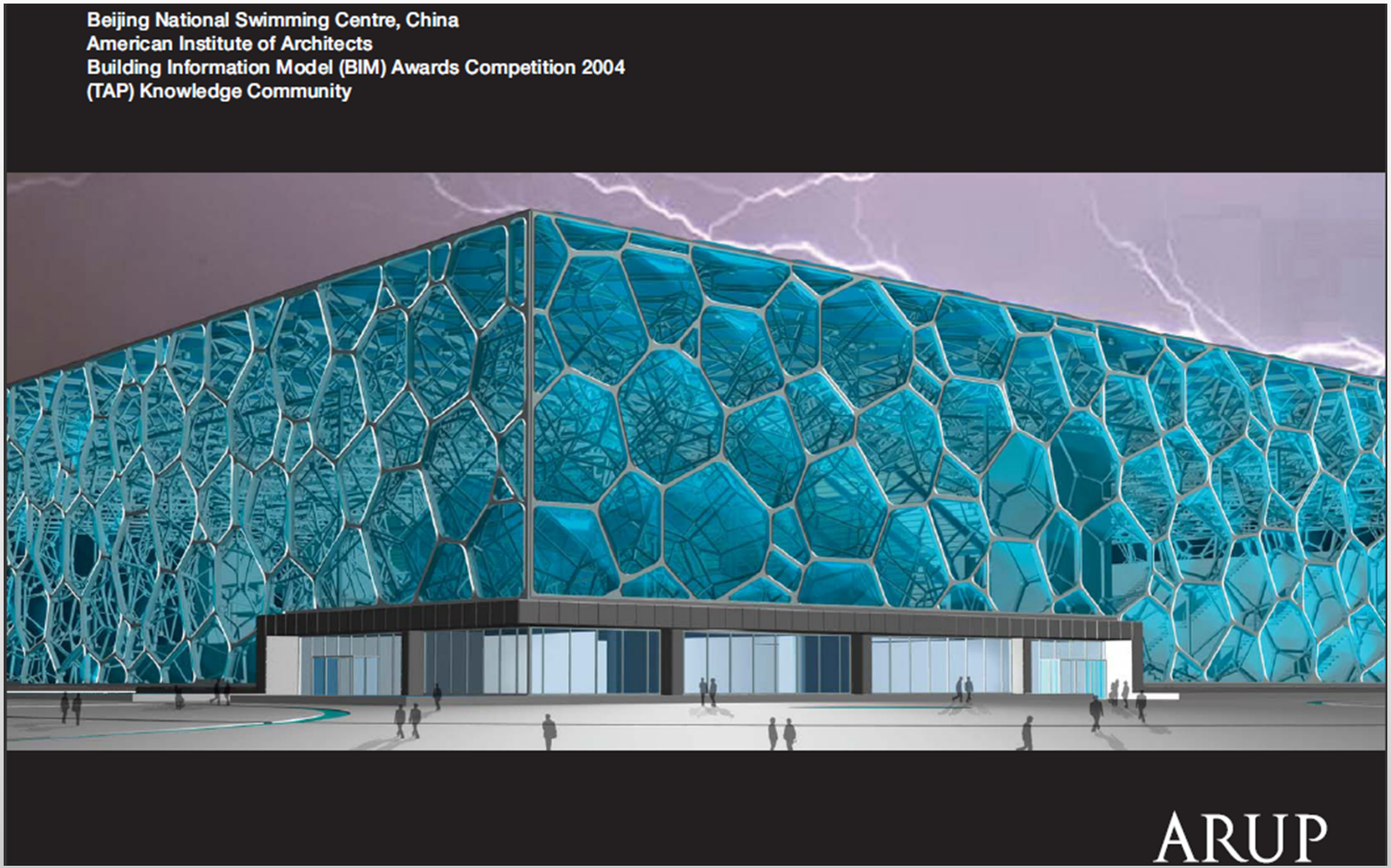
BIM and AECM (Bentley Systems)

- **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

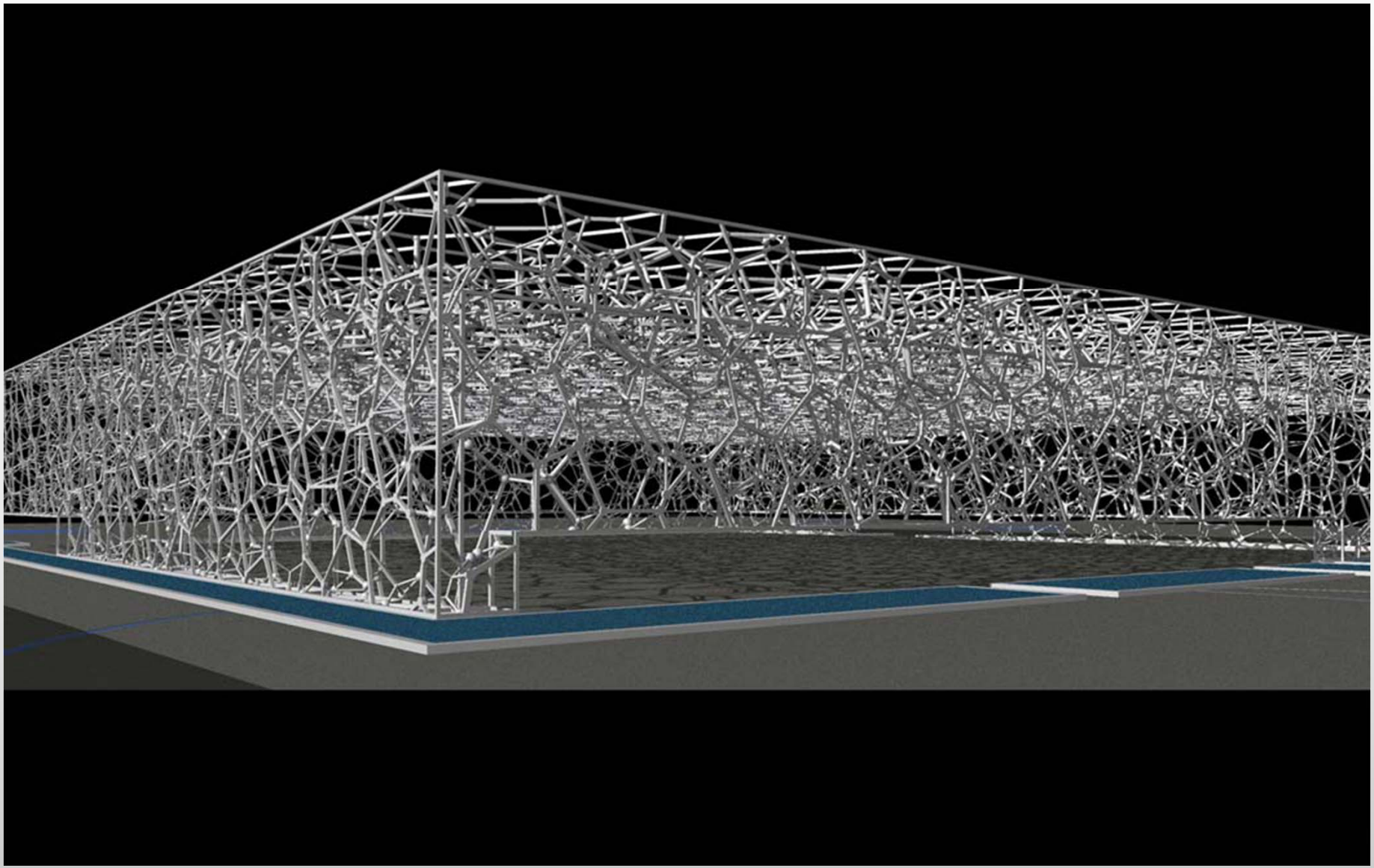
BIM and AECM (Bentley Systems)

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

BIM and AECM (Bentley Systems)



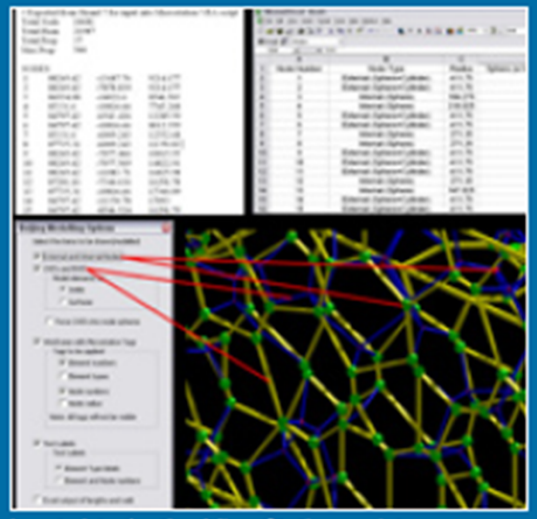
BIM and AECM (Bentley Systems)



BIM and AECM (Bentley Systems)

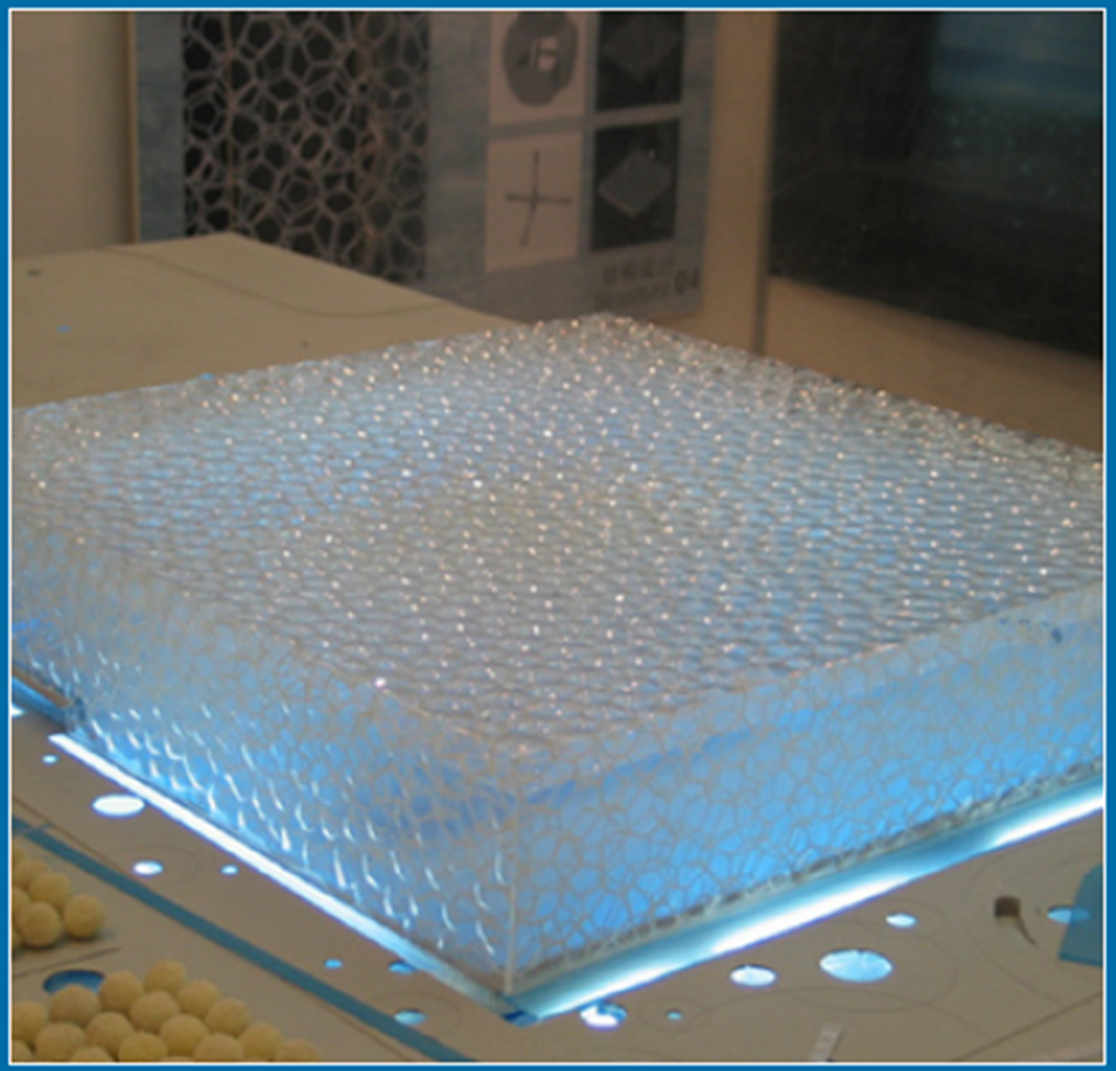
- Interoperability was solved using Bentley products
- Import 3D max 3D model that won the competition
- Create STL file for rapid prototyping
- Continual import and export of CAD models
- Continual visualizations from Bentley structural
- Full documentation of entire steel structure

BIM and AECM (Bentley Systems)



Input data for the MicroStation scripts

Rapid prototype resin model



Completed prototype model with ETFE pillows

BIM and AECM (ArchiCAD)

- **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

BIM and AECM (ArchiCAD)

- 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

BIM and AECM (ArchiCAD)

- **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 capabilities- does 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

BIM and AECM (ArchiCAD)

- 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.

BIM and AECM (Digital Project)

- **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*

BIM and AECM (Digital Project)

- 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

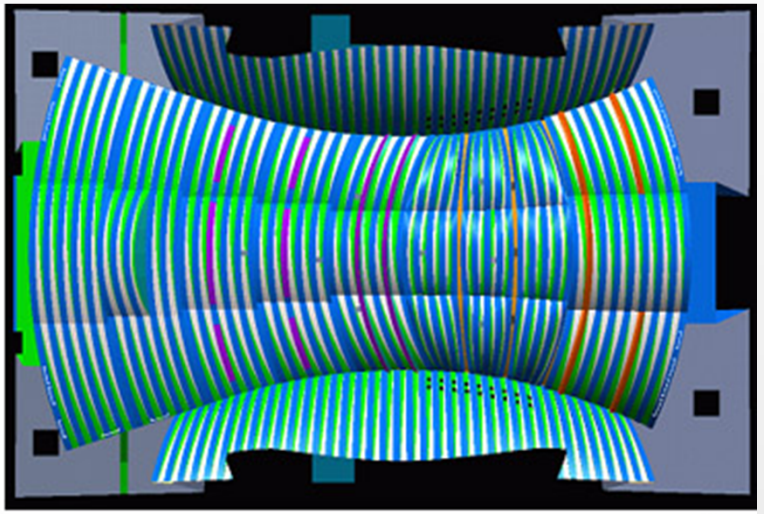
BIM and AECM (Digital Project)

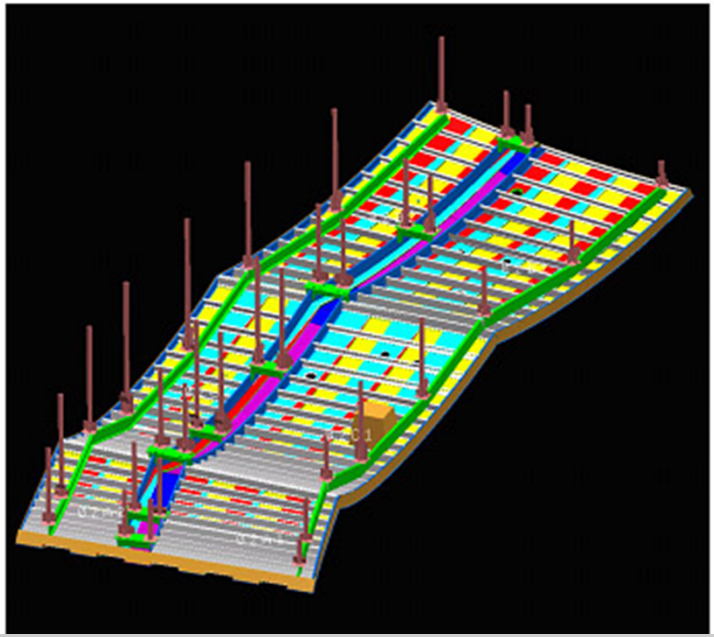
- **CATIA Digital Project (Strength)**
- Powerful and complete parametric modeling capabilities
- Able to model large and complex projects
- Able to control surfaces and assemblies

BIM and AECM (Digital Project)

- **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)

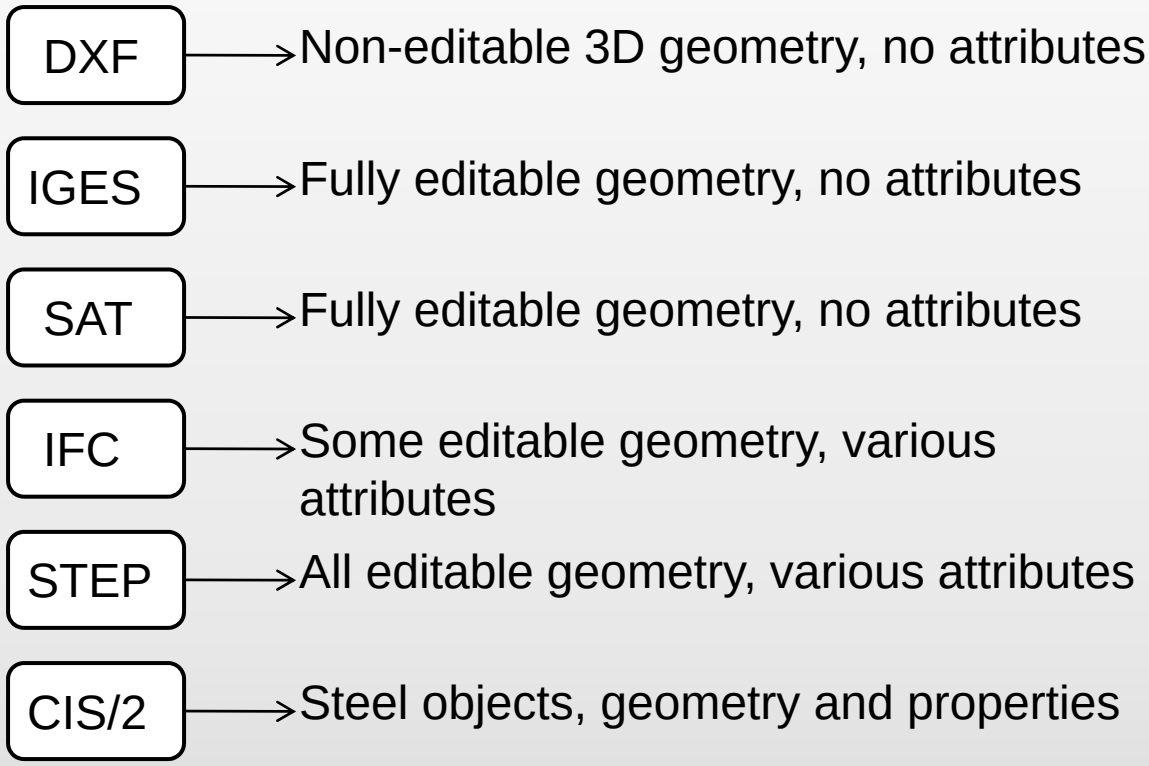




BIM and AECM (Architectural design)

- 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.

BIM and AECM (Interoperability)



BIM and AECM (Interoperability)

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

BIM and AECM (Interoperability)

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

BIM and AECM (Interoperability)

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

BIM and AECM (Interoperability)

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

BIM and AECM (Interoperability)

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

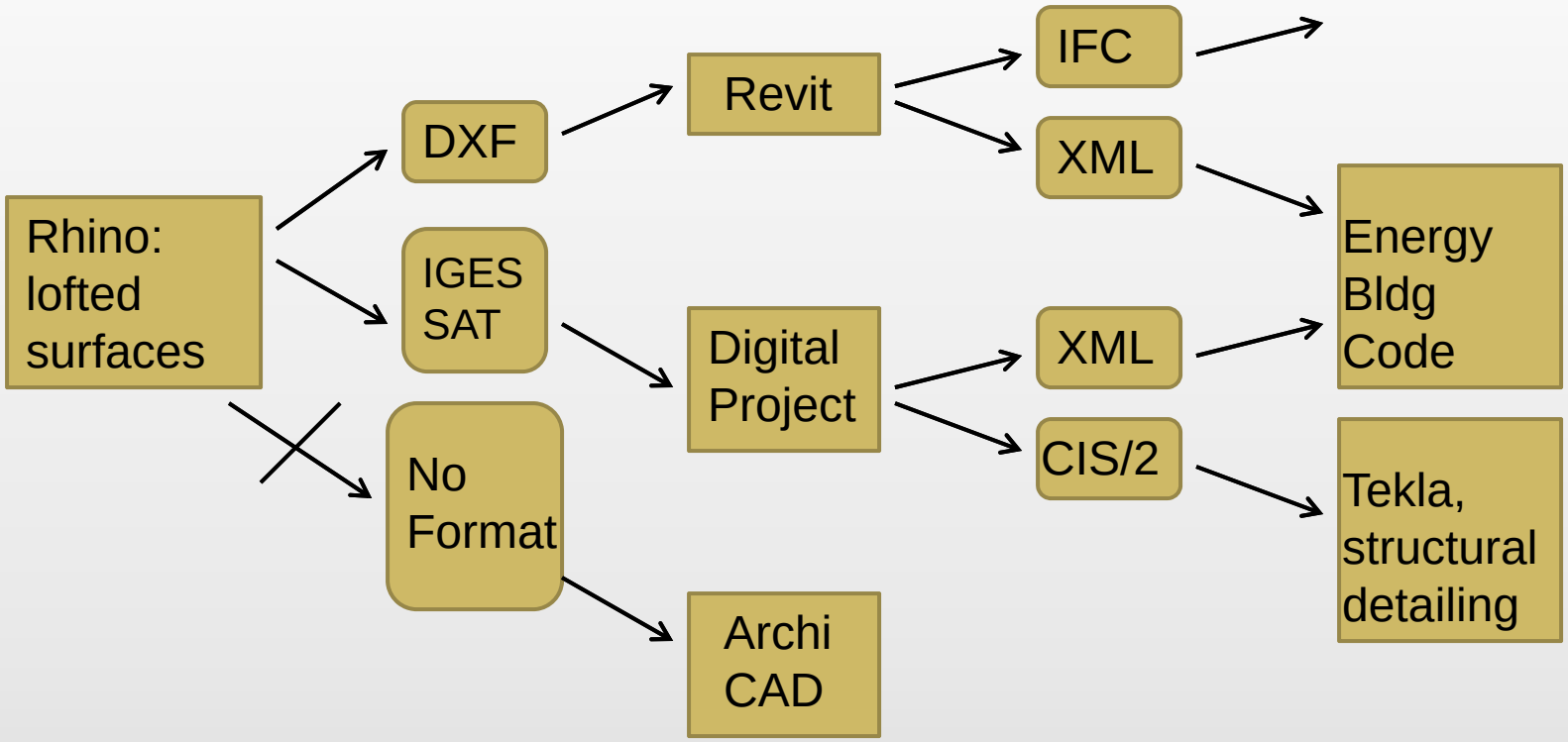
BIM and AECM (Interoperability)

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

BIM and AECM (Interoperability)

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

BIM and AECM (Interoperability)



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

BIM and AECM (Interoperability -IFC)

- 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)

BIM and AECM (Interoperability -IFC)

- 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

BIM and AECM (Interoperability -IFC)

Revit Architecture

ArchiCAD

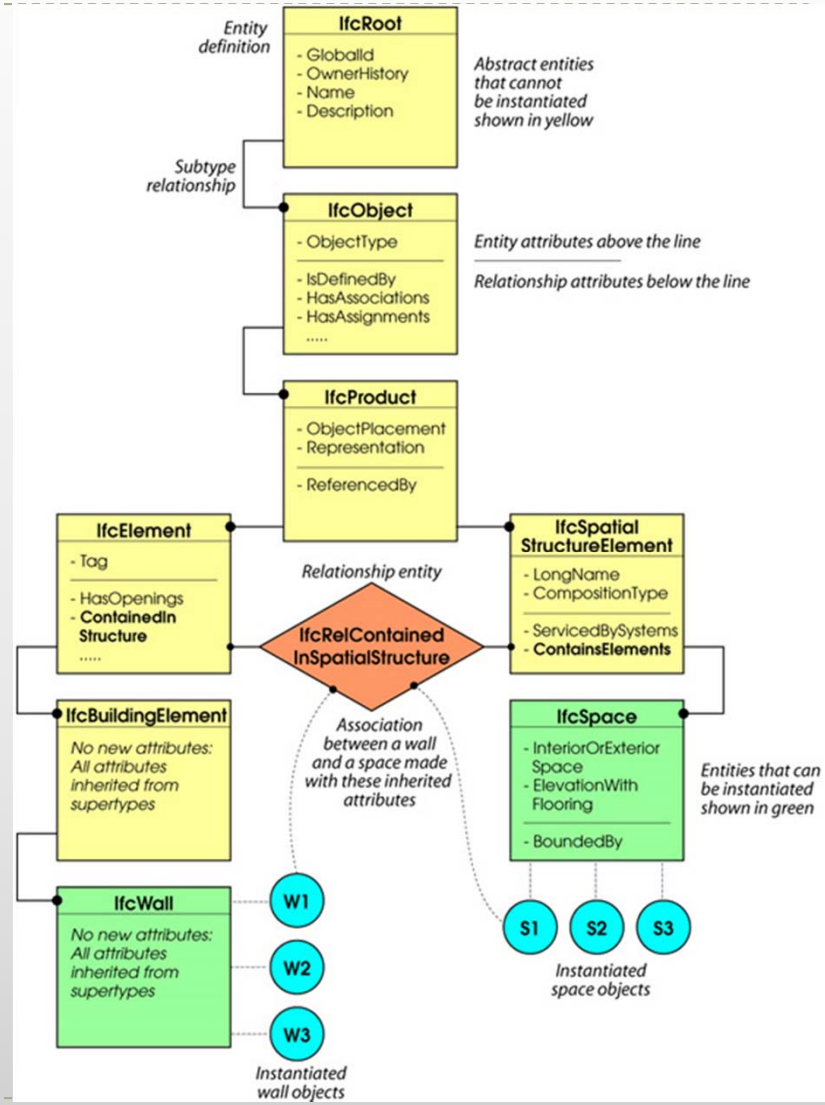
Bentley Architecture

Digital Project

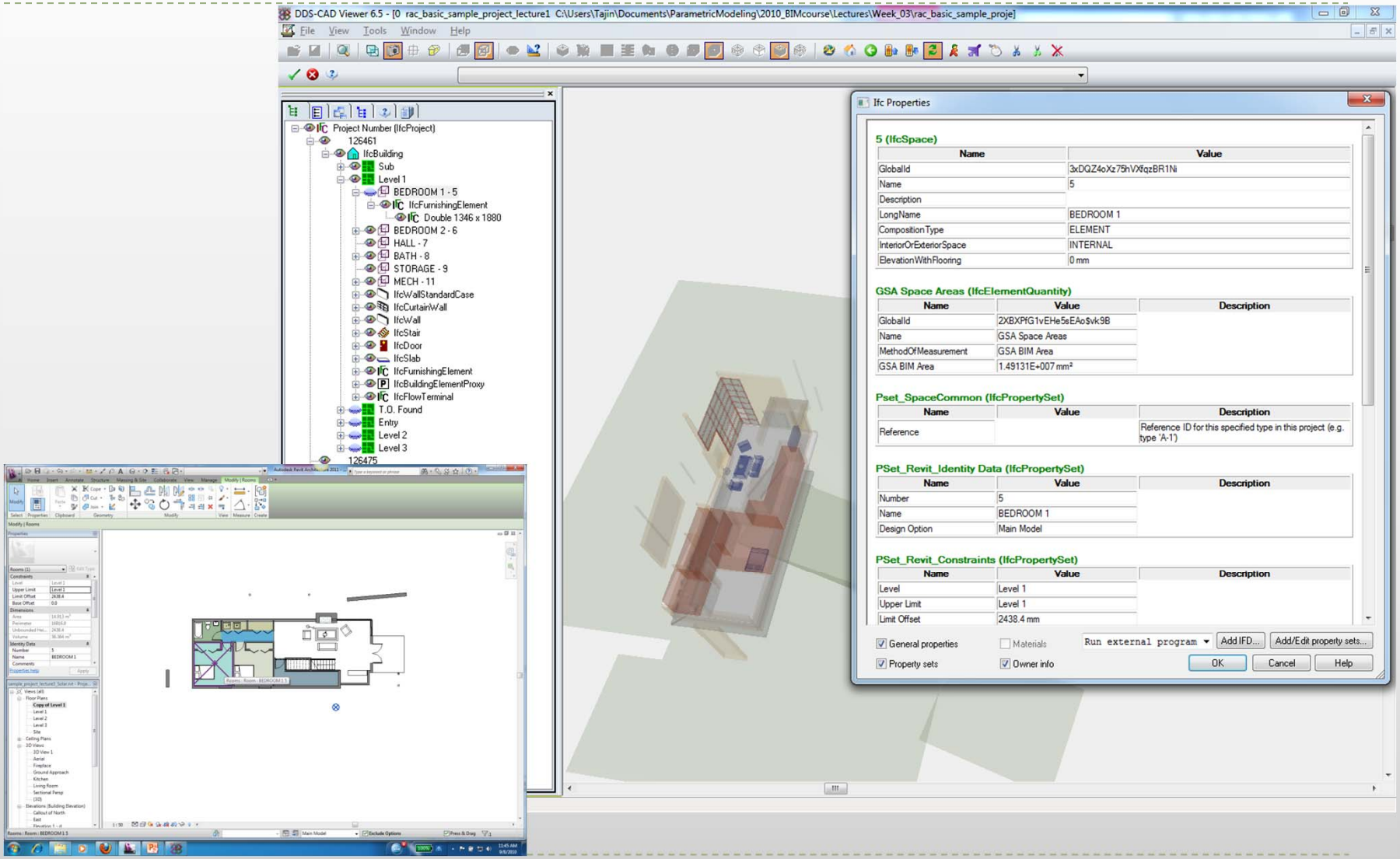
IFC

BIM and IFC are still emerging technology

http://www.ifcwiki.org/index.php/Free_Software



BIM and AECM (Interoperability -IFC)



BIM and AECM (Interoperability -IFC)

- 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

BIM and AECM (Interoperability-XML)

- 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.

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       <Latitude>42.358300</Latitude>
       <Longitude>-71.060300</Longitude>
     </Location>
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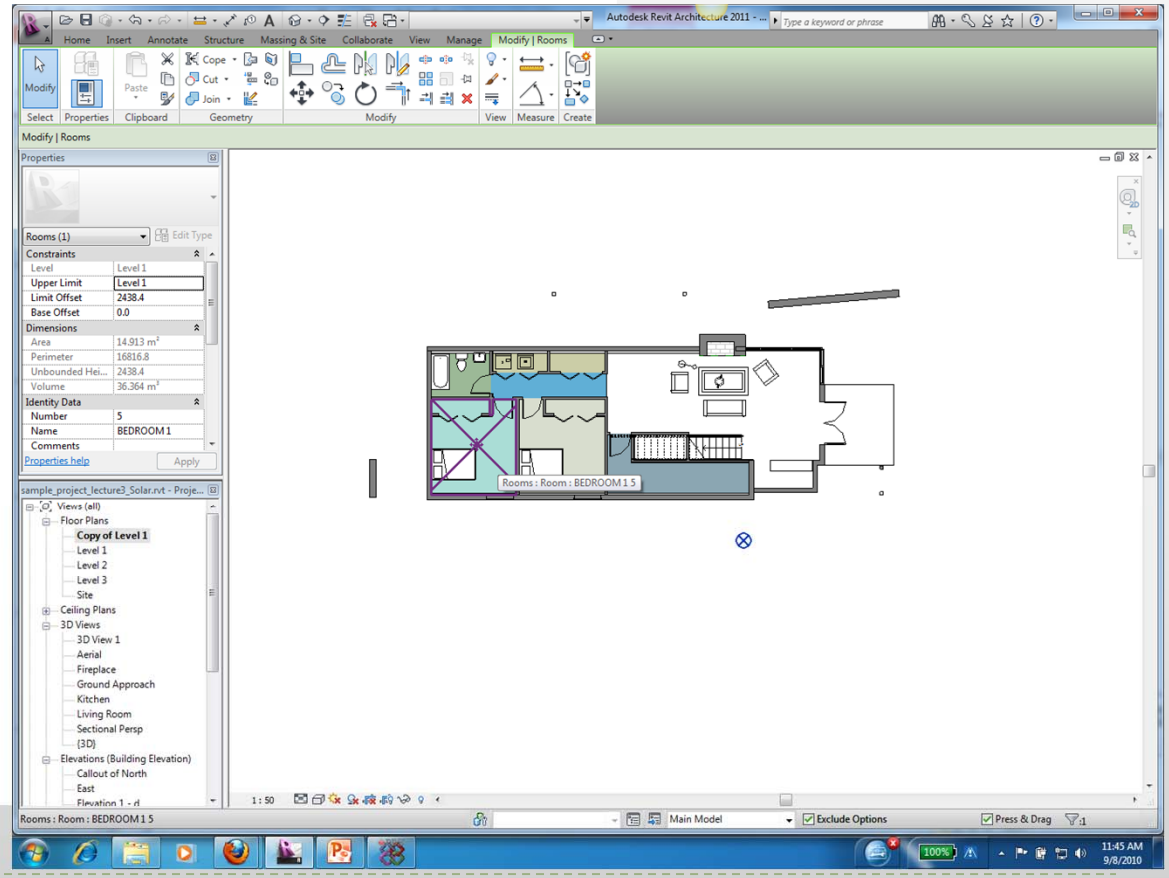


BIM and AECM (Interoperability-XML)

- 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

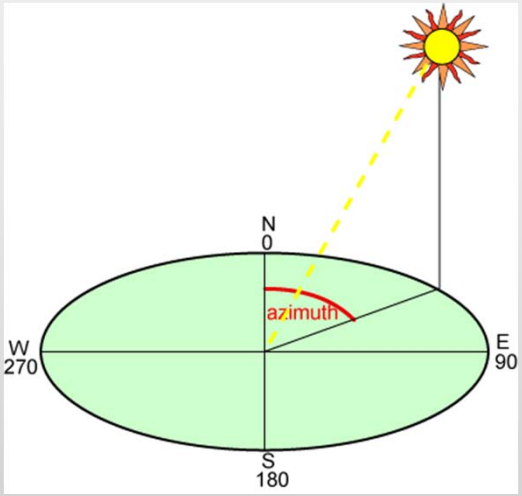
Using BIM in design

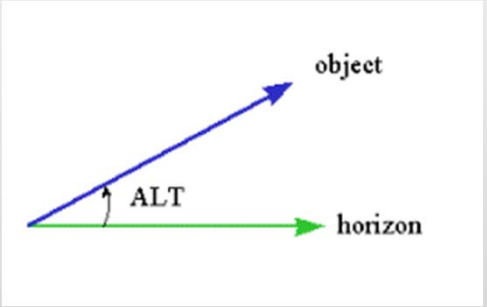
- Solar Studies
  - Project North and True North
  - Exporting sun study animations
- Material Quantity Takeoff
  - Filtering materials
  - Calculating for recycled material
- Creating Mass
  - in place mass
  - conceptual mass

Solar Studies

Suns position measured by

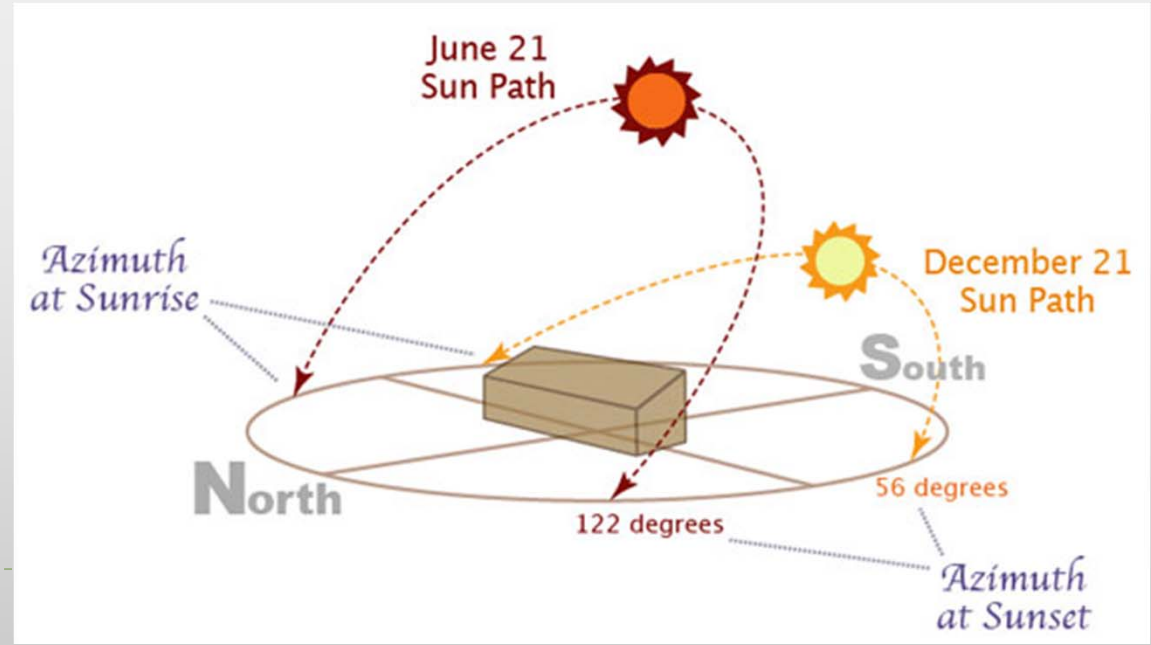
- **Azimuth** of an object is the angular distance along the horizon to the location of the object. By convention, azimuth is measured from north towards the east along the horizon (this may vary)
- **Altitude** is the suns elevation measured in angles from the horizontal plane





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

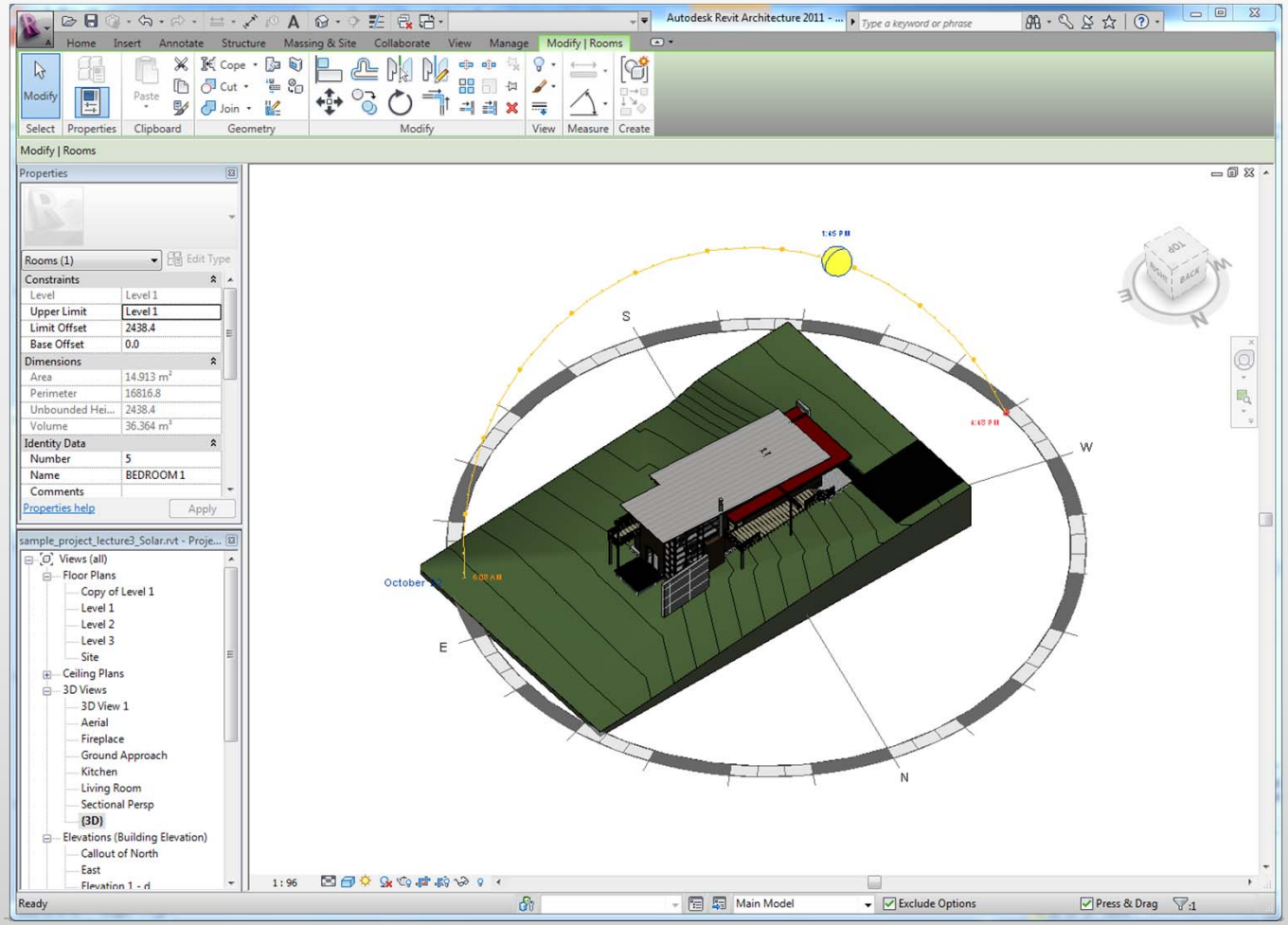
Solar Studies (without changing orientation)

- Summer solstice 21 June

- Winter solstice 21 December

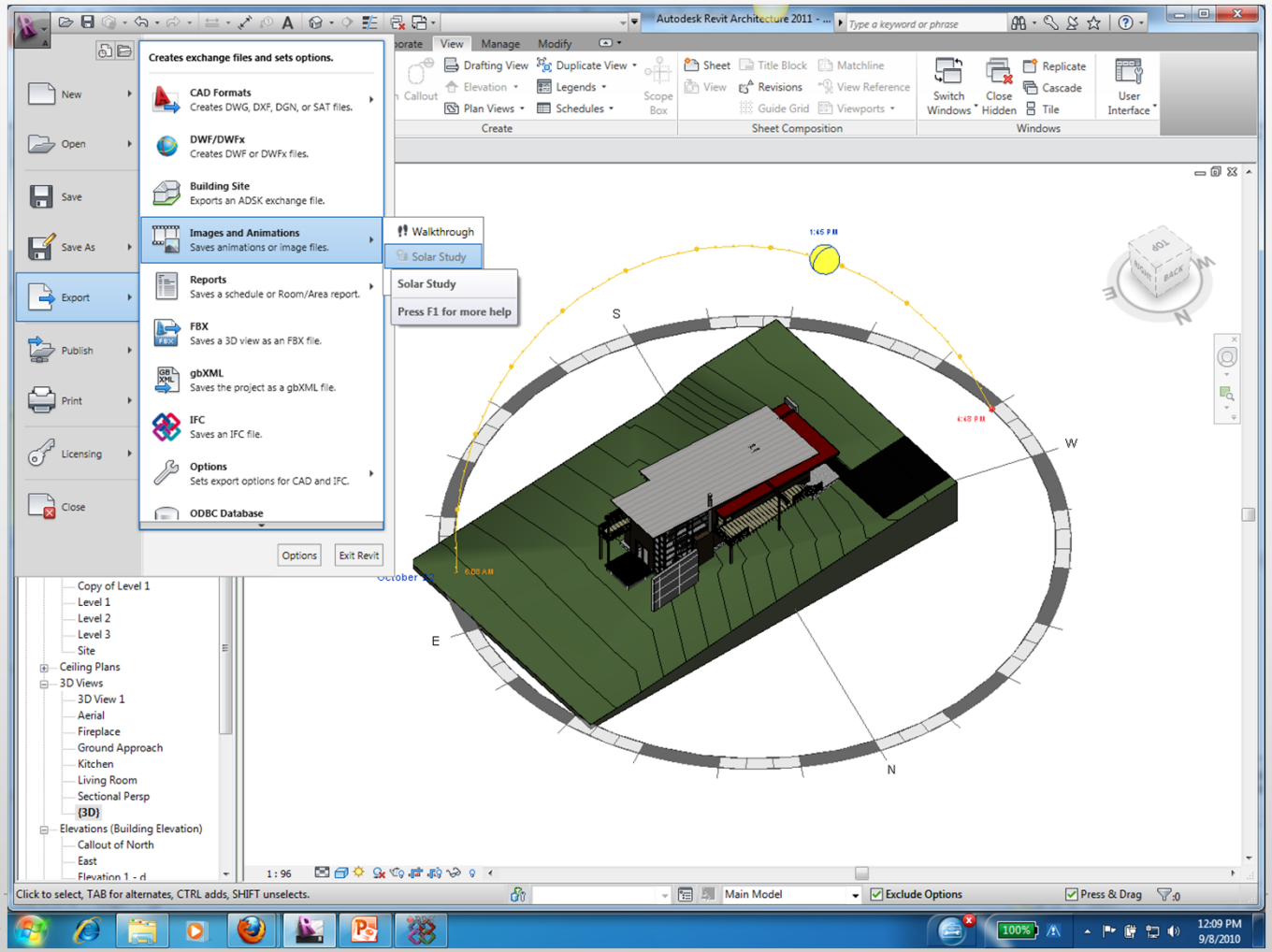
Solar Studies (using solar path tool)

- Turn sun path on



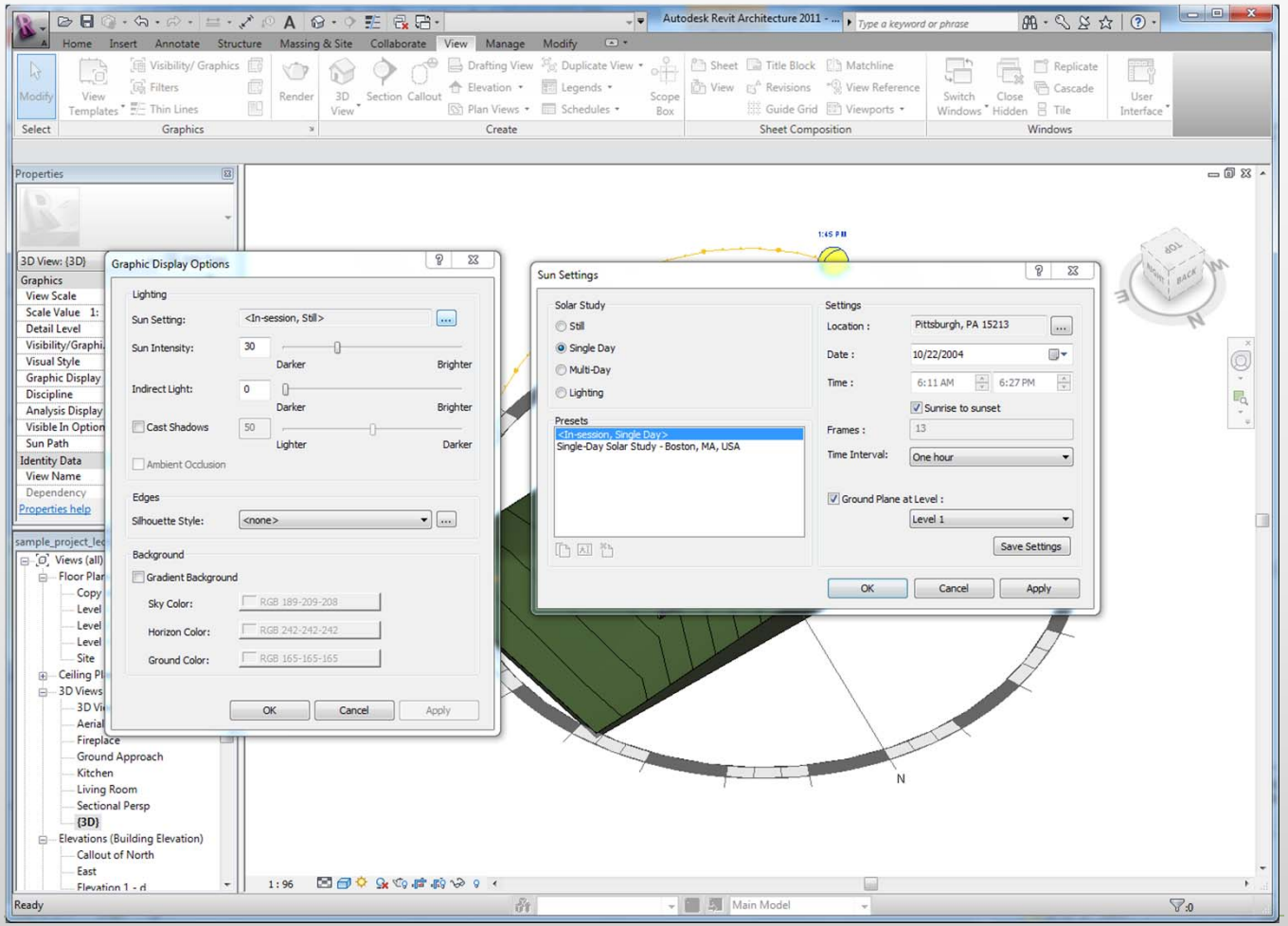
Solar Studies (export solar study)

- By default solar study export is grayed out



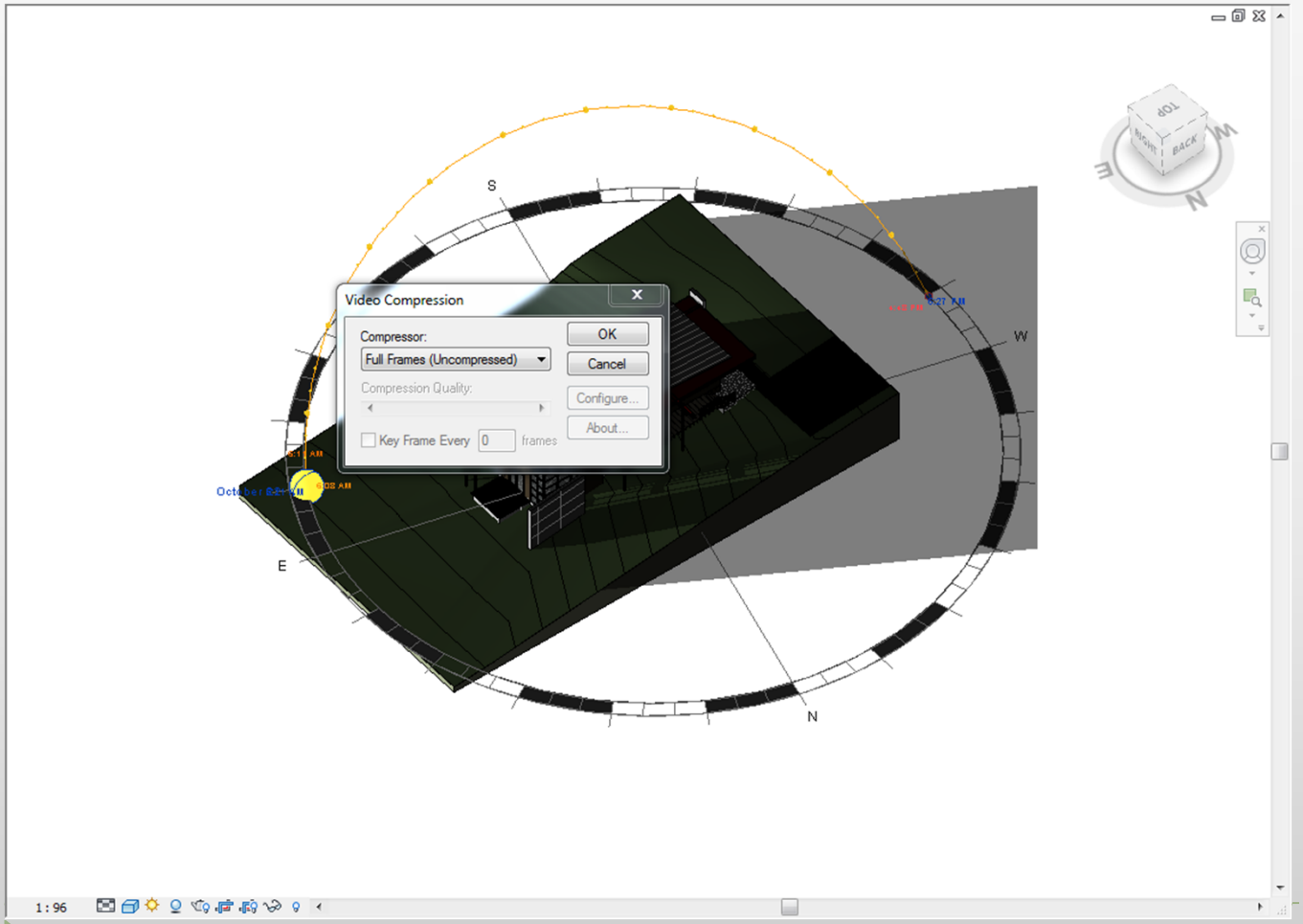
Solar Studies (export solar study)

- Graphic display options to pick Single day, location and time

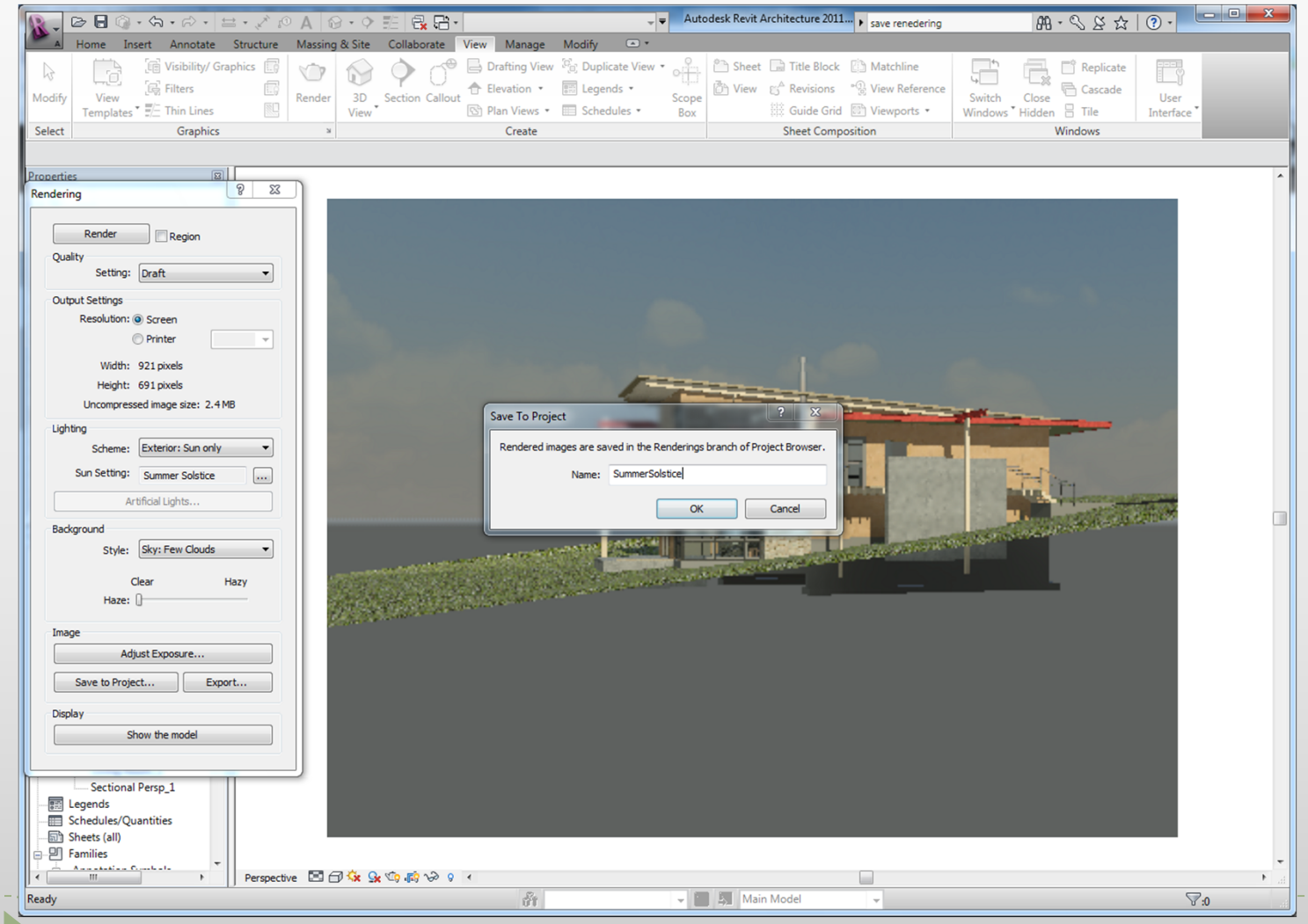


Solar Studies (export solar study)

- Make sure cast shadows is selected and then export



Solar study (Rendering a solar study)



Solar Study (Find declination)

NOAA NATIONAL GEOPHYSICAL DATA CENTER

Search NGDC

Data | Declination | FAQ | SPIDR | Geomagnetism home | Models & Software | Space Weather | WMM | Web Links

NOAA > NESDIS > NGDC > Geomagnetism

comments | privacy policy

Estimated Value of Magnetic Declination

To compute the magnetic declination, you must enter the location and date of interest.

If you are unsure about your city's latitude and longitude, look it up online! In the USA try entering your zip code in the box below or visit the U.S. Gazetteer. Outside the USA try the Getty Thesaurus.

Search for a place in the USA by Zip Code: [ ] Get Location

Enter Location: (latitude 90S to 90N, longitude 180W to 180E). See Instructions for details.

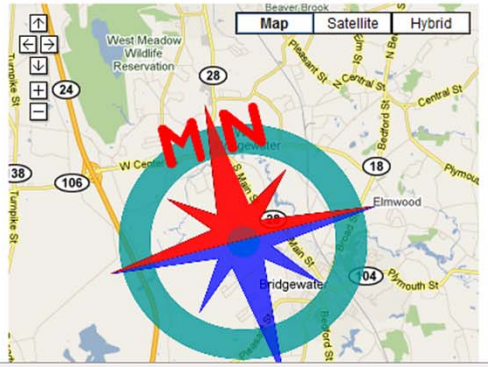
Latitude: 42 (•) N ( ) S **Longitude:** -71 ( ) E (•) W

Enter Date (1900-2015): Year: 2010 Month (1-12): 9 Day (1-31): 7

Compute Declination

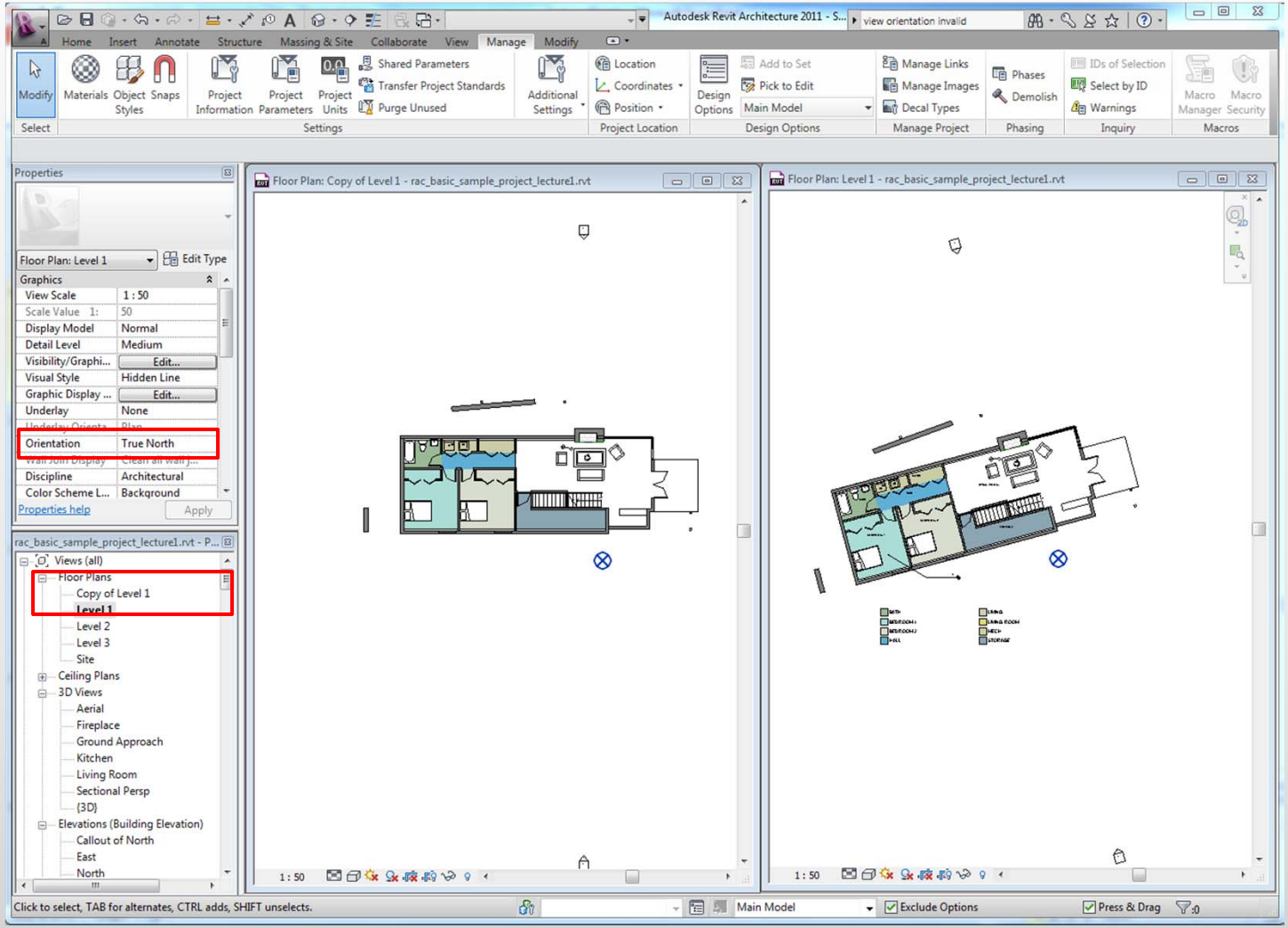
Declination = 15° 1' W changing by 0° 3' E/year

For more information, visit:
Answers to some **frequently asked questions** | **Instructions** for use | **Today's Space Weather**

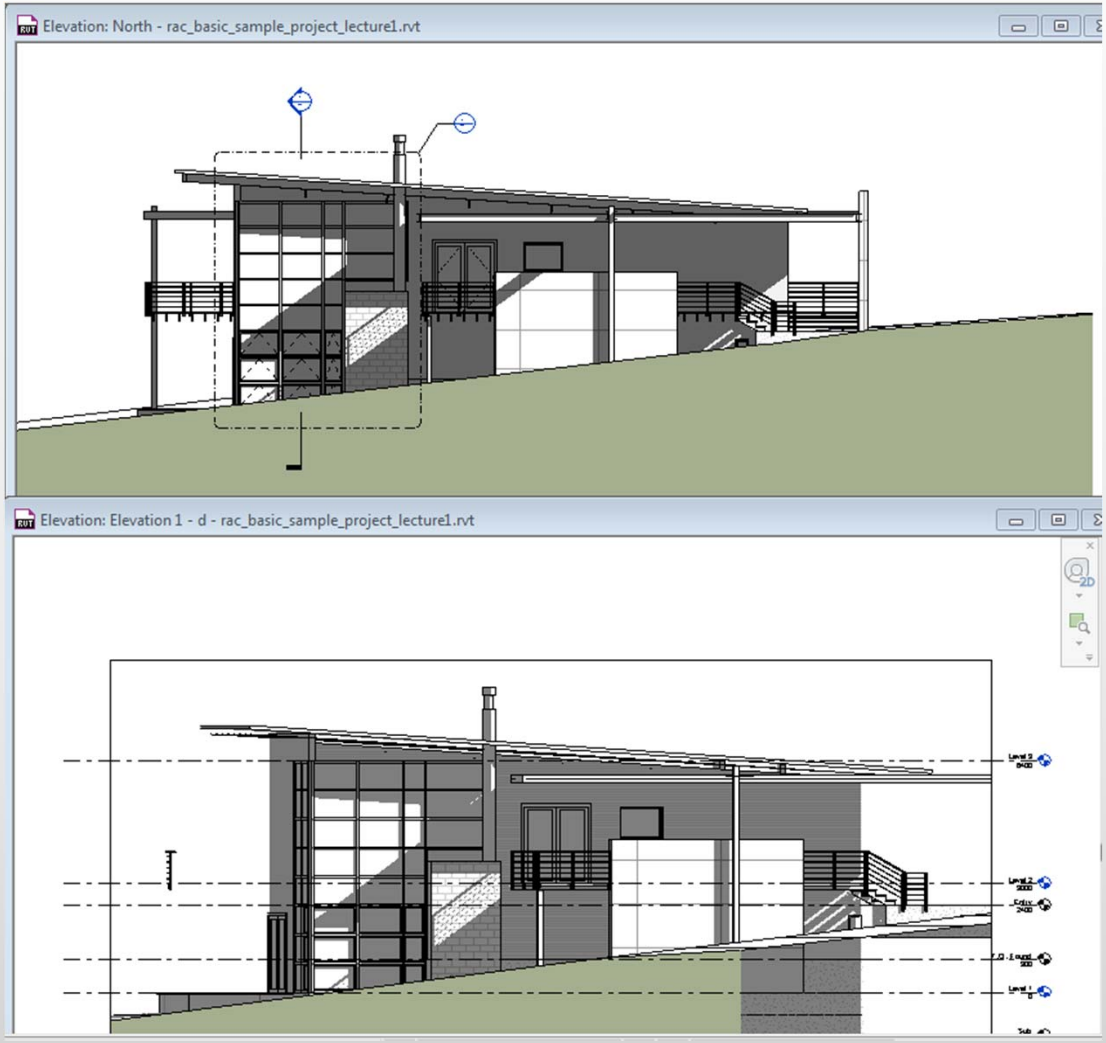


Done

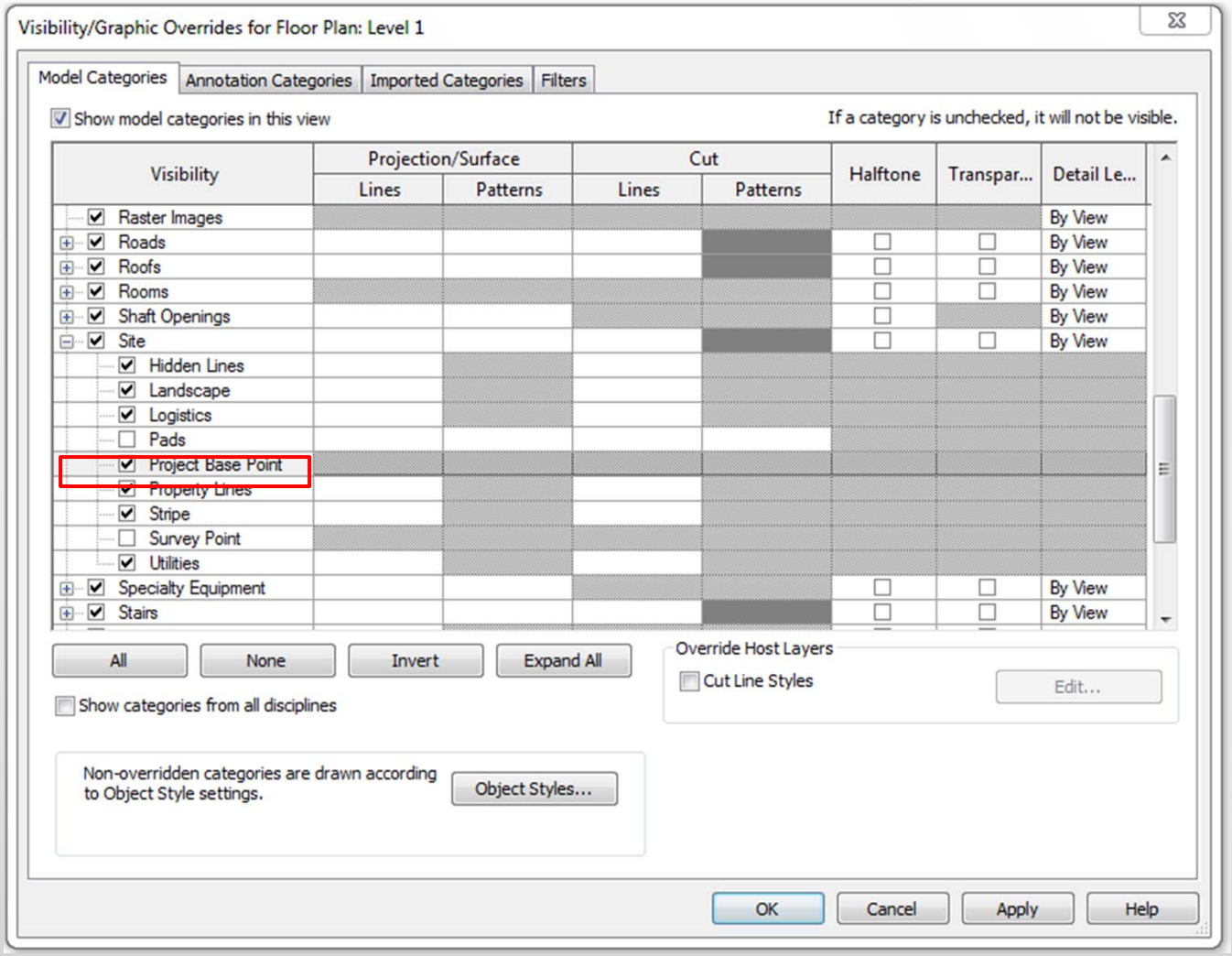
Solar Study (Copy level and change to True North)



Solar Study (Compare lighting for in same situations)

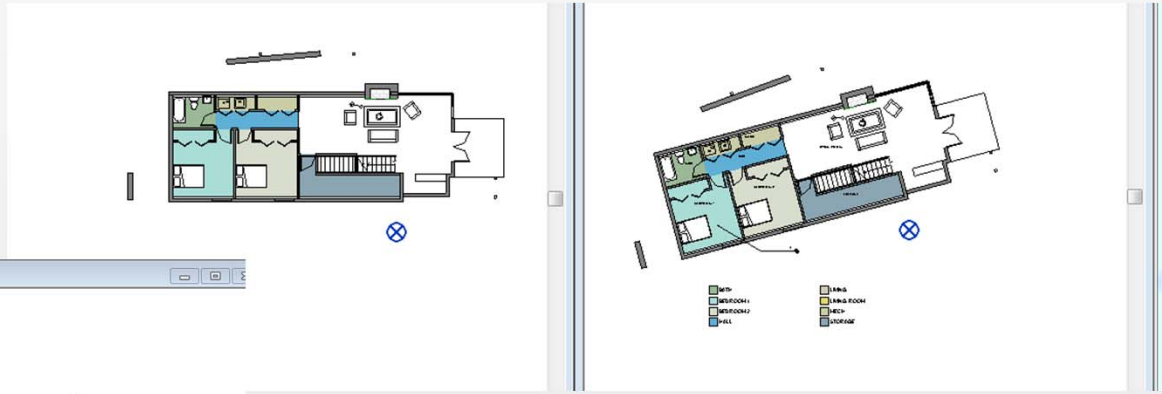


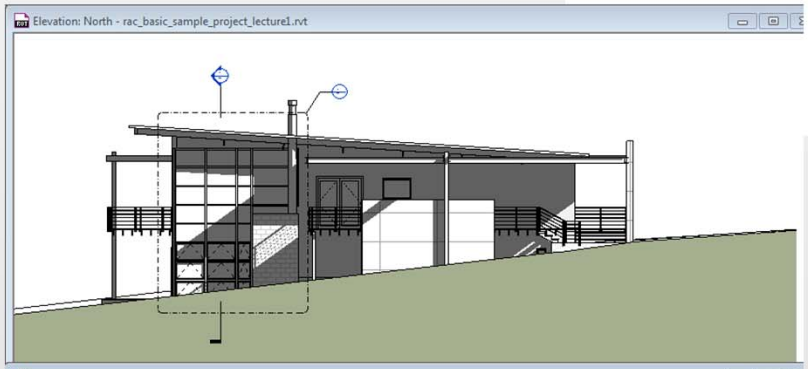
Solar Study (Project base point) Model Cat>Site>

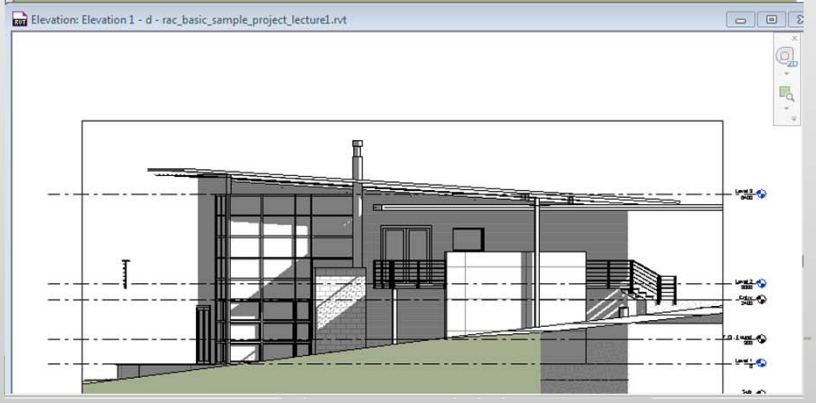


Solar Study (Exercise: 01)

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

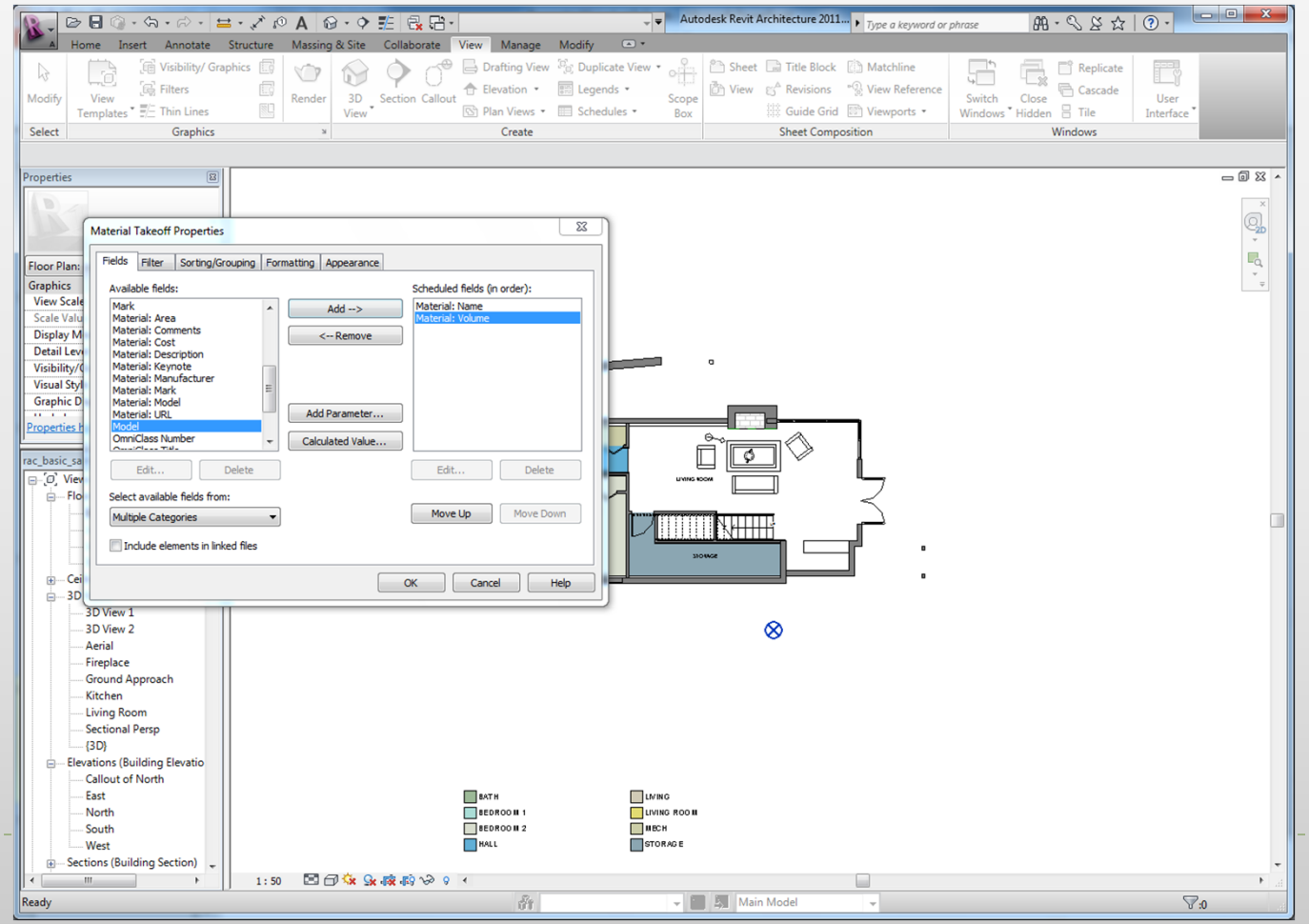






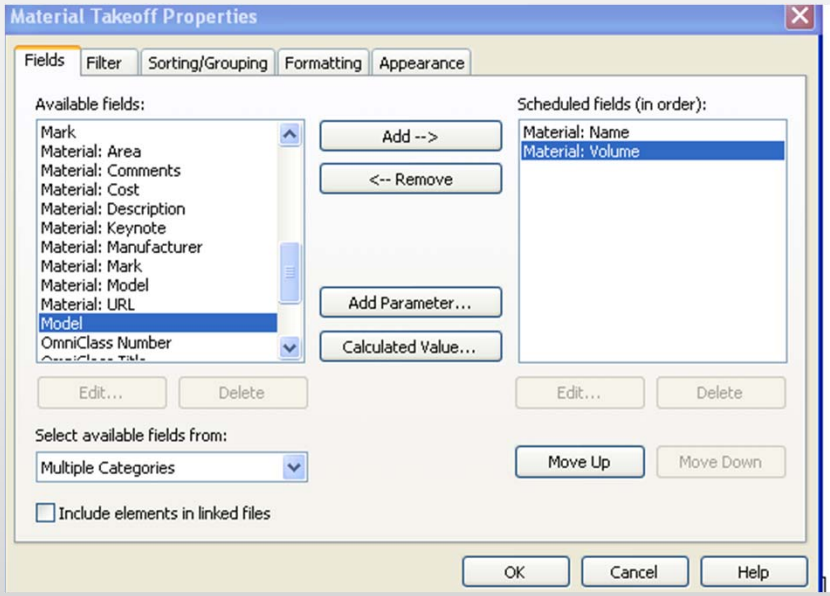
Revit Schedules (Material takeoff)

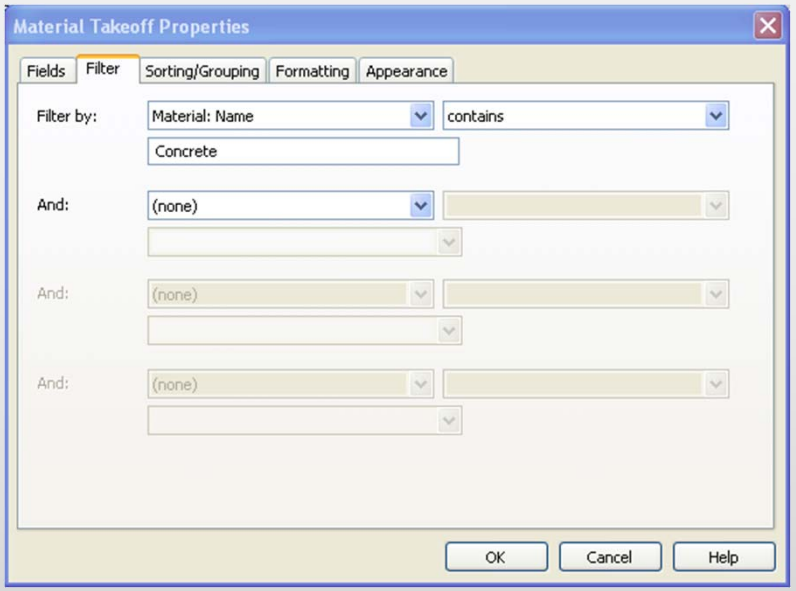
- In the New Material Takeoff dialog, choose multi-category
- In the Material Takeoff Properties dialog, for Available Fields, select the material name and volume



Revit and Recycled material

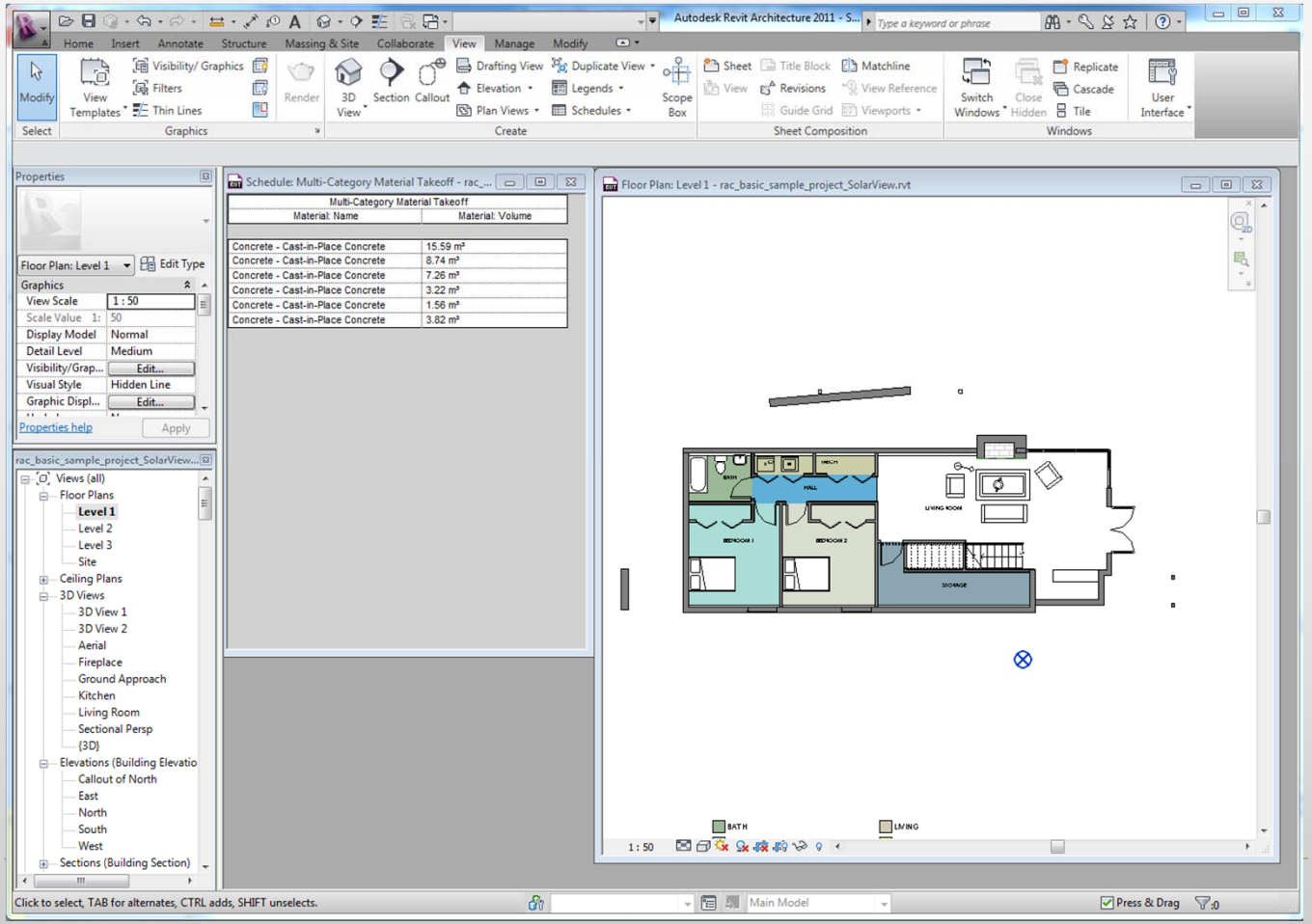
- In the New Material Takeoff dialog, choose multi-category
- In the Material Takeoff Properties dialog, for Available Fields, select the material name and volume, Use filter and choose Material: Name, contains and type Concrete (this is case sensitive)





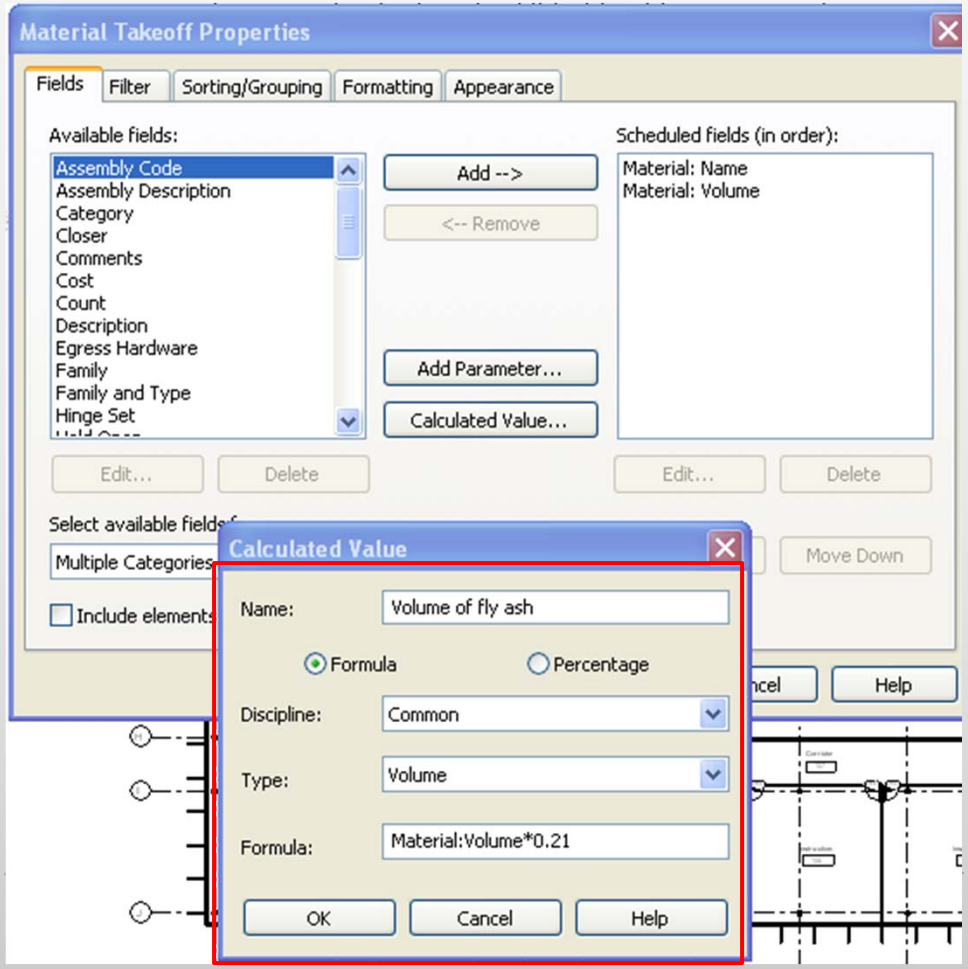
Revit and Recycled material

- In the Material Takeoff Properties dialog, for Available Fields, select the material name and volume, Use filter and choose Material: Name, equals and type In place Concrete



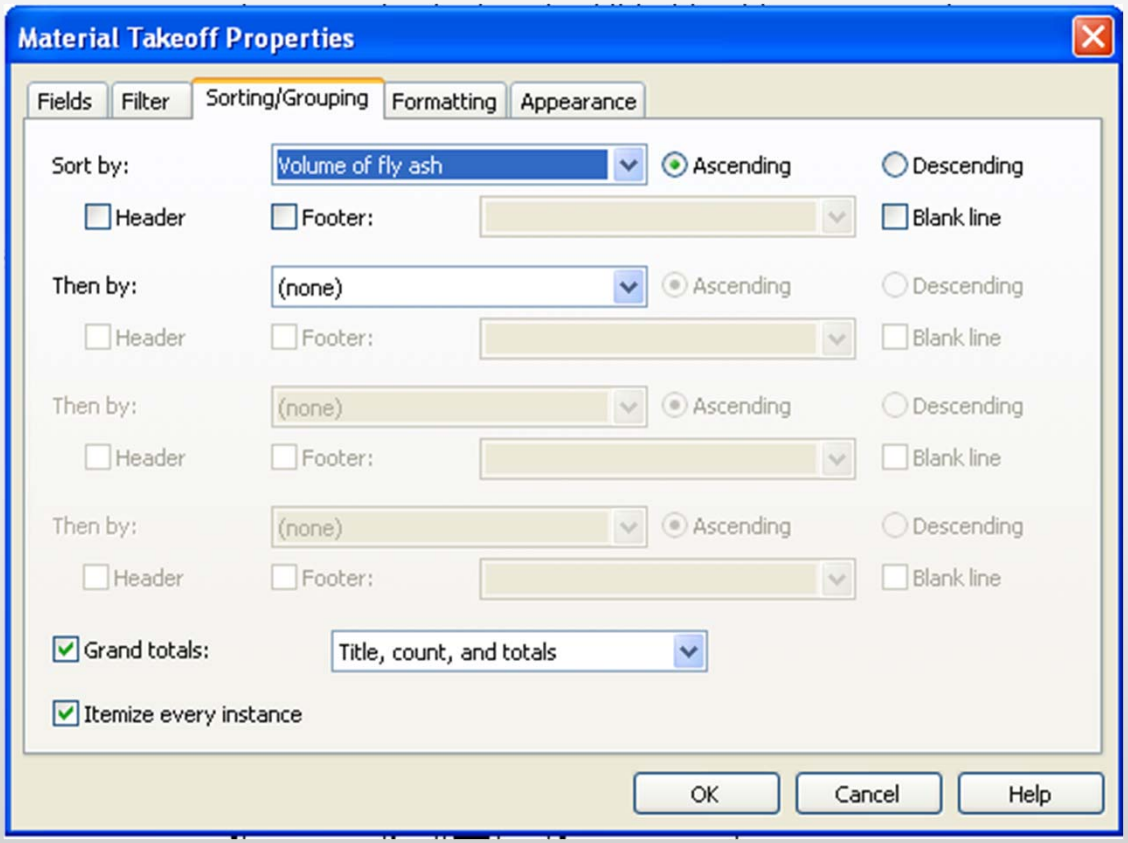
Calculating Recycled material

- 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,



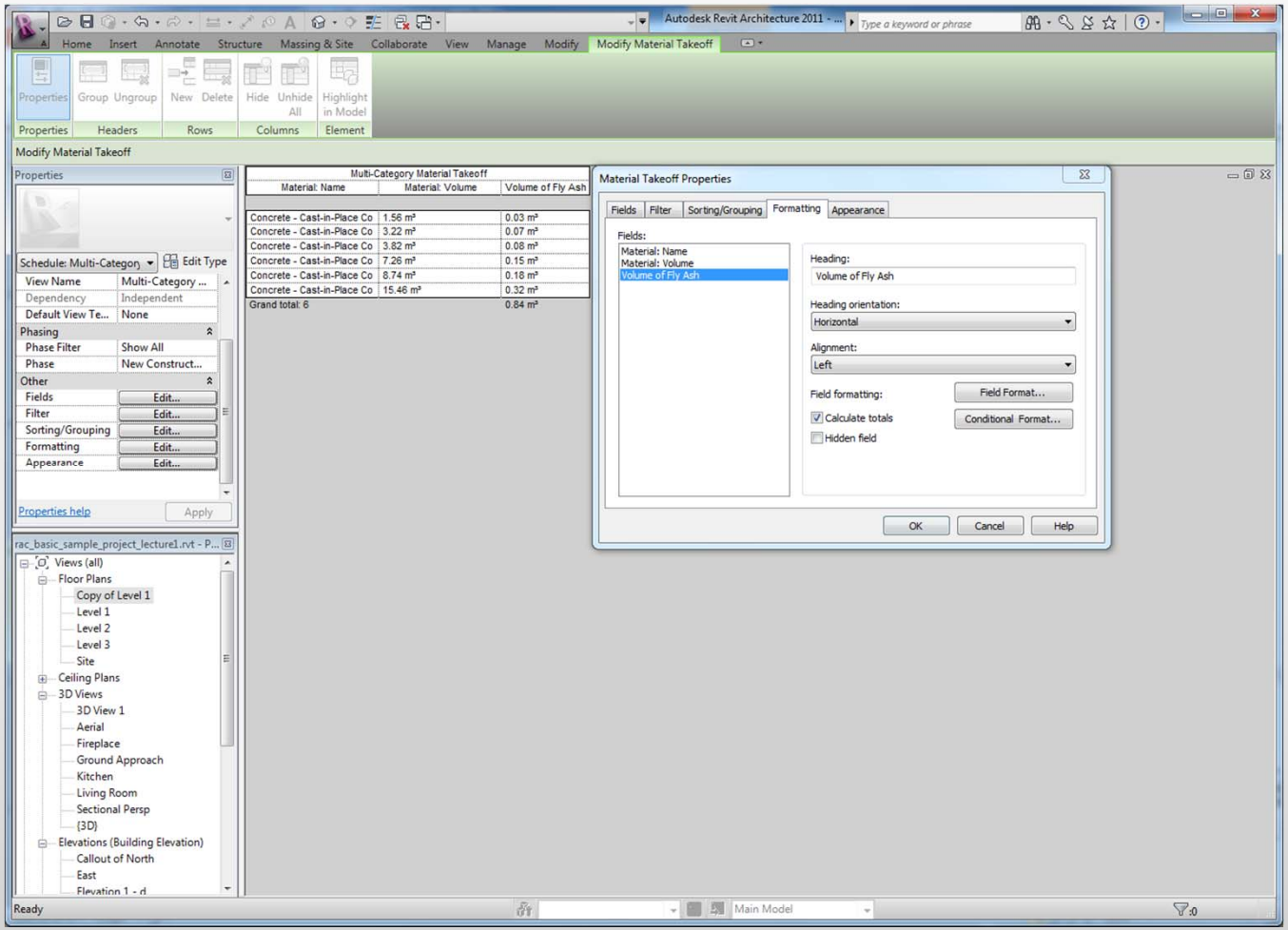
Revit and Recycled material

- Select grand totals in the sorting tab



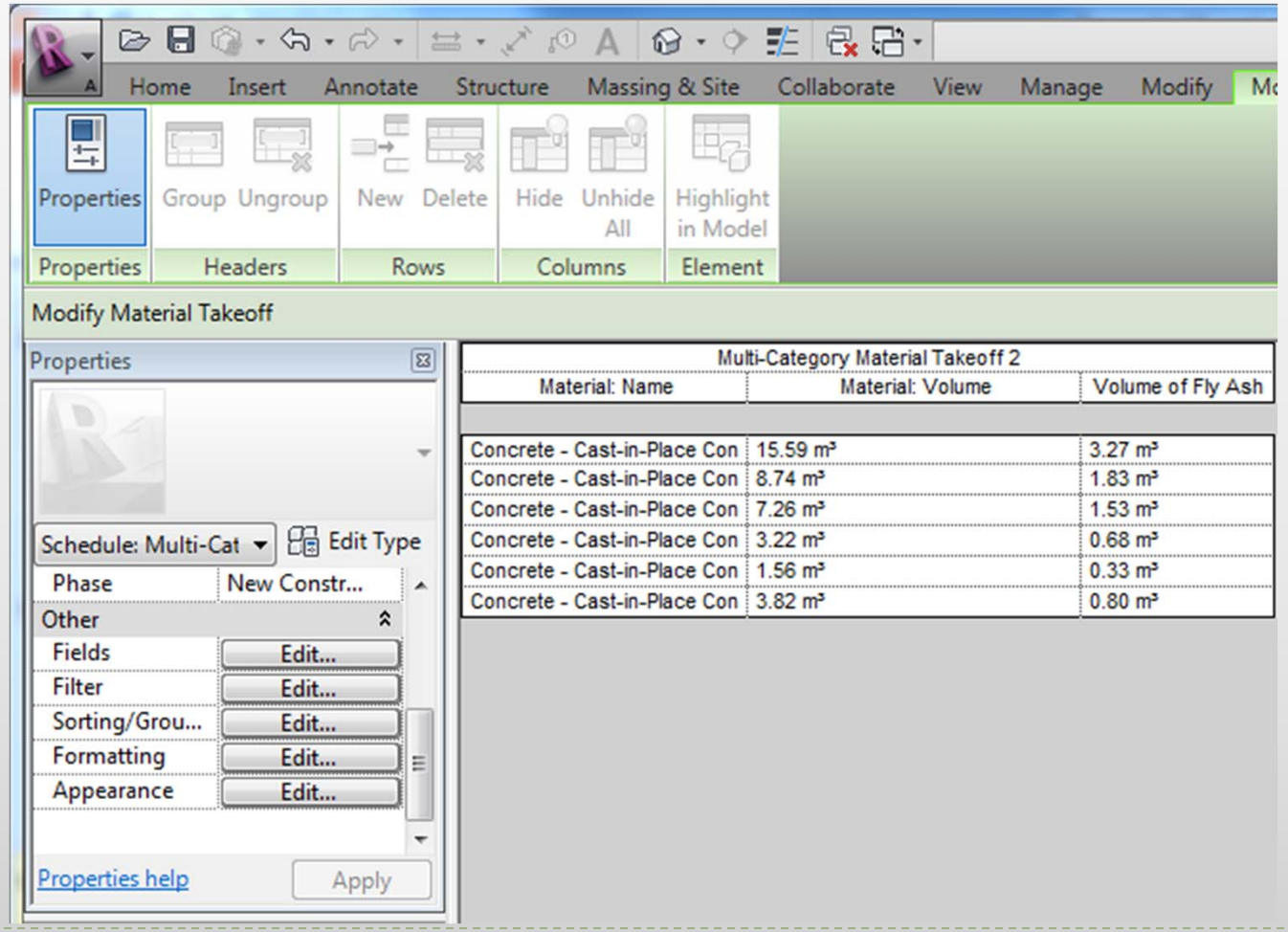
Revit and Recycled material

- Select grand totals in the sorting tab



Revit and Recycled material

- Summary of the schedule



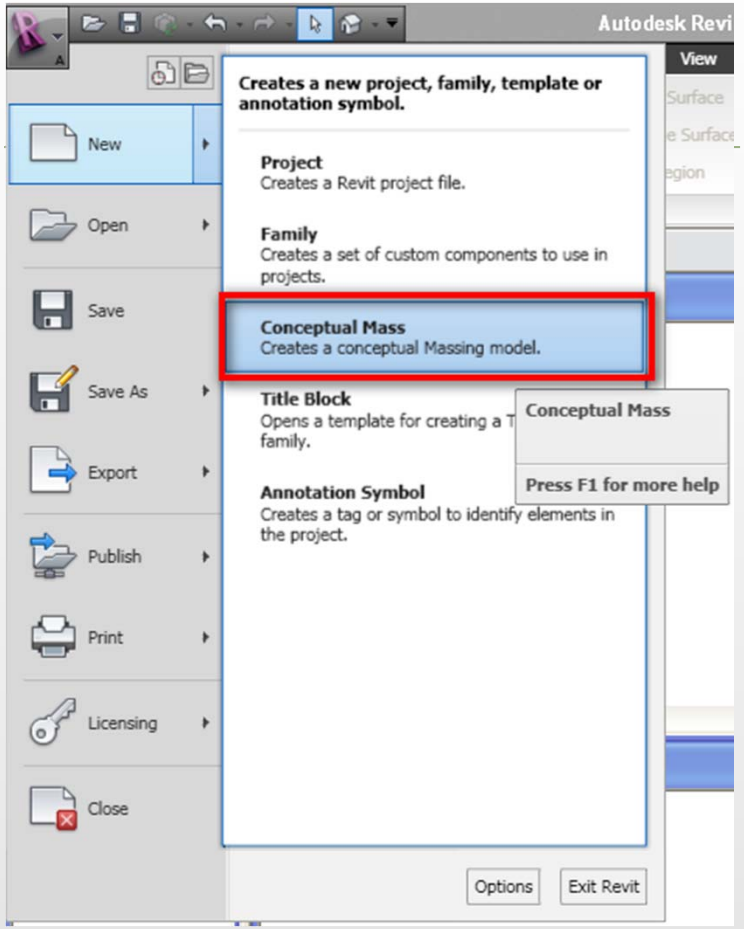
Revit and Recycled material (Ex-02)

- 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

Mass Modeling

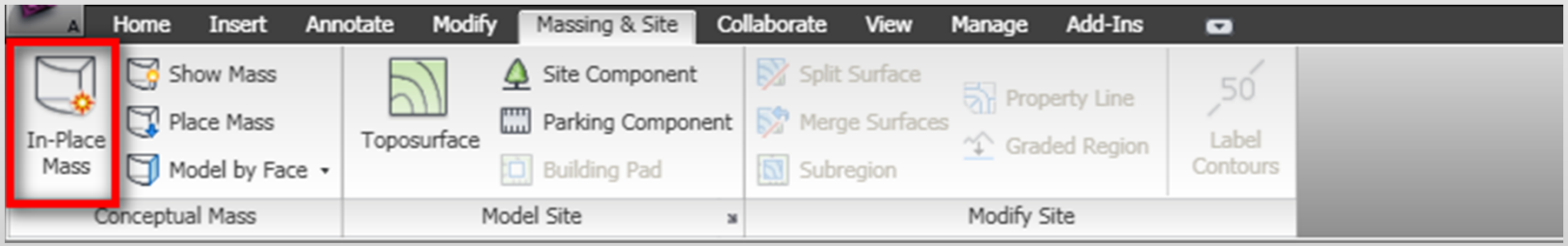
- Conceptual Mass

  > Select from the main **New** menu



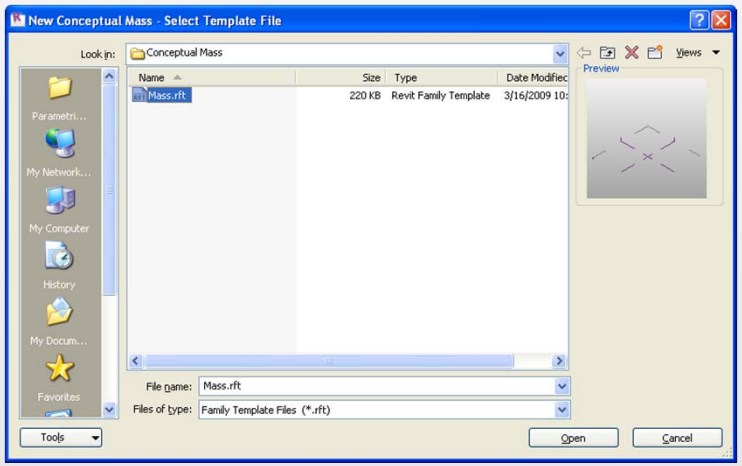
- In-Place Mass

  > start from **Massing & Site**

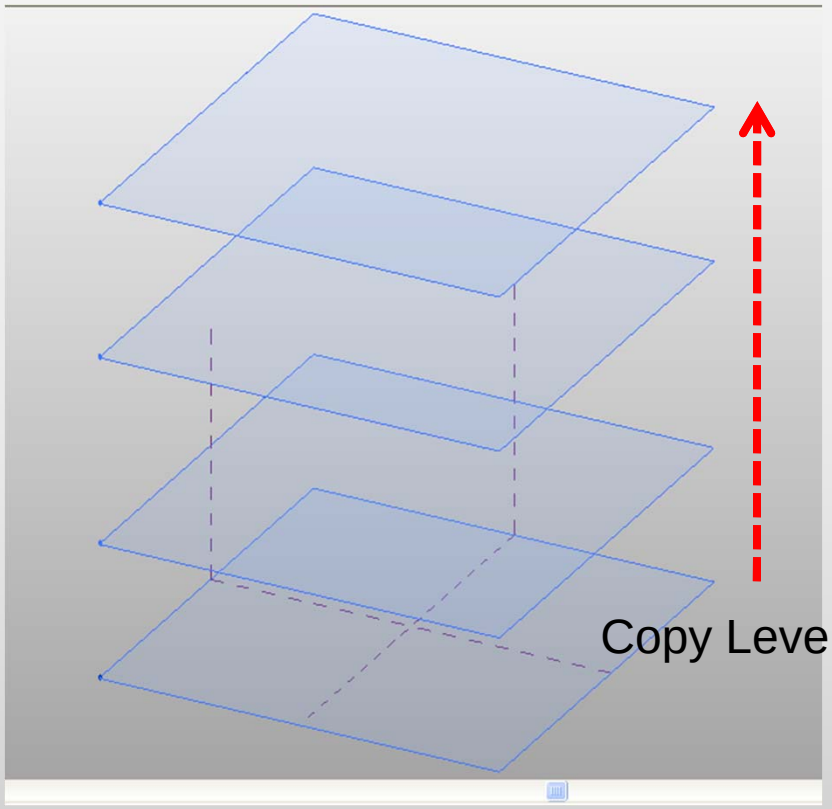


Conceptual Mass

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

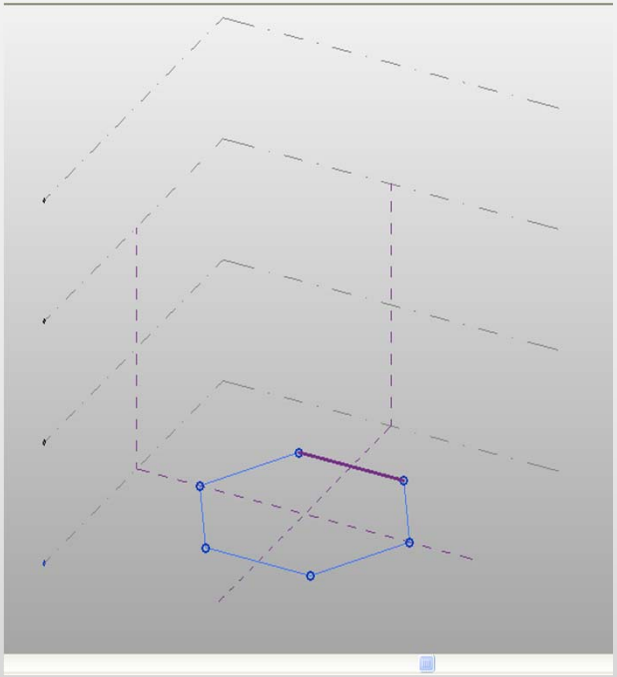


Template

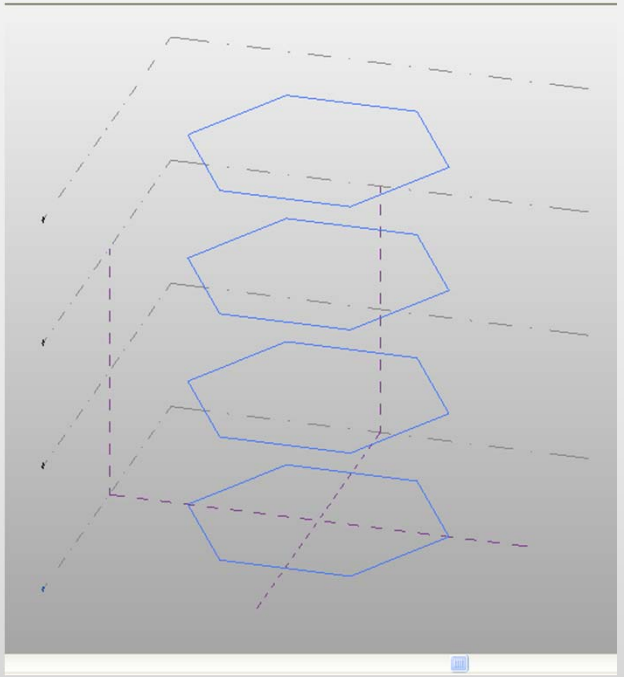


Conceptual Mass

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



Hexagon profile

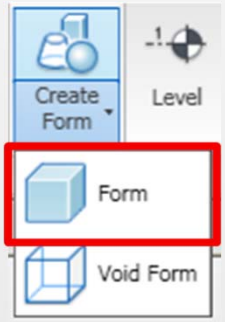


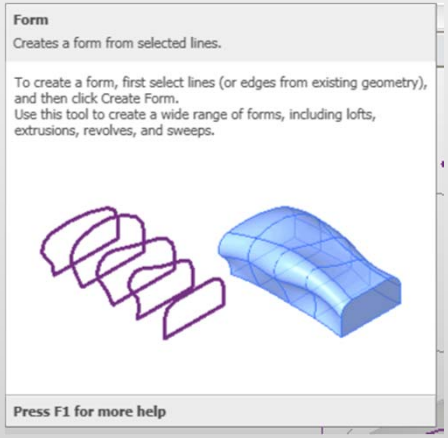
Duplicate profiles

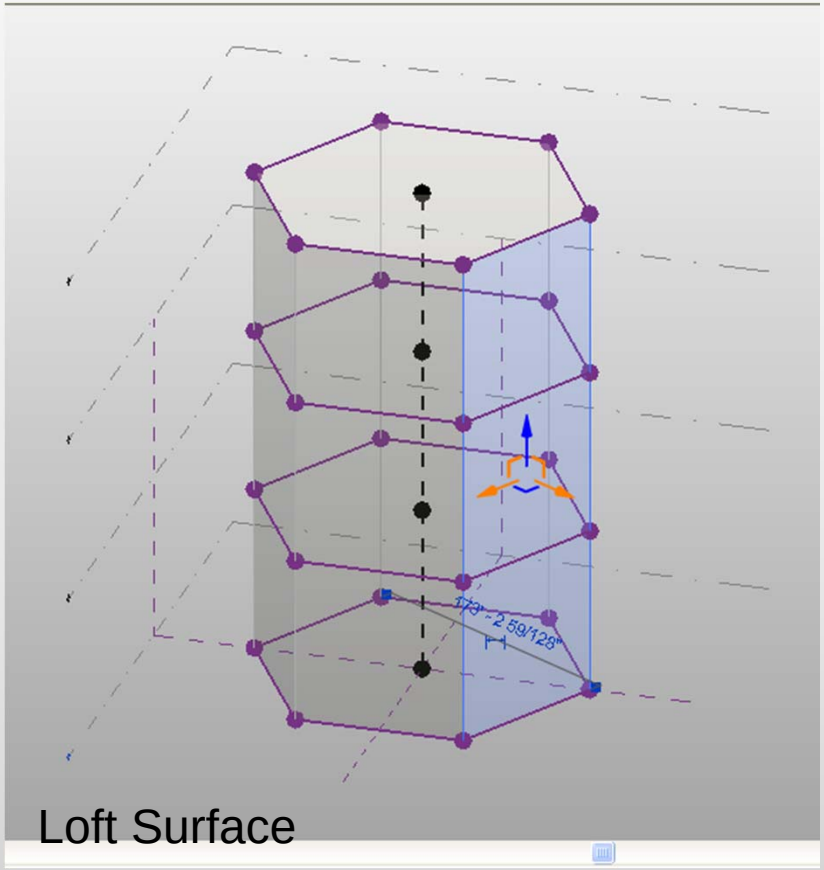
Conceptual Mass

- Step 03: Create the mass from the selected lines.

  Create → Create Form



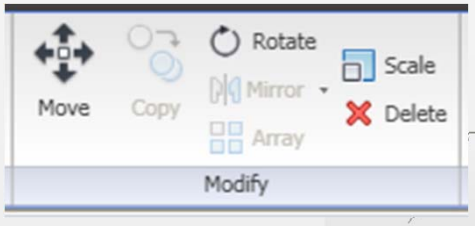


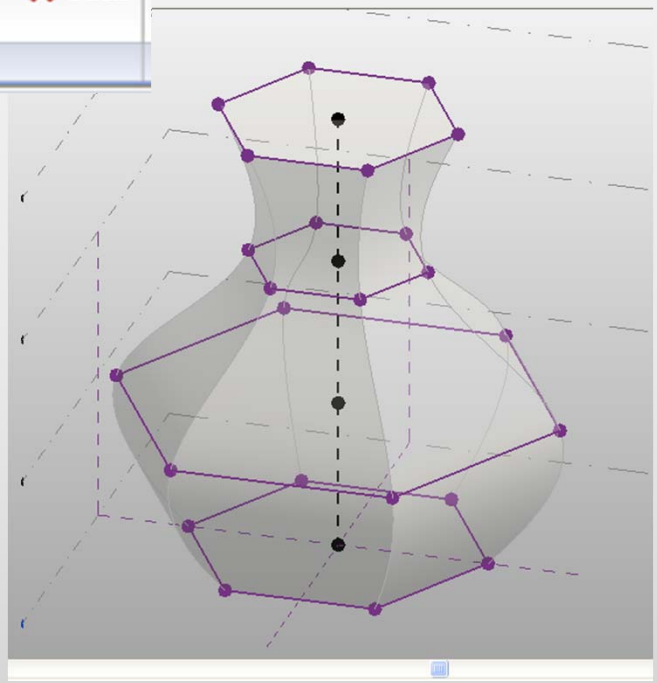


Conceptual Mass

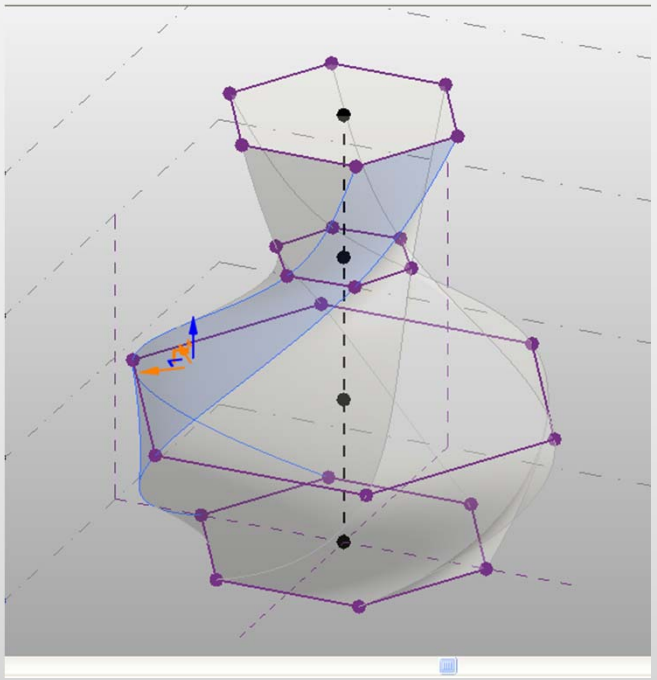
- Step 04: Modify mass by changing profiles.

Modify Form → Modify





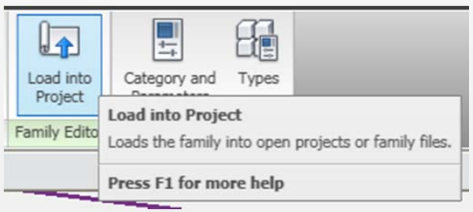
Scale



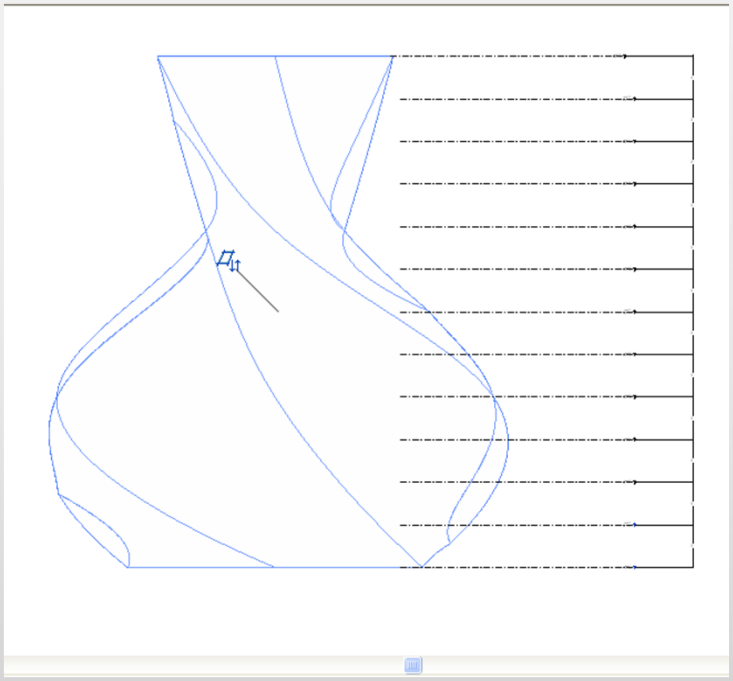
Rotate

Conceptual Mass

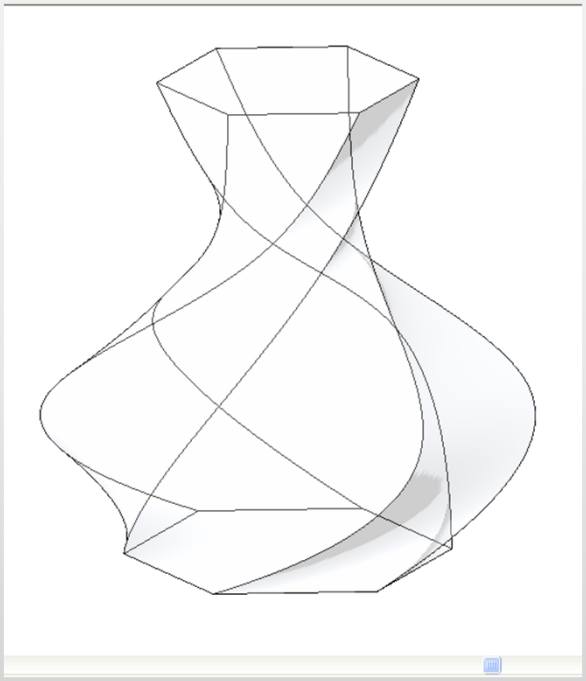
- Step 05: Load the Mass to the project.



Modify Form → Family Editor → Load into Project



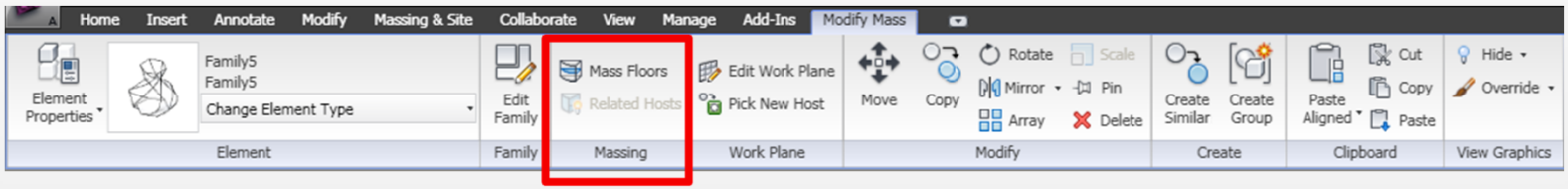
Elevation view



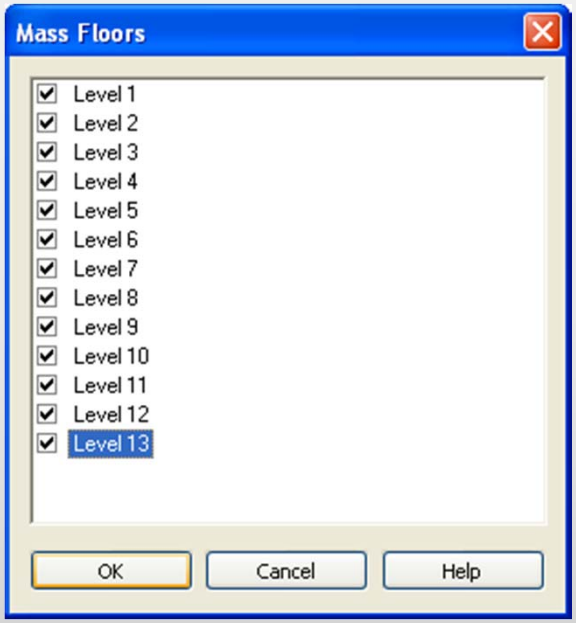
Perspective Shading with Edges

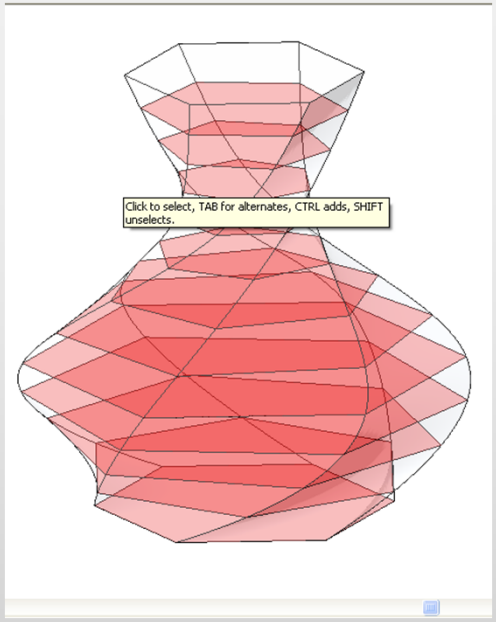
Conceptual Mass

- Step 06: Create Mass Floors.



Modify Mass → Massing → Mass Floors



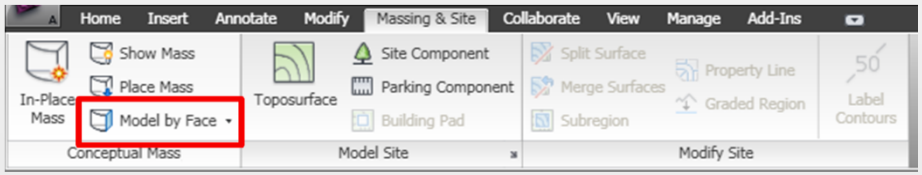


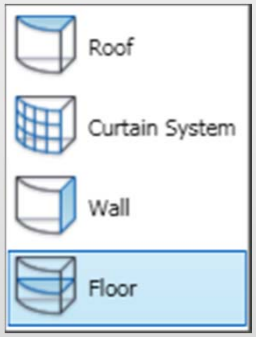
Select levels for mass floors creations.

Conceptual Mass

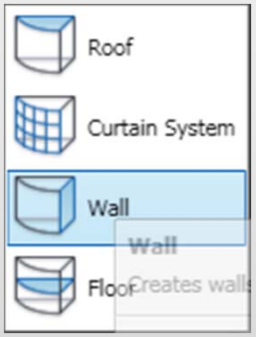
- Step 07: Create floor and wall elements.

Massing & Site → Conceptual Mass → Model by Face

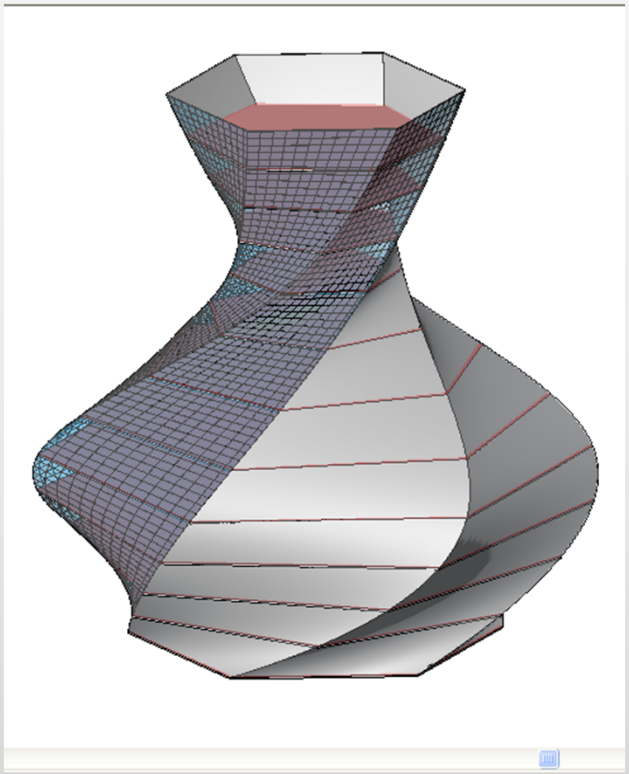




→ Floor

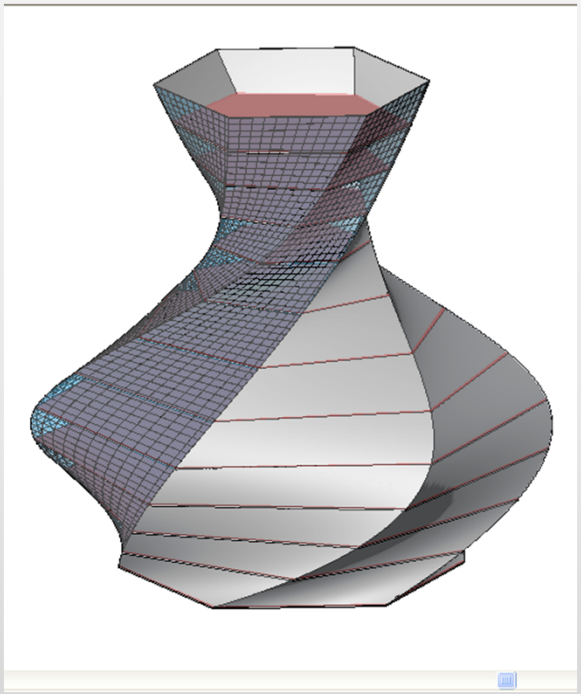


→ Wall



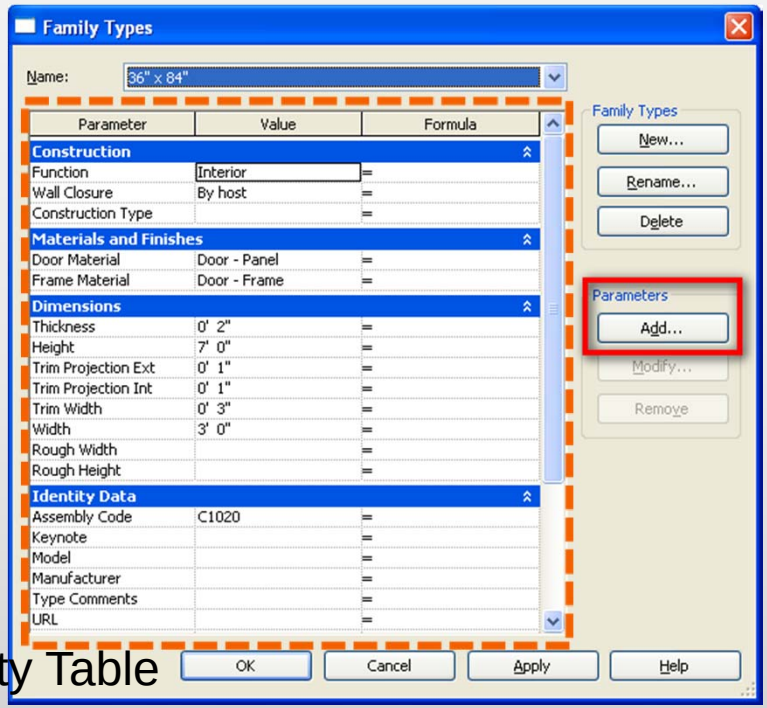
Conceptual Mass (Excersice:03)

- 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

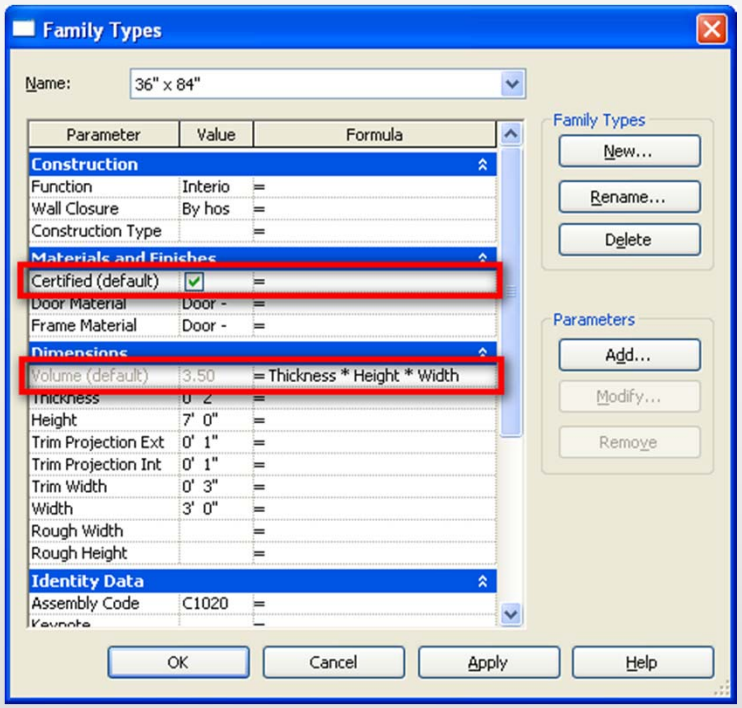
- For Existing Family -> **Edit** Family
- Step 01: Choose Types from Family Properties
- Step 02: Add new parameter to the property table..



Property Table

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,

Volume = Thickness* Height*Width