48-749 Special Topics
Parametric Modeling with BIM

Fall Semester 6-12 units • R1.30-4.30• MM102

Carnegie Mellon University
School of Architecture

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Lecture 1

- Course introduction
- What is BIM ?
- How we use it
- Overview of Revit 2009/2010

Course Introduction

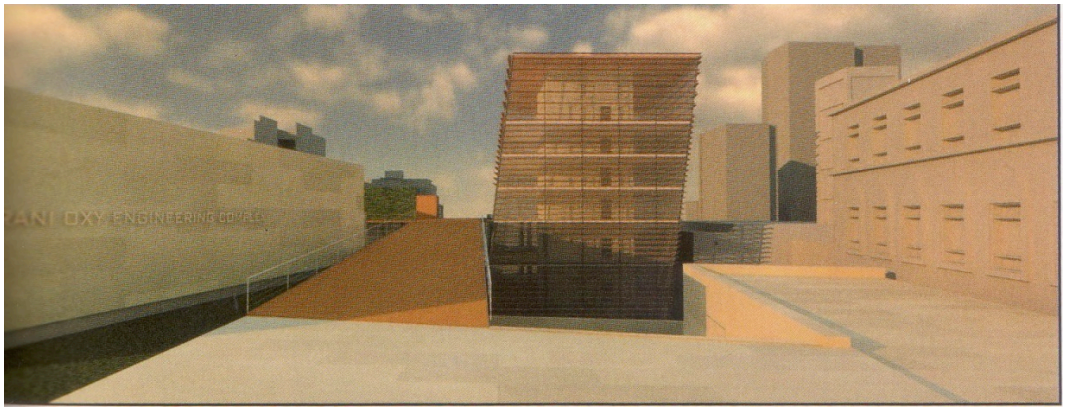
- This course is to prepare students for modeling architectural geometry through development of parametric schemes for architecture applications.
- For students with no programming background, this course is a half-semester course, which supplies the basis of understanding parametric geometric construction mechanisms.
- For all students, the full semester course is regarded as the venue for pursuing individual projects relating to advanced geometric constructions with parametric computation.
- The course will use Revit Architecture 2010, and .NET framework.

Course credit (6-12)

- All students are initially evaluated for 6 units (half-semester course). Students who score *at least* C+ at mid-semester may proceed to the full semester course for credit.
- The project and any accompanying preparatory assignments will be worth an additional 3 units.
- Students may add to their skill and degree of difficulty by completing a Revit-based advanced parametric modeling assignment for an additional 3 units.
  This is required of all Computational Design students.

Course Motivation

- BIM tools, such as Revit, offer a parametric 3D model which can generate information early in the design process (quantity take–offs, solar studies, day-lighting simulation, fabrication possibilities)
- With more parametric control over designed components designers can explore variations, analyze design artifacts, customize components for evaluation and be more efficient.



Course schedule

Date	Lecture and topic	Assignment
Week 1 08/27	**Introduction to building information modeling** *Introduction to Revit Architecture 2010*	
Week 2 09/03	**BIM capabilities** *Construction of a simple project*	**MA 1**
Week 3 09/10	**BIM in the AECM domain** *Revit (Lighting Studies, Recycled content calc^{n})*	**MA 1 due/MA 2**
Week 4 09/17	**Type of families** *Revit Modeling 3d Families I*	
Week 5 09/24	**Categories and Parameters** *Revit Modeling 3d Families II*	**MA 2 due/MA 3**
Week 6 10/01	**Encoding Design Rules** *Revit Modeling 3d Families III*	
Week 7 10/08	**Prototyping** *Revit Modeling 3d Families IV*	**MA 3 due**

Course schedule

Date	Class	Assignment
Week 8 10/22	**Introduction to .NET SDK** *Introduction to .NET SDK and C#*	**Project**
Week 9 10/29	**Introduction to Database** *Database and SQL*	
Week 10 11/05	**Databases used to automating modeling process** *Databases I and II*	**Project proposal**
Week 11 11/12	**Databases used to automating modeling process** *Databases III and IV*	
Week 12 11/19	**LEED credit evaluation using:** *Databases I - IV*	
Week 13 11/25-27	**Thanksgiving Holiday (NO CLASS)**	
Week 14 12/03	**Project assistance**	
Week 15 12/10	**Review** **Final Presentation**	**Projects due**

What is BIM

- The acronym BIM (Building Information Model(ing)) was coined in the early 2002 (attributed to Jerry Laserin though the concept predates this by at least 15 years)
- BIM relies on the creation and collection of interrelated computable information about a building project
- BIM processes revolve around virtual models that make it possible to share information through out the building industry

What is BIM

- These models are embedded with data, which, when shared among design team members, can reduce errors and facilitate an integrated process.
- The federal government has predicted savings of $15.8 billion annually from an integrated process.
- Projects today using BIM properly save 5-12% on overall process costs

What is BIM?

- BIM is an information based system that builds long term value and advances innovation
  - It can improve how projects are designed and built
  - It improves the environment and builds economic value
- BIM can be looked at in this course as "Beyond Information Models" to understand the nature of the concept
- For clarity we will use bim to represent applications– Archicad, Microstation/GCand Revit bim tools

What BIM is not

- BIM is neither a single building model
  nor a single database

  (series of interconnected models and databases)

- BIM is not a replacement for people

- BIM is neither perfect nor a panacea

What BIM is not

- BIM is not 3D
- BIM does not have to be 3D.
- Example : A spread sheet can be a BIM
- BIM is not complete
- BIM is not a software application–
  (eg, Revit, ArchiCAD or Microstation/GC etc)

How BIM is used pragmatically

- As a distributed relational parametric database

- *So where does the knowledge manifest itself?*

How BIM is used in this course

- Focus is on the power of bim tools mainly to evaluate facets of sustainable building design
- Using information from a BIM we are able to count, sort and calculate different requirements set by sustainable building rating systems
  - Material resources
    - Recycled material content
  - Water resources
    - Water usage and savings
  - Energy use
    - Energy use reduction by optimizing façade/envelope of building

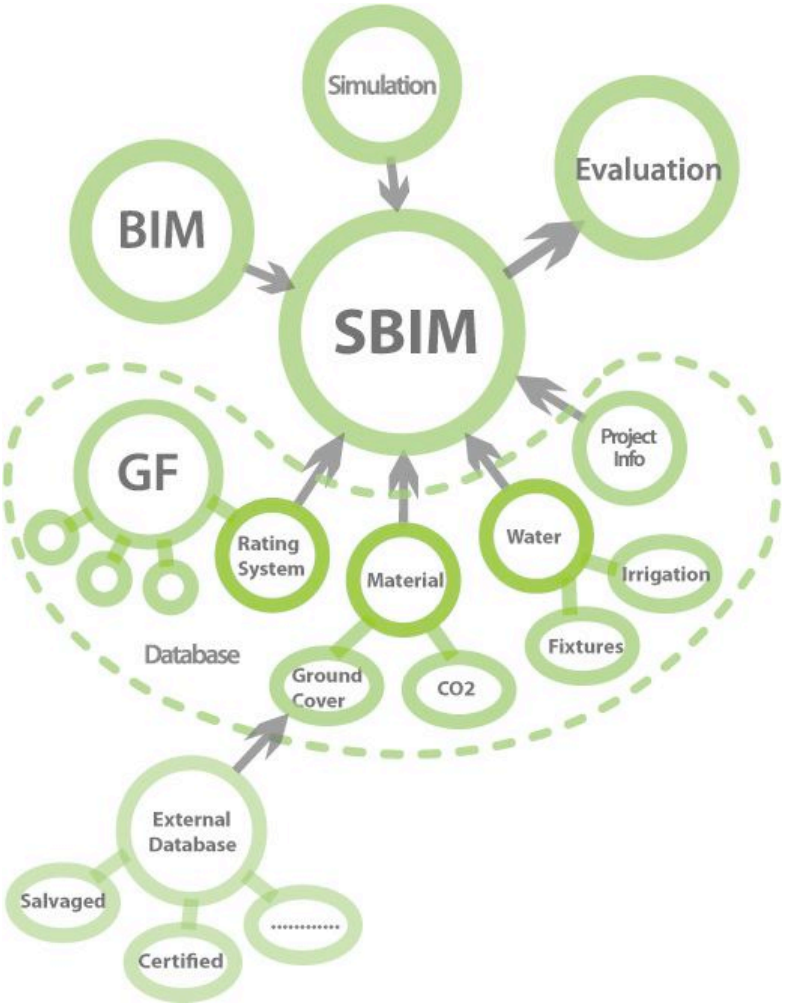
How BIM is used in this course

- Sustainable building rating systems are defined as tools which examine the performance or expected performance of a 'whole building' and translate that examination into an overall assessment that allows for comparison against other buildings
  - LEED (Leadership in Energy and Environmental Design) – USGBC
  - BREEAM (Building Research Establishment's Environmental Assessment Method) – UK
  - CASEBEE (Comprehensive Assessment System for Building Environmental Efficiency) – Japan

Overview of rating systems

General Assessment Area	LEED 3.0	Green Star	BREEAM
Management		Management	Management
Energy & Atmosphere	Energy	Energy	Energy
Emissions		Emissions	Pollution
Sustainable Sites	Sustainable sites	Land Use and Ecology	Land Use and Ecology
		Transportation	Transportation
Water Efficiency	Water Efficiency	Water	Water
Indoor Air Quality	Indoor Air Quality	Indoor Environmental Quality	Health and Well Being
Quality of Service			
Materials and Resources	Materials and Resources	Materials	Materials
Innovations	Innovations	Innovation	
Culture and Heritage			

Structure of our Application



Revit as a bim software

- Creates a 3D 'parametric' model which produces an abstraction of plans, elevations, sections and schedules using databases.
- Propagates and manages changes throughout these databases so that a change to any part of the database is reflected in all other associated parts of the database
- Captures and preserves information for collaboration and reuse by additional industry-specific applications

Revit as a bim software

- Bidirectional Associatively
- All views (eg, plan, section, schedule) use the same database
- No updates needed (automatic)
- Parametric Relationships
  - Software manages and coordinates changes

    Example:
    You have equally spaced windows across an elevation. Length of elevation changes. The spacing between the windows changes but the relationship of equal spacing is maintained

Revit vs. AutoCAD

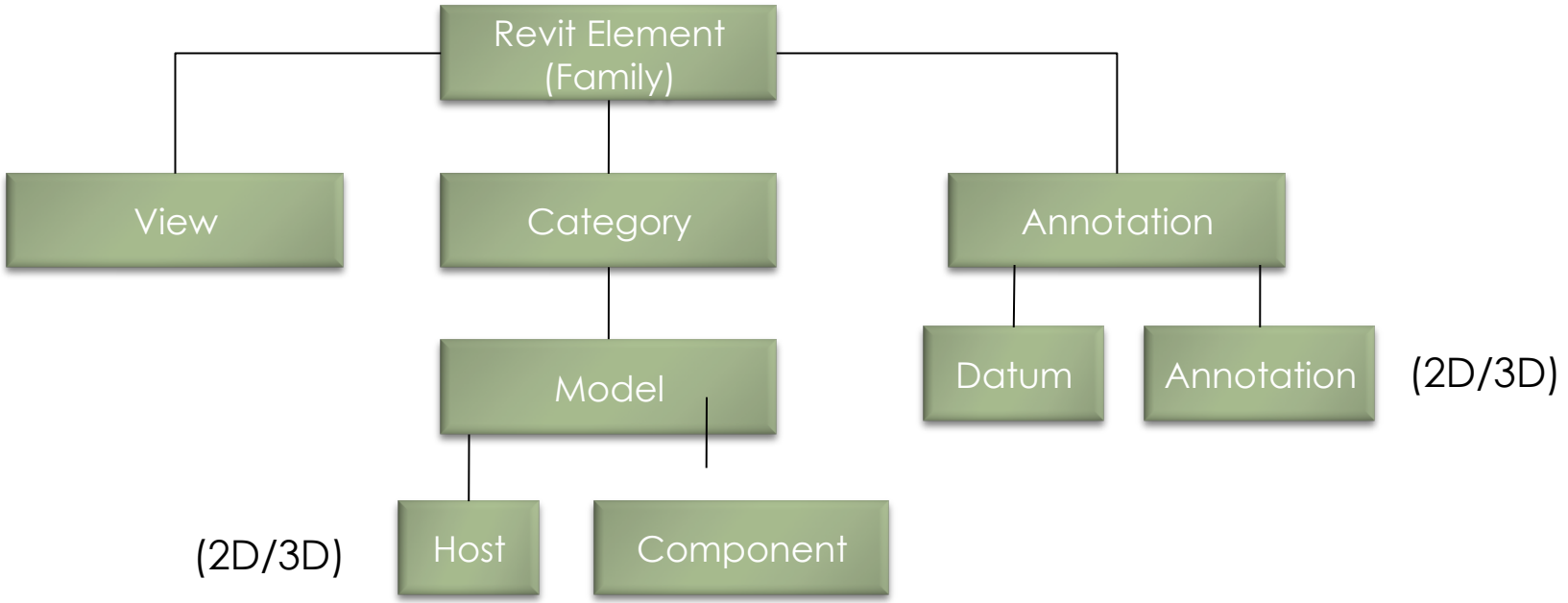
- Revit is a true architectural model (not just geometry)
- Revit is parametric
- Revit uses “families” not blocks
  (eg, doors, windows)
- Revit uses alignment instead of osnaps
- Revit has multiple design views
  (plan, elevation, perspective, section)

Revit vs. AutoCAD

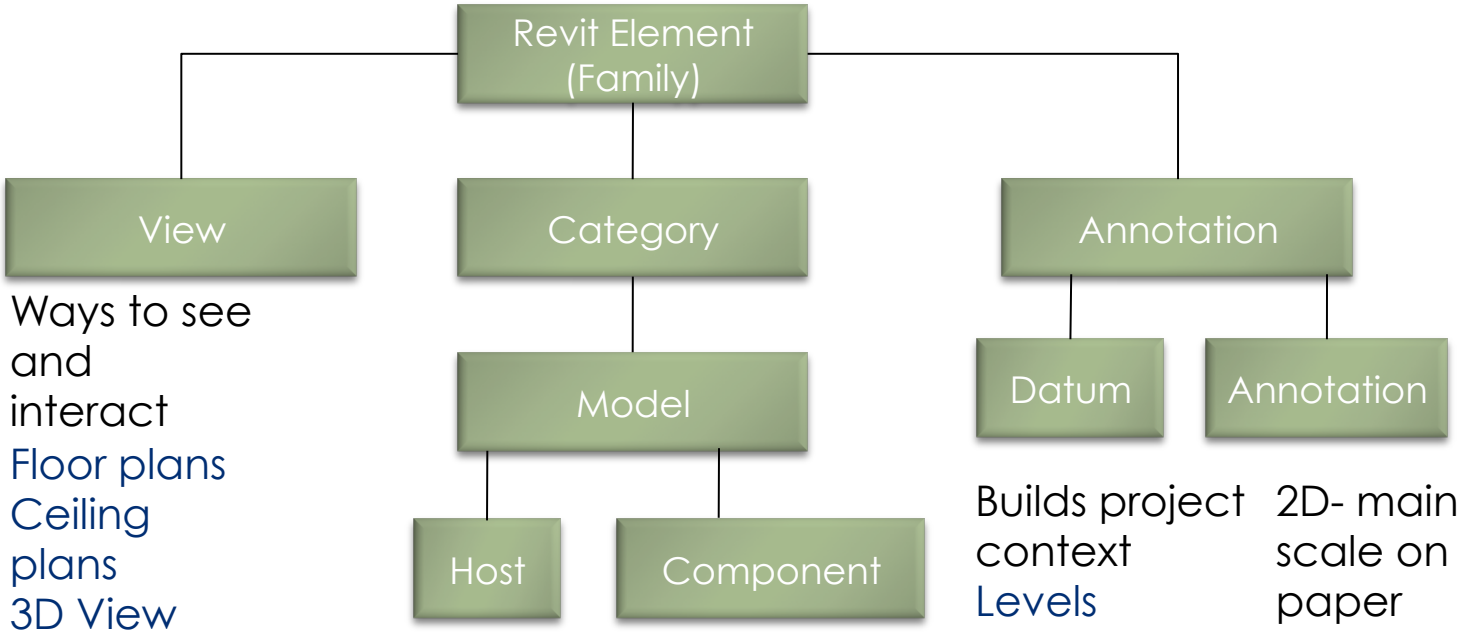
- No command line or layers in Revit
  - Visibility controlled by categories
- Revit uses single file, multiple users projects
- Revit imports/exports AutoCAD file type (.DXF and .DWG)

Revit Fundamentals

- Revit Parametric Elements
  - Every Element in Revit is considered a family
  - Each family belongs to a category



Revit Fundamentals



Ways to see and interact
- Floor plans
- Ceiling plans
- 3D View
- Elevation
- Sections
- Schedules

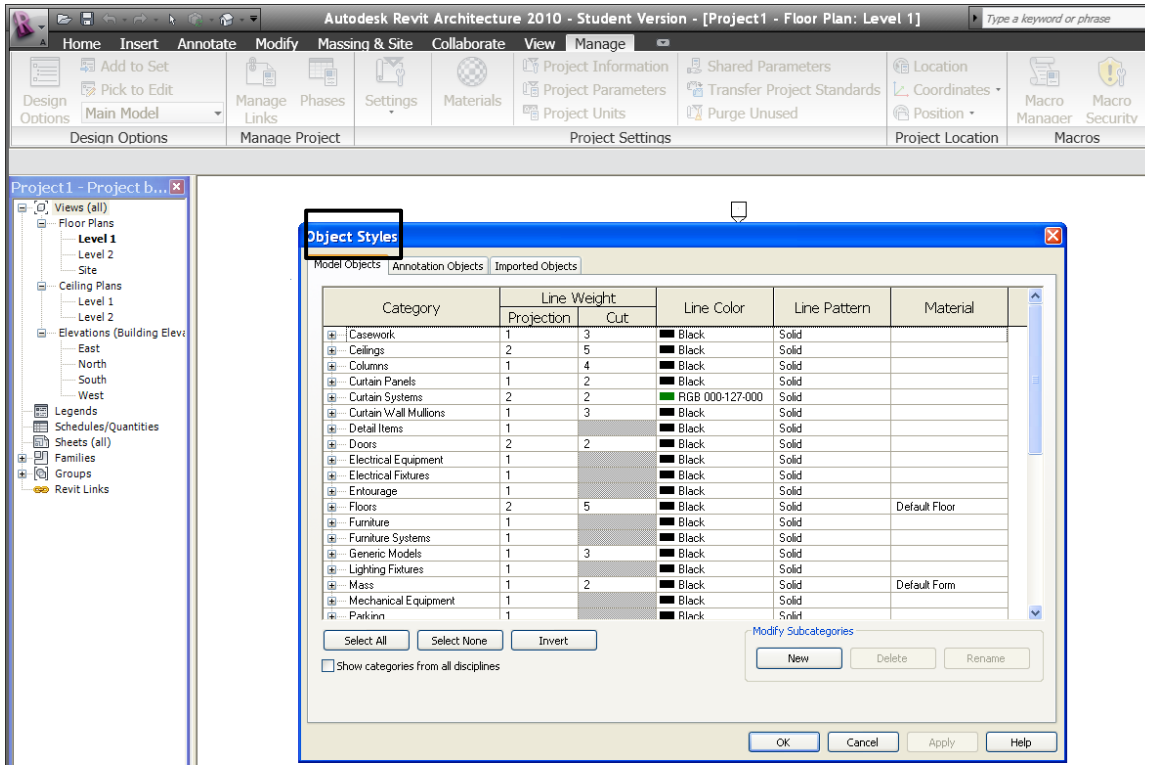
Built in place -
- Floors
- Walls
- Roofs
- Ceilings
- Stairs
- Ramps

Everything else in the model -
- Doors
- Windows
- Furniture
- Specialty items

Builds project context
- Levels
- Column grids
- Reference planes

2D- maintains scale on paper
- Dimensions
- Text notes
- Symbols

Revit Fundamentals- Model



Manage> Settings> Object Styles

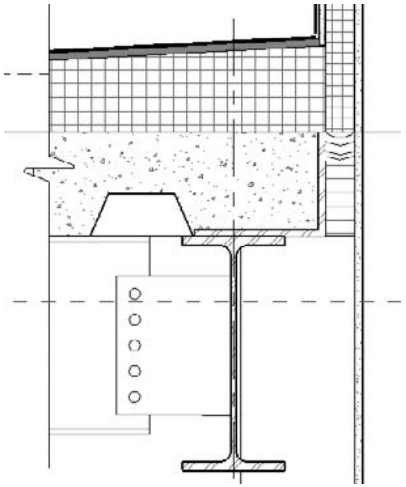
Model categories include elements like walls, floors, roofs etc.

Model elements appear by default in all view-plan, elevations, section and 3D views

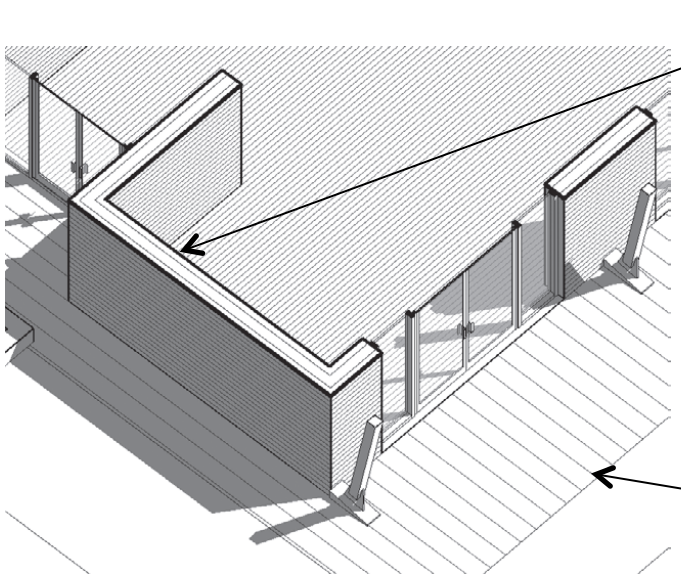
Detailed components only appear in views that they are placed.

Projection view shows elements where they have not been cut

Revit Fundamentals- Model

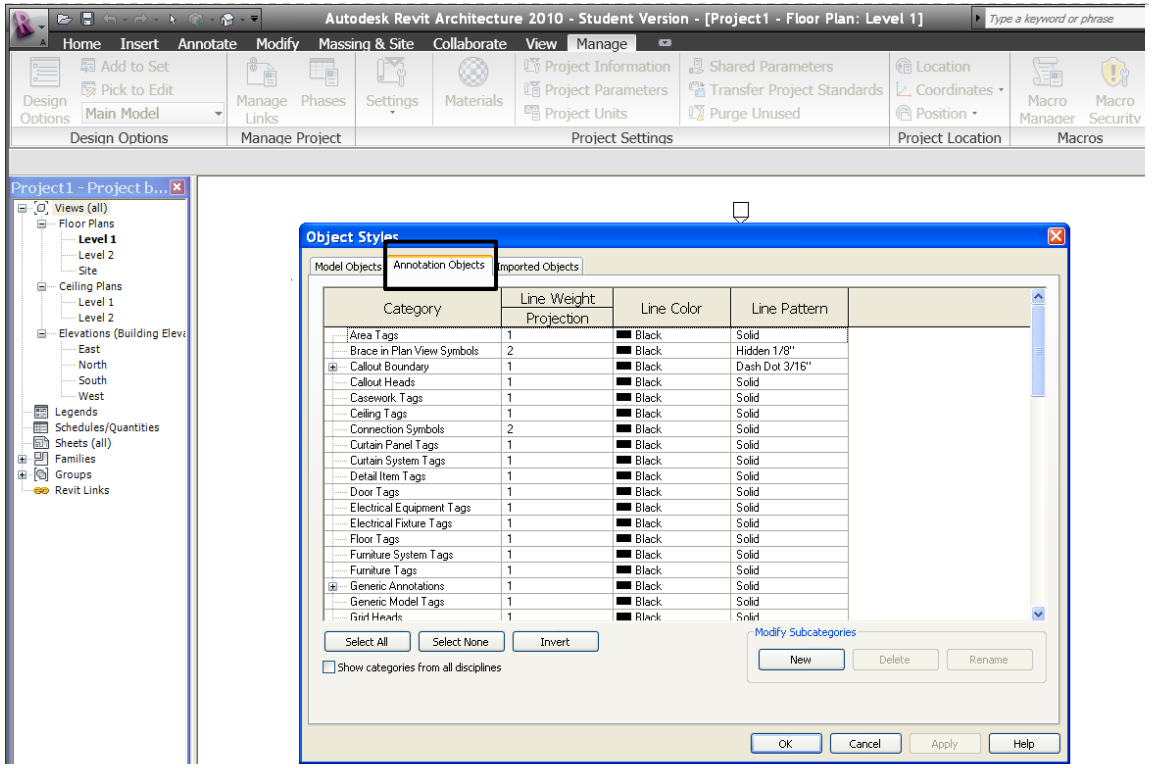


Detailed components only appear in views that they are placed.



Projection view shows elements where they have not been cut

Revit Fundamentals- Annotation

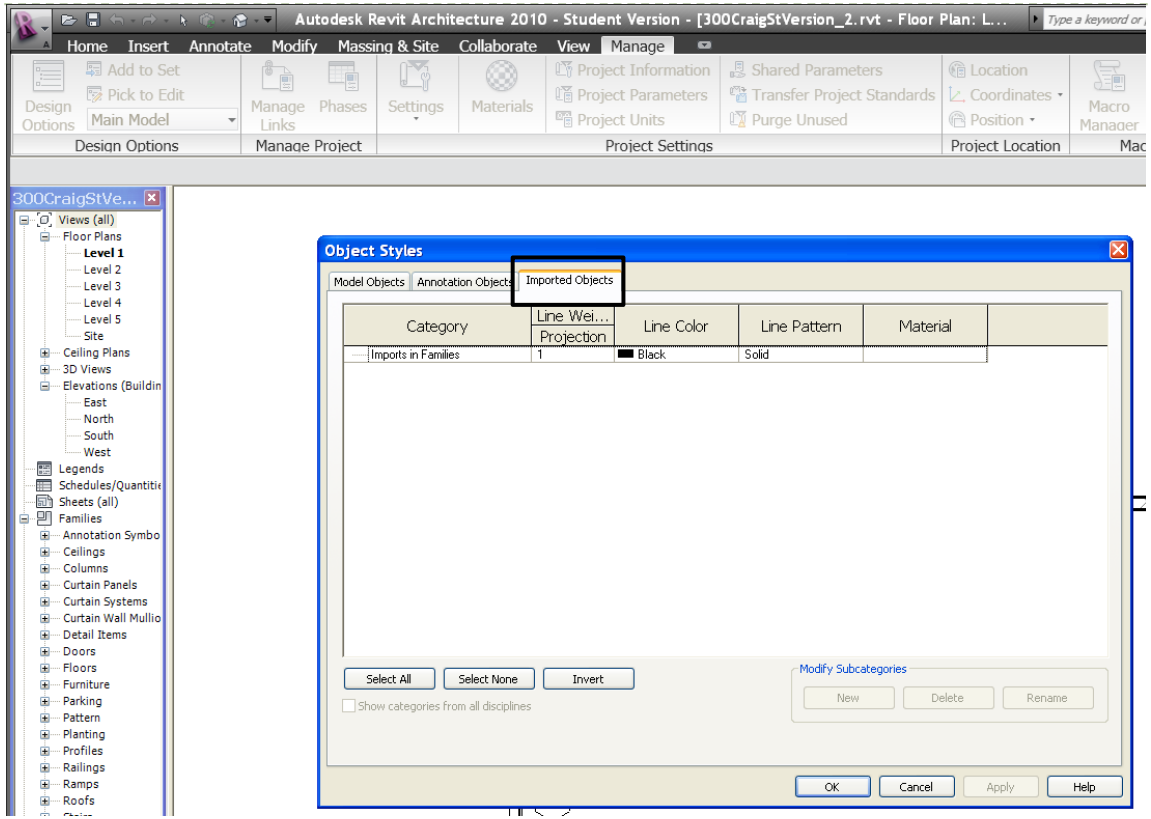


Annotation categories include annotations, symbols and descriptive data

Examples- dimensions, tags, callouts

Annotations such as grids, sections, levels are 2D graphics but have 3D characteristics as they appear in other views

Revit Fundamentals- Views



Views are considered parametric elements

Properties can be defined to display information

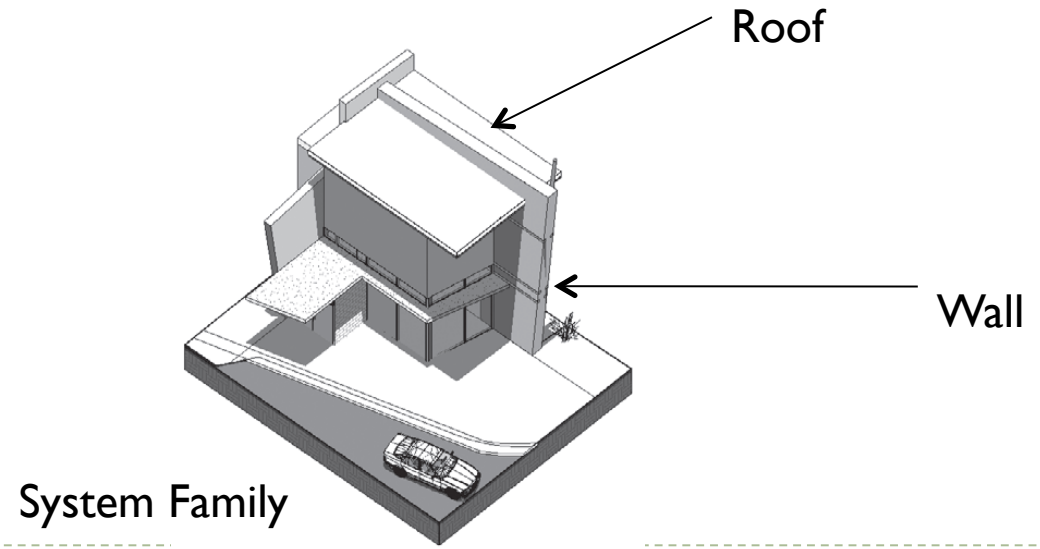
Schedules are also abstract ways to view a model

Revit Fundamentals- Parametric element

- A parametric element is something which can change size, material and graphic look but is still the same fundamental element.
- Most elements in Revit allow for the creation of variations of a base type.
  - Example each type of door typically represents a variation in size, material, color, but is derived from the same family
- Type parameters affect all instances in the same family
- Instant parameters affect only the selected instance

Revit Families

- System Families
- Component Families
- In-Place Families
- Difference lies in their creation methods, in what context they are created and the types of parameters available

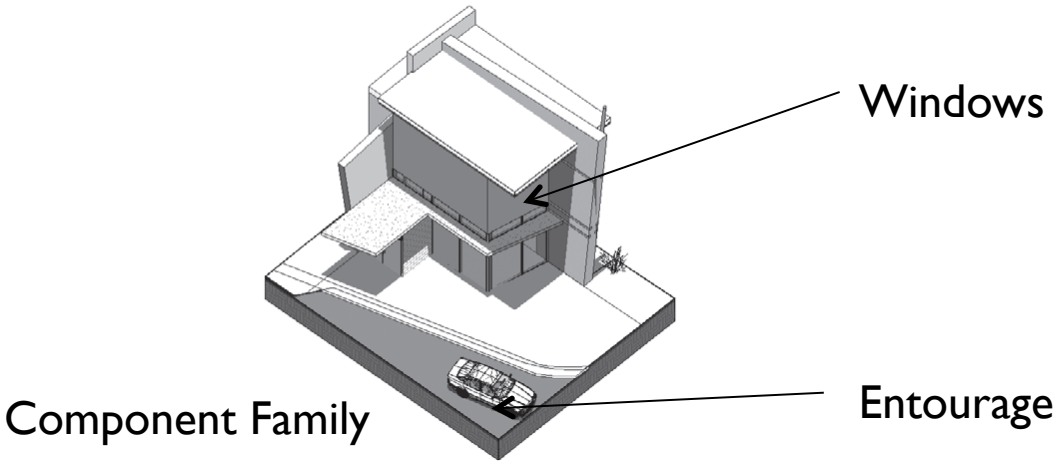


Revit Families- System Families

- They are made of limited categories–
  walls, roofs, floors, ceilings, stairs, railings, mechanical equipments and topo surfaces
- They have different creation methods:
  - Walls – draw/place a wall
  - Floor/Roof – has to be in *Sketch Mode* then it generates a 3D model
  - Floors and railings more detail in *Sketch Mode* that has additional features that floors do not have

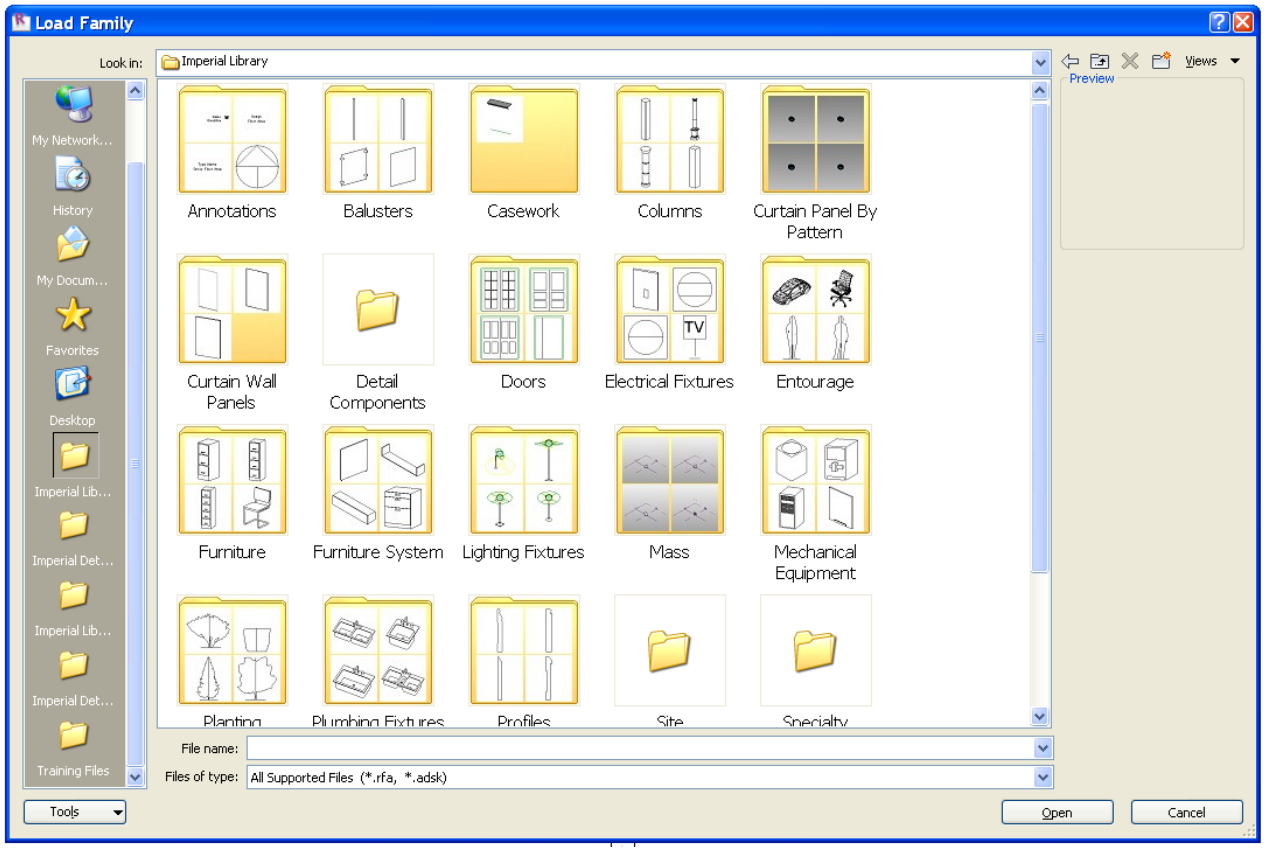
Revit Families- Component Families

- Components or standard families are created outside the project environment using the family editor.
  These are stored in an external library which can be loaded into the project.
- Each component belongs to a specific Revit category.
- They have their own extension .rfa



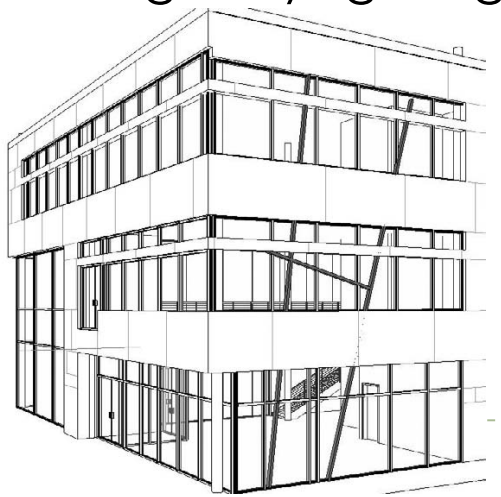
Revit Families- Component Families

- Go to insert tab > Choose Load Family

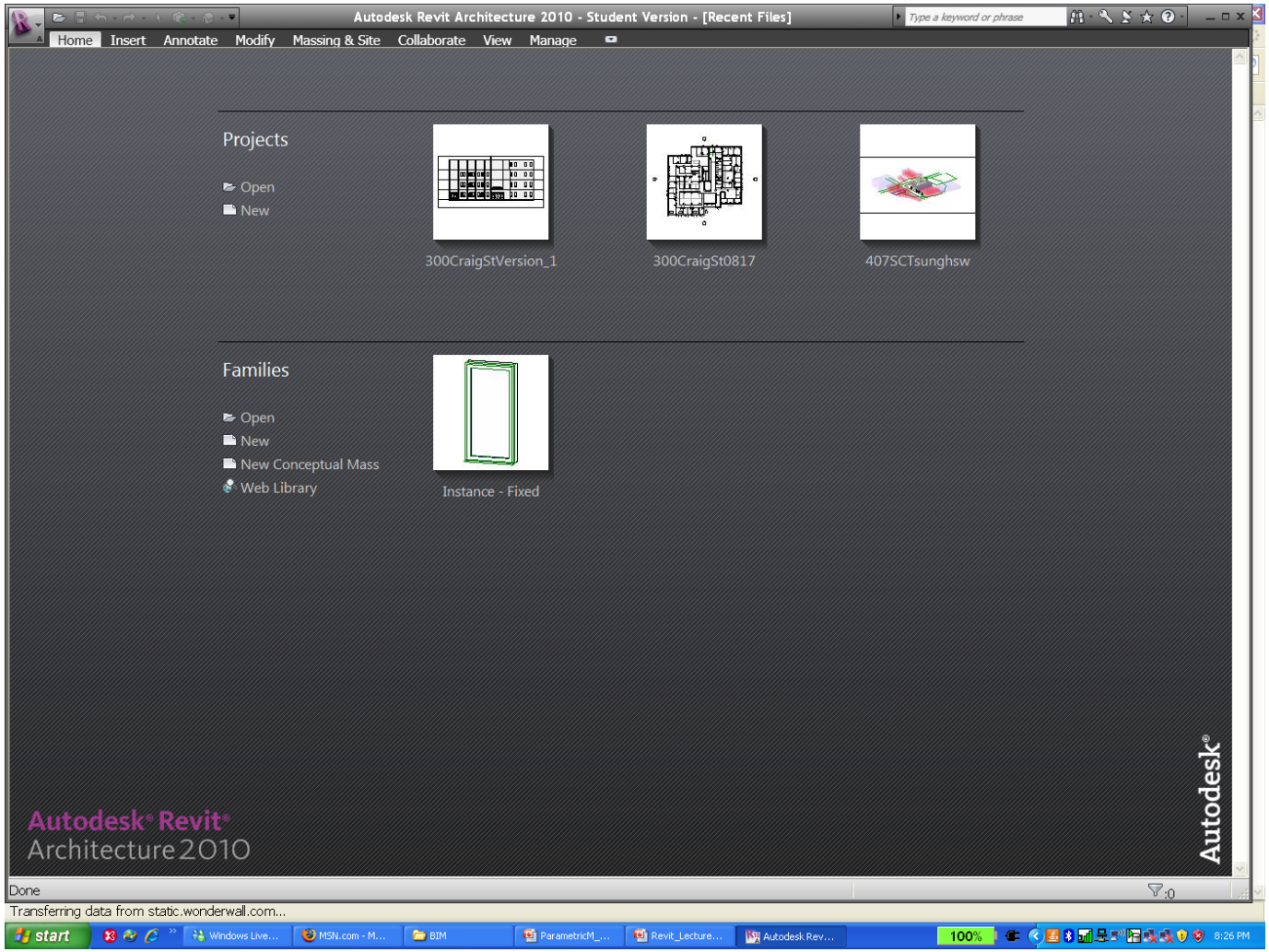


Revit Families- In Place Families

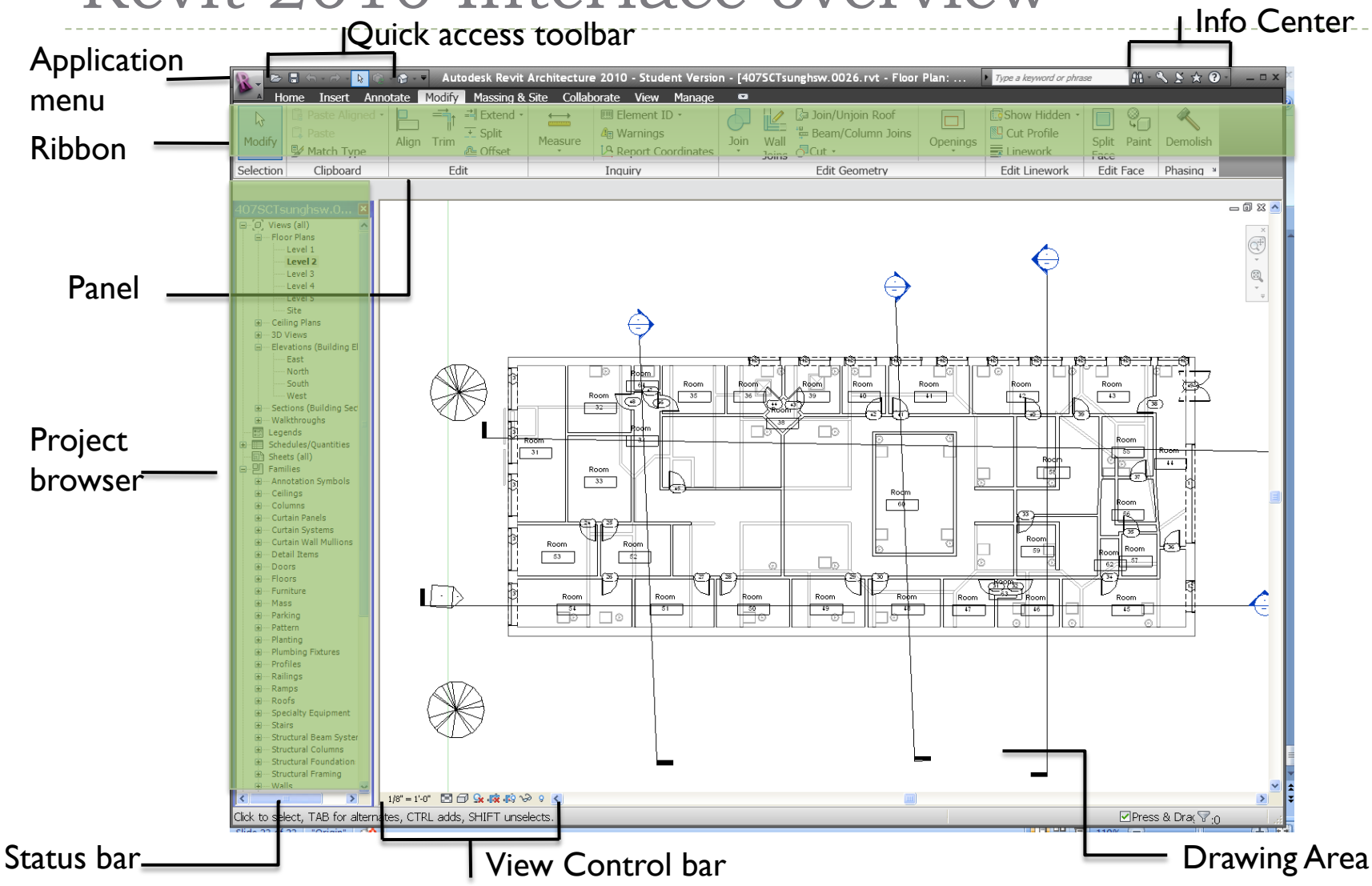
- In place families are custom elements that are specific to a project and the conditions of the project.
- The model grays out and becomes in-selectable when such families are made.
  - Example, a non vertical wall shape or skewed mullion
- These can be copied from project to project
- These do not interface well with energy modeling, day lighting tools or direct-to-fabrication .



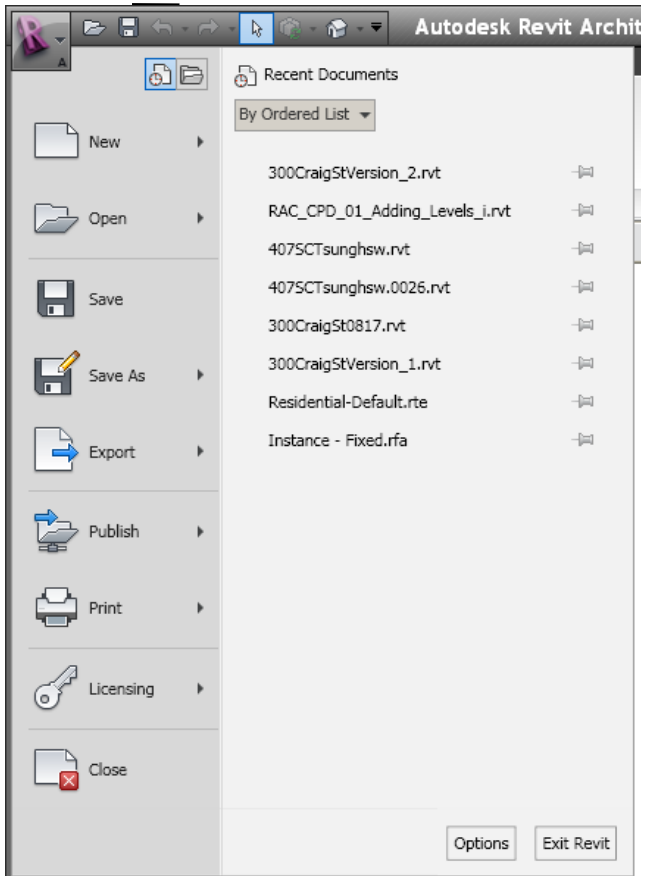
Revit 2010 Interface Overview



Revit 2010 Interface overview

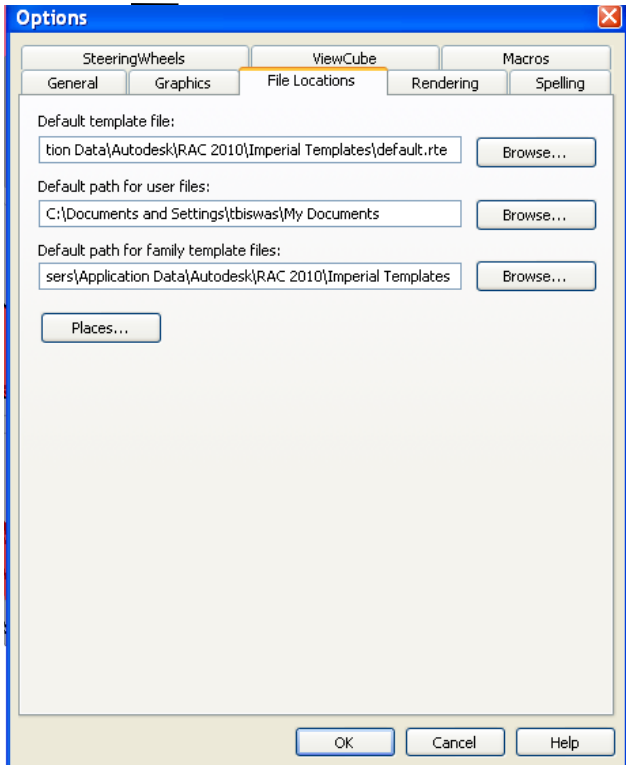


Revit 2010 Interface, Application menu



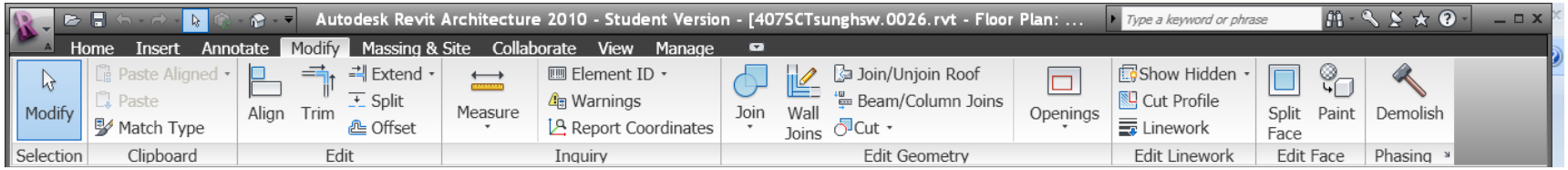
- The big purple R on top left
- It allows to open and create new/ existing projects/families
- Allows to save and export in various formats
  - RVT = Revit Projects
  - RTE= Revit Templates

Revit 2010 Interface, Application menu



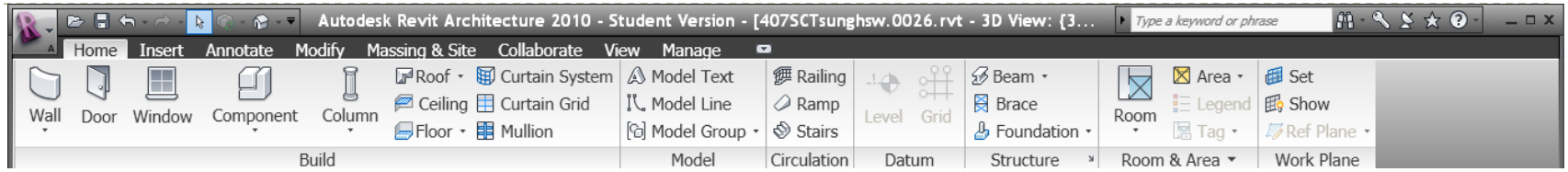
- Option allows the following settings
  - File location
  - Settings relevant to steering wheels
  - The view cube
  - Spelling
  - Macro
  - General settings-such as saving time intervals

Revit 2010 Interface, Ribbon

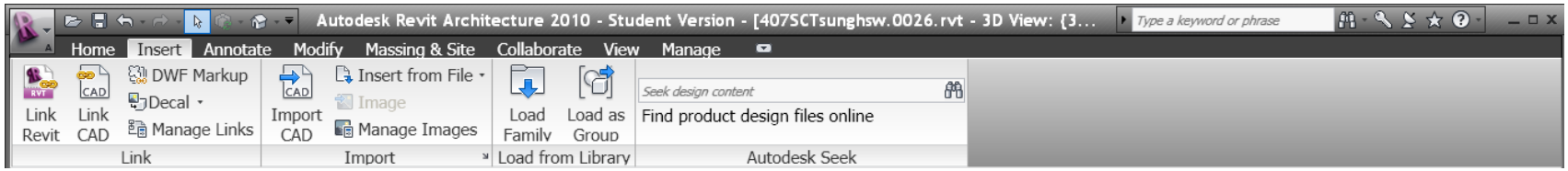


- The ribbon is organized in tabs and panels
- Eight Tabs
  - Home
  - Insert
  - Annotate
  - Modify
  - Massing and Site
  - Collaboration
  - View
  - Manage

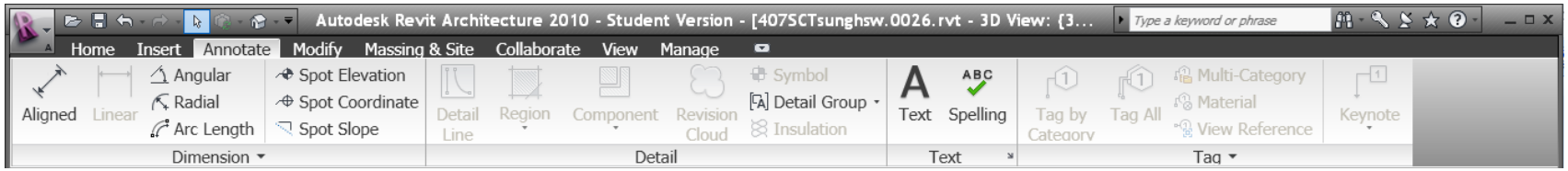
Revit 2010 Interface, Ribbon



Home- contains all tools to create 3D elements

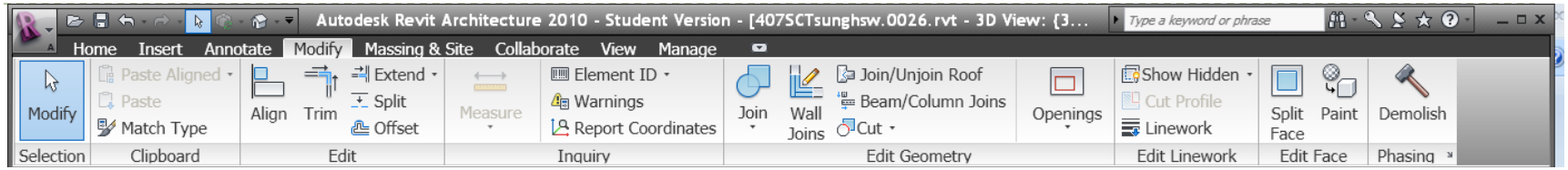


Insert – imports and manages CAD files and Raster images

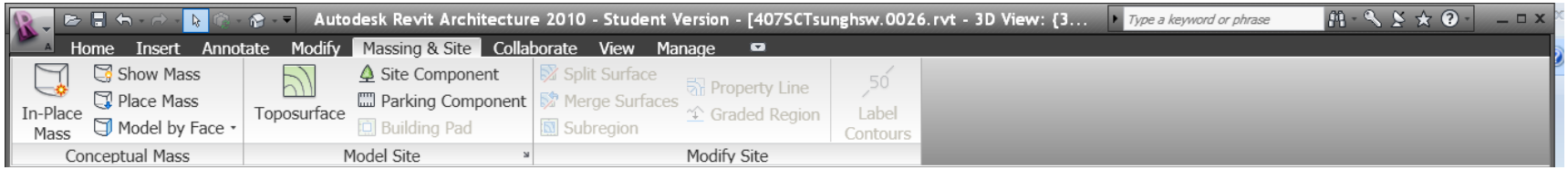


Annotate – Contains all tools for adding 2D elements to describe building model in a project

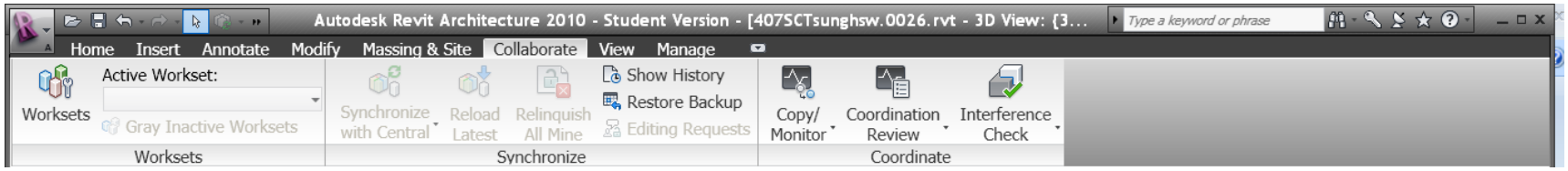
Revit 2010 Interface, Ribbon



Modify – Once elements are created they have to be changed or edited

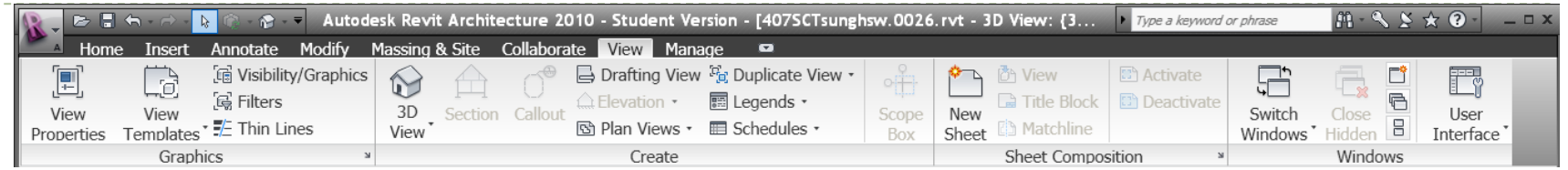


Massing and Site – creating and modifying conceptual mass models

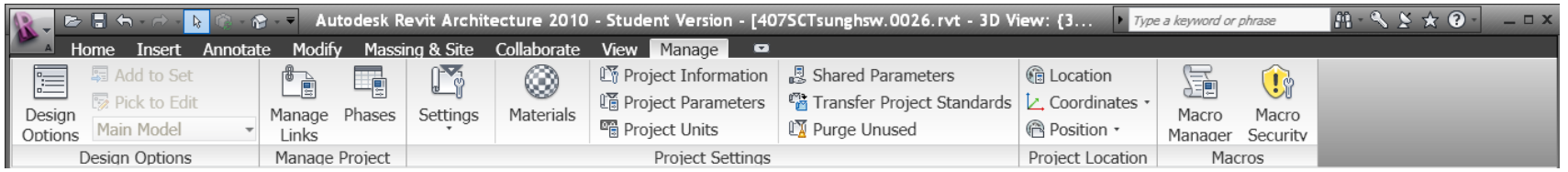


Collaborate – Tools that aid in collaboration on the same project

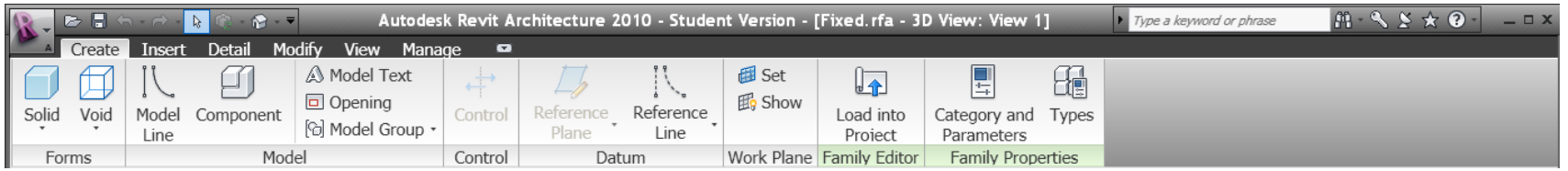
Revit 2010 Interface, Ribbon



View – Many views are different queries into the Revit database

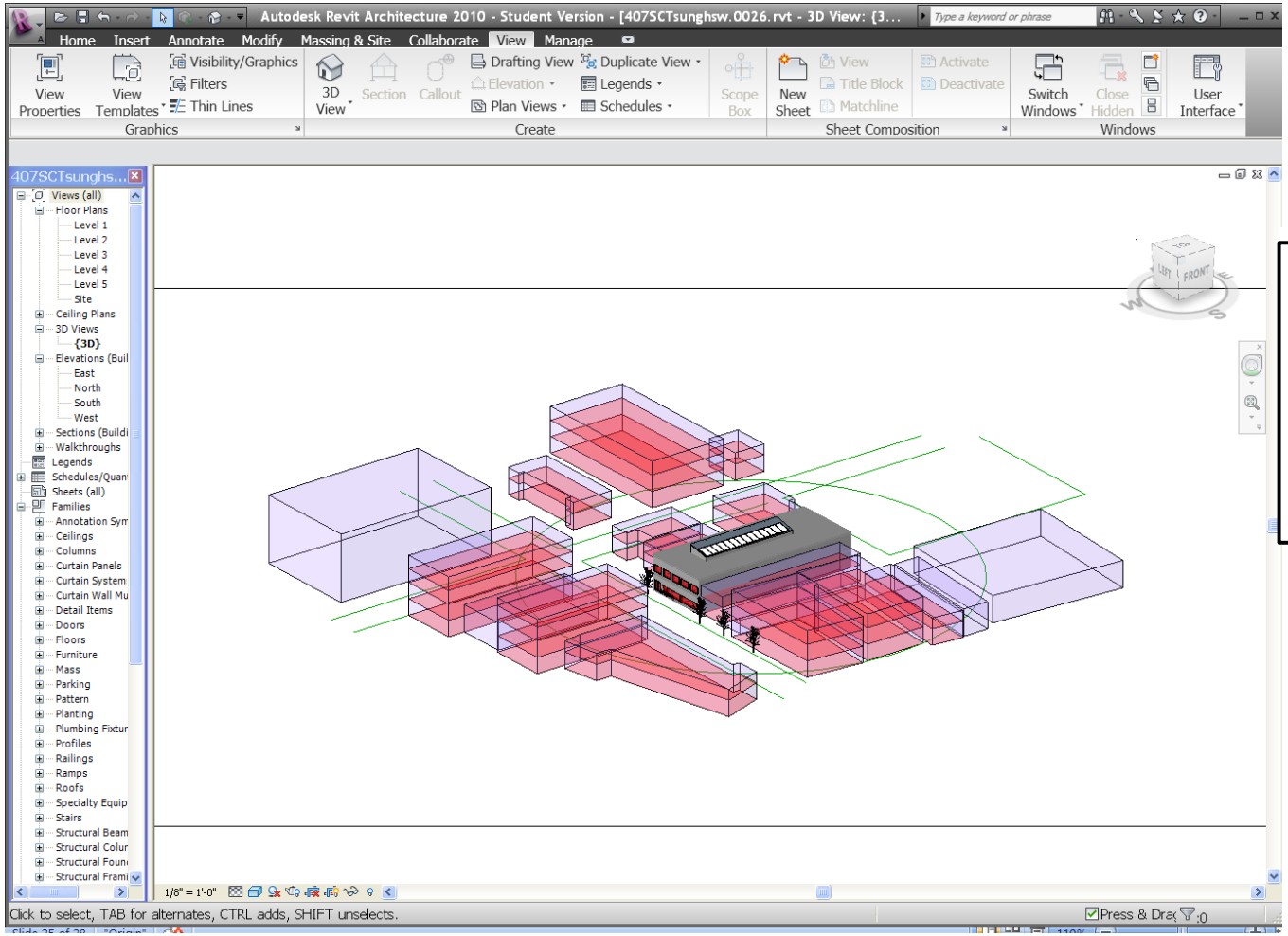


Manage – Design options as well as project related settings are located here



Create – Only available on family editor, necessary tools to create a family

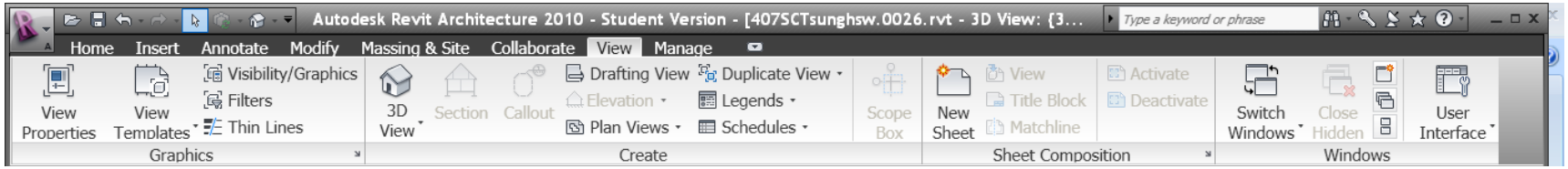
Revit 2010 Interface, View window

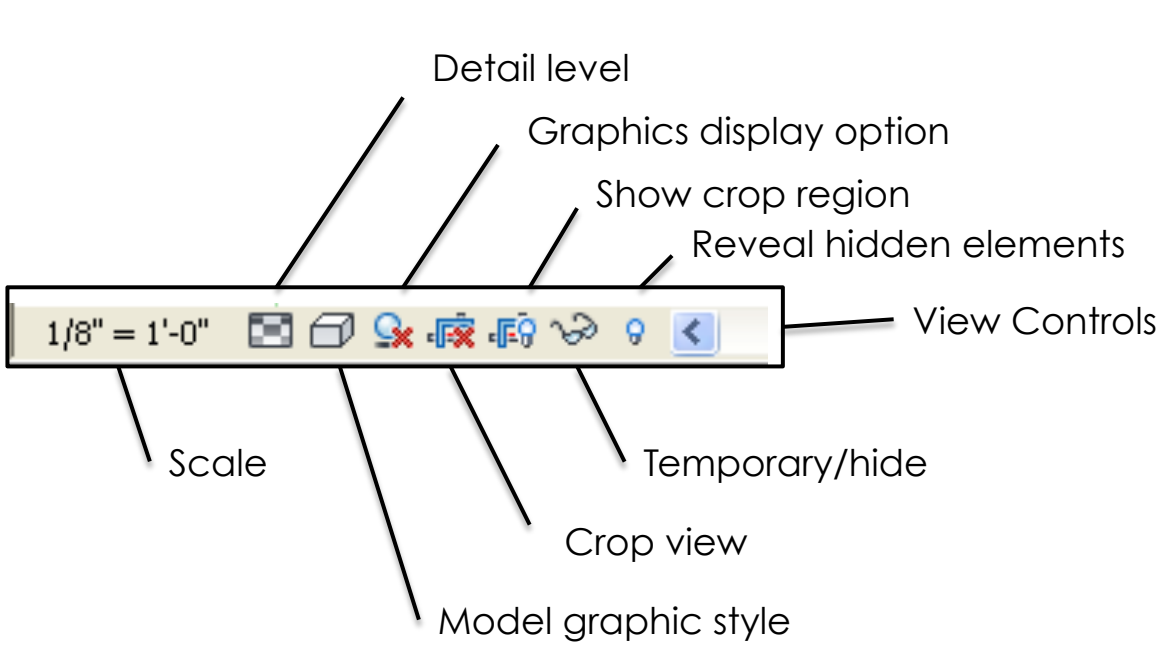


Steering wheel and View Cube

View Controls

Revit 2010 Interface, View window



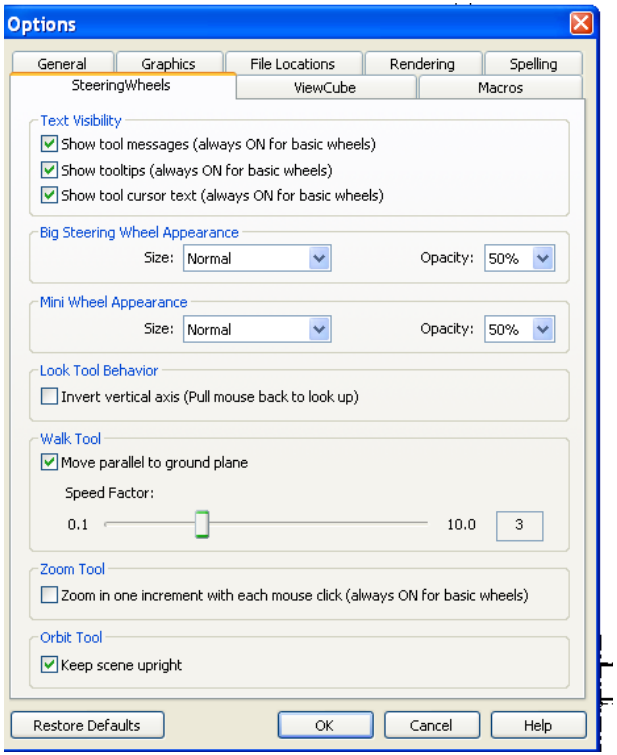


Steering wheel
Allows 2D zoom, pan and rewind

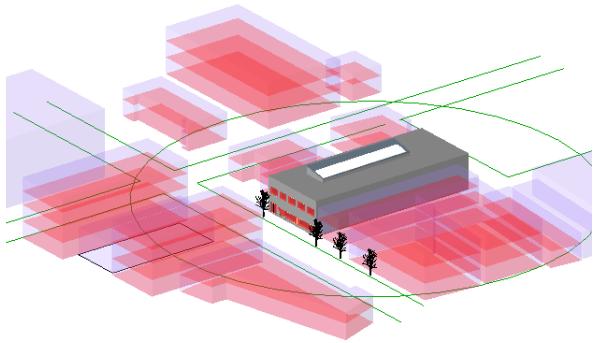
Revit 2010 Interface, View window

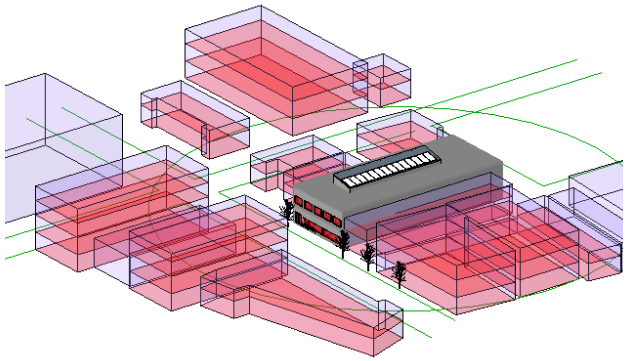
Navigation Wheel (F8)

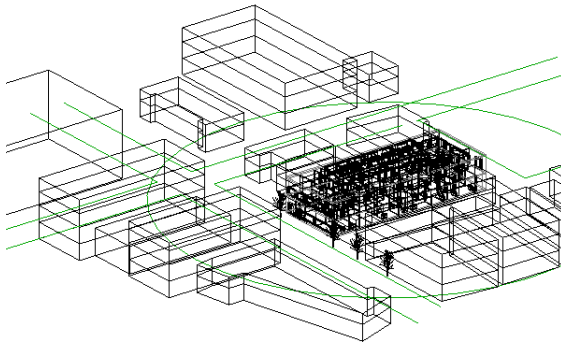
Right click and choose Options… to set the Steering Wheel parameters

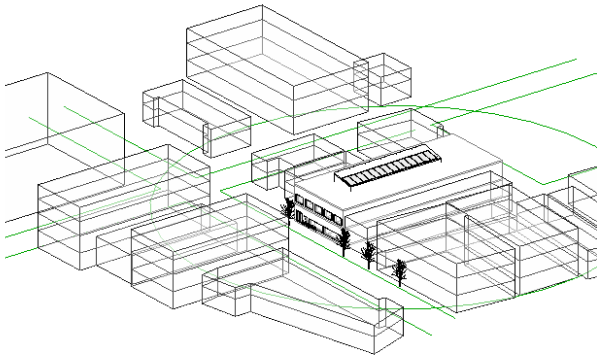


Revit 2010 Interface, View window



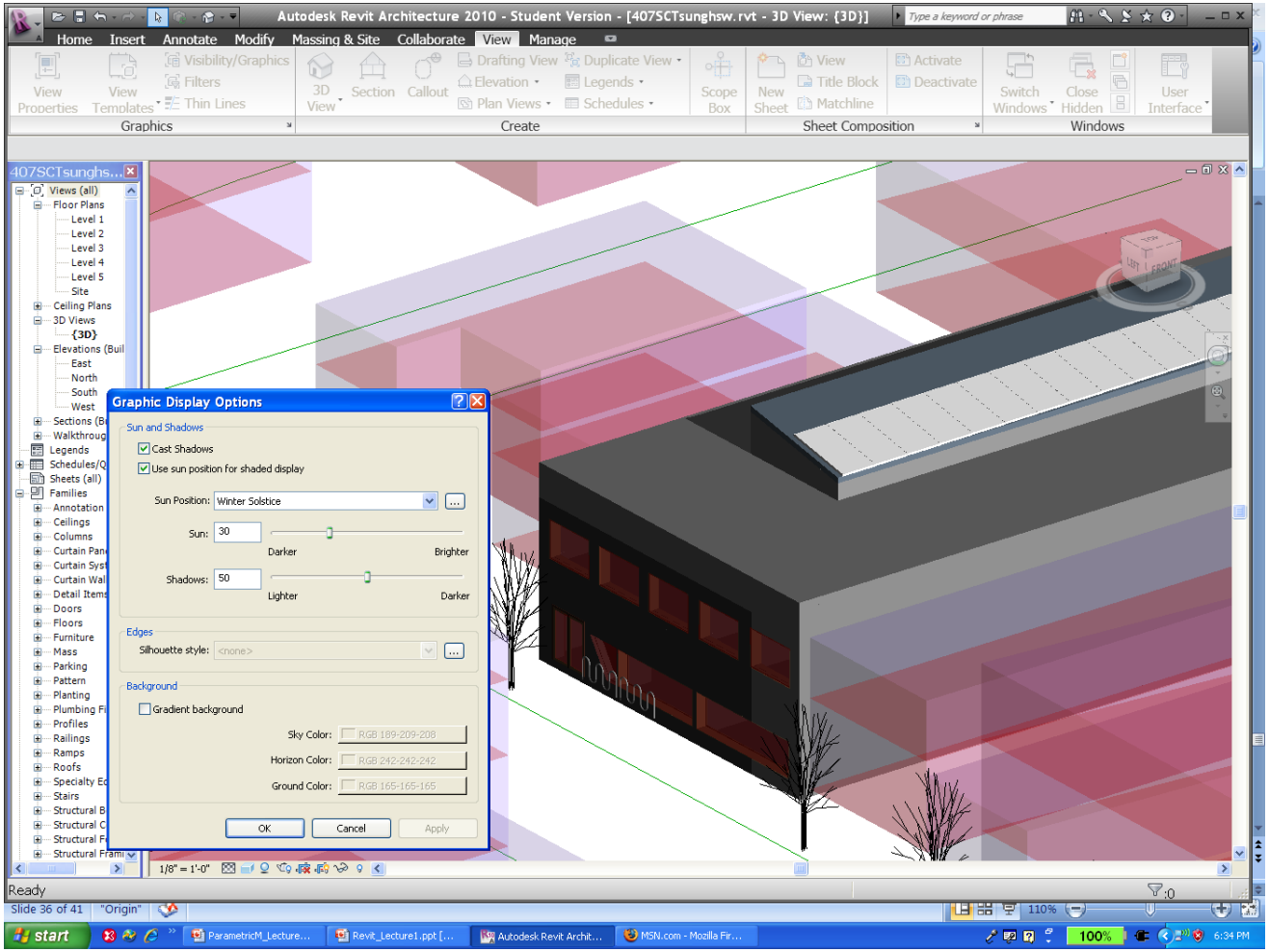






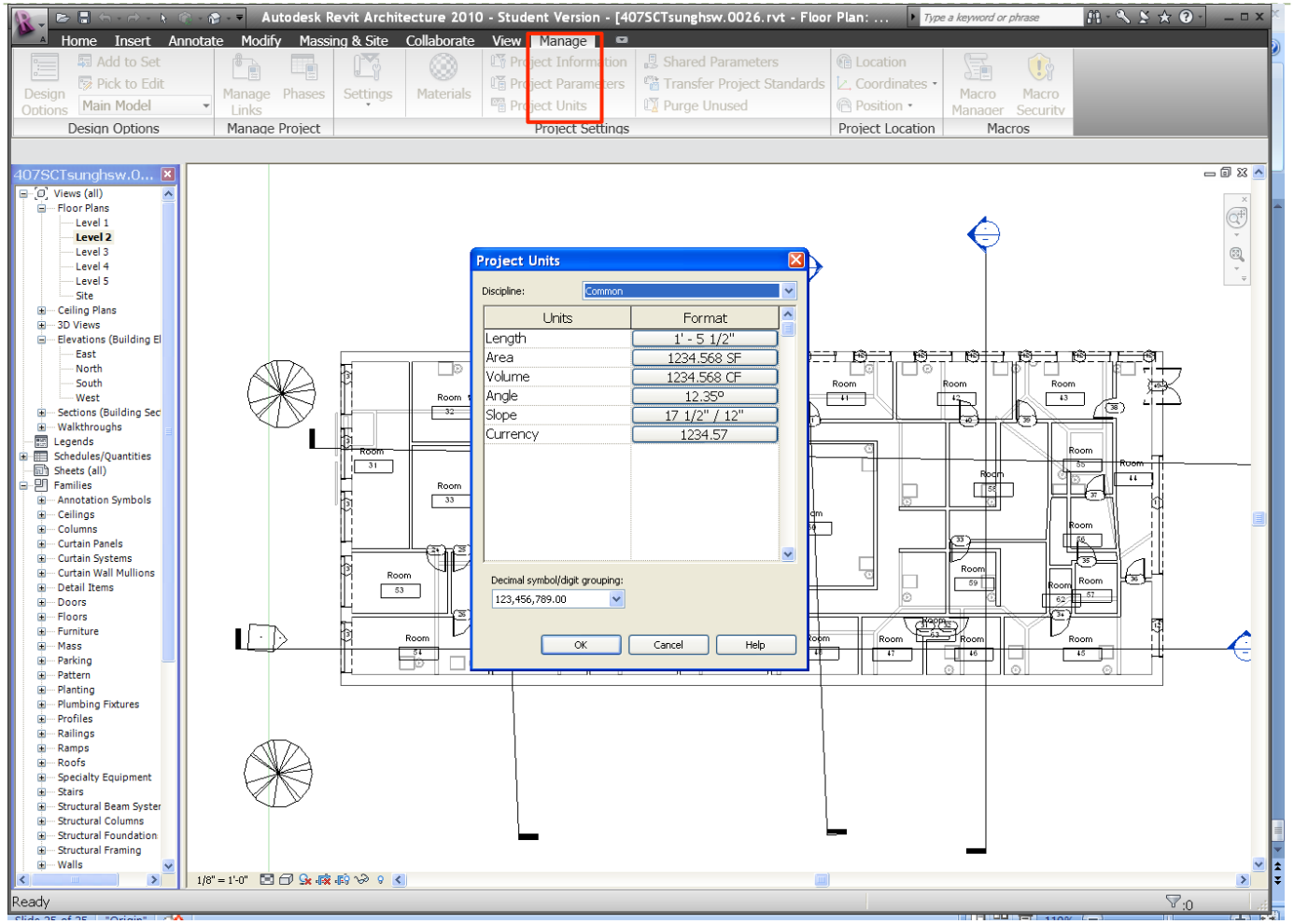
- Wireframe
- Hidden Line
- Shading
- Shading with Edges

Revit 2010 Interface, View window



Graphic display options

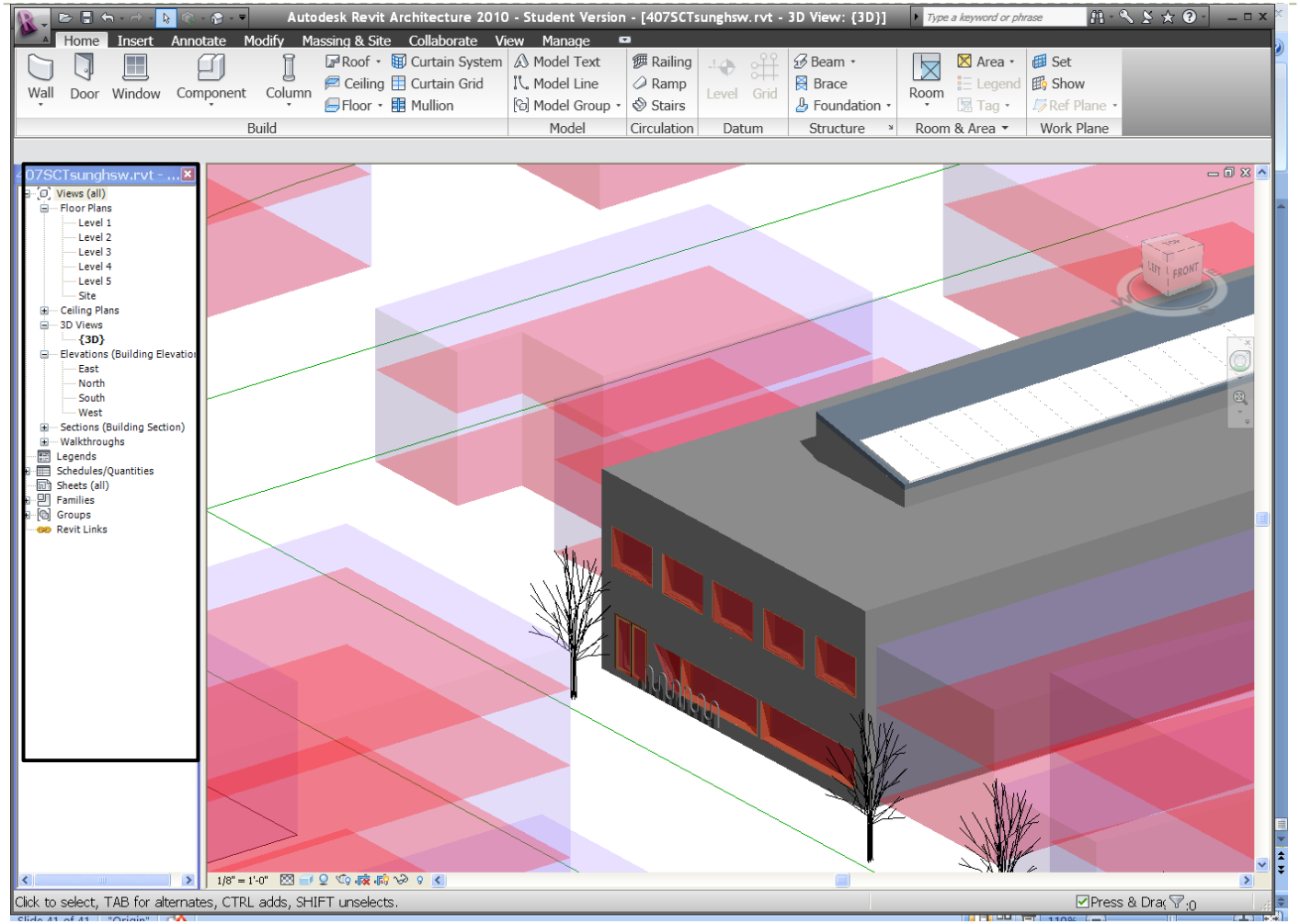
Revit 2010 Interface- Units and settings



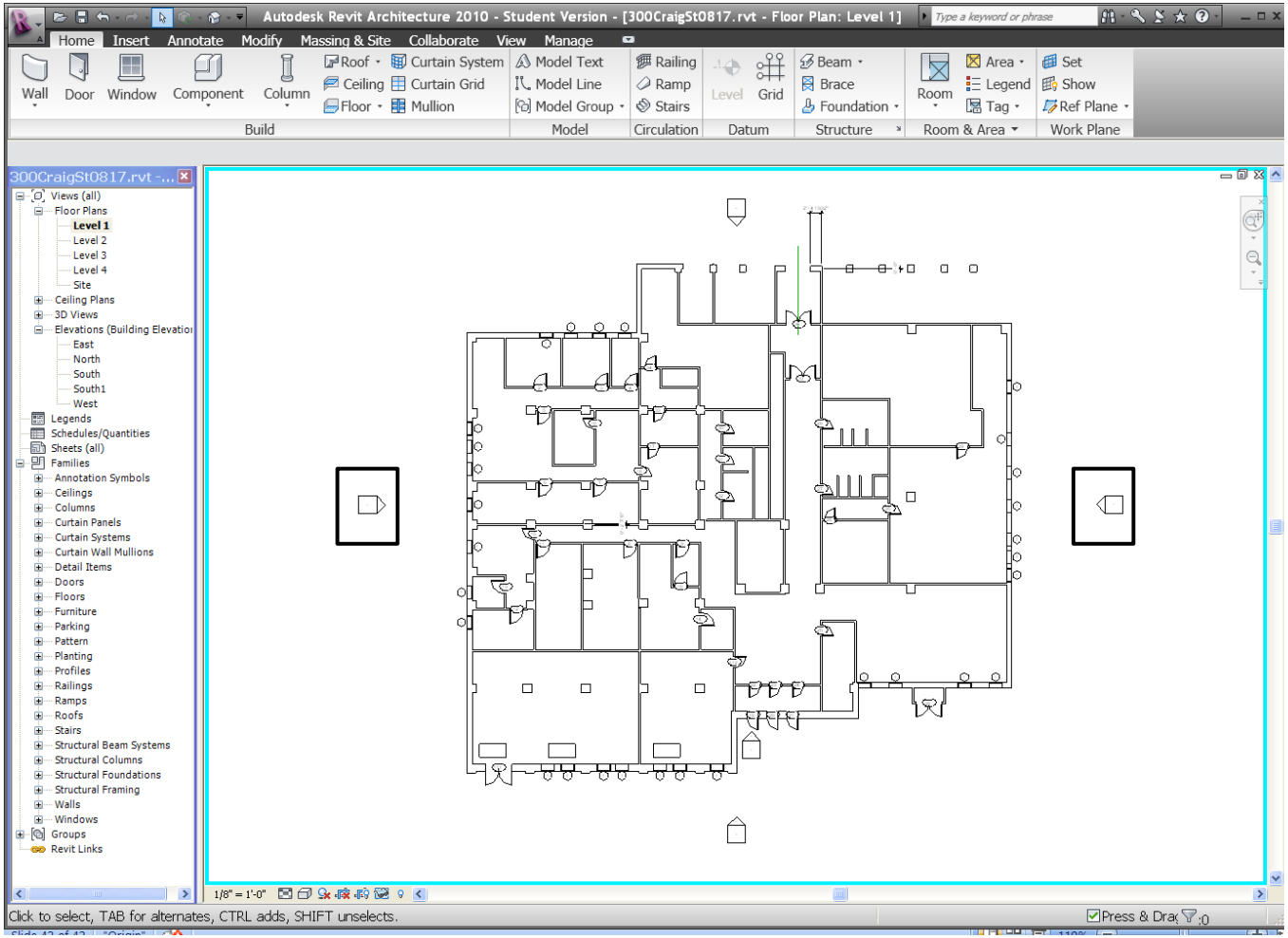
Revit 2010 Units and settings

- Units for the following can be set for a project by going to the Manage Tab> select Project Units
  - Length
  - Area
  - Volume
  - Angle
  - Slope
- For Snaps go to Manage Tab> Settings> snap
  - Revit enables to set increments for adding various elements of the project.
  - The Dimension Snap is the increment, in which the cursor moves while creating components.

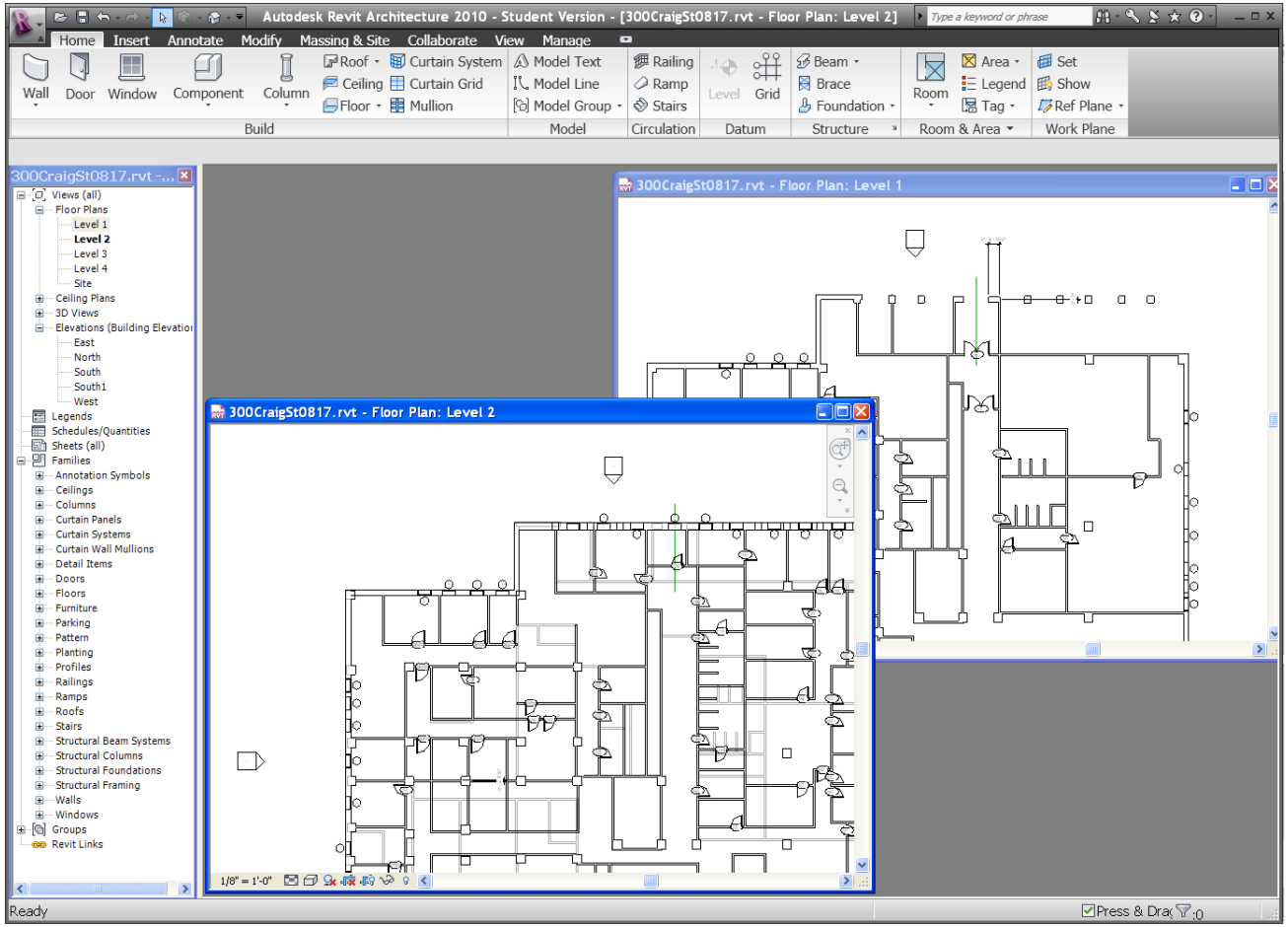
Revit 2010 Project browser



Revit 2010 Elevation markers



Revit 2010 Project windows

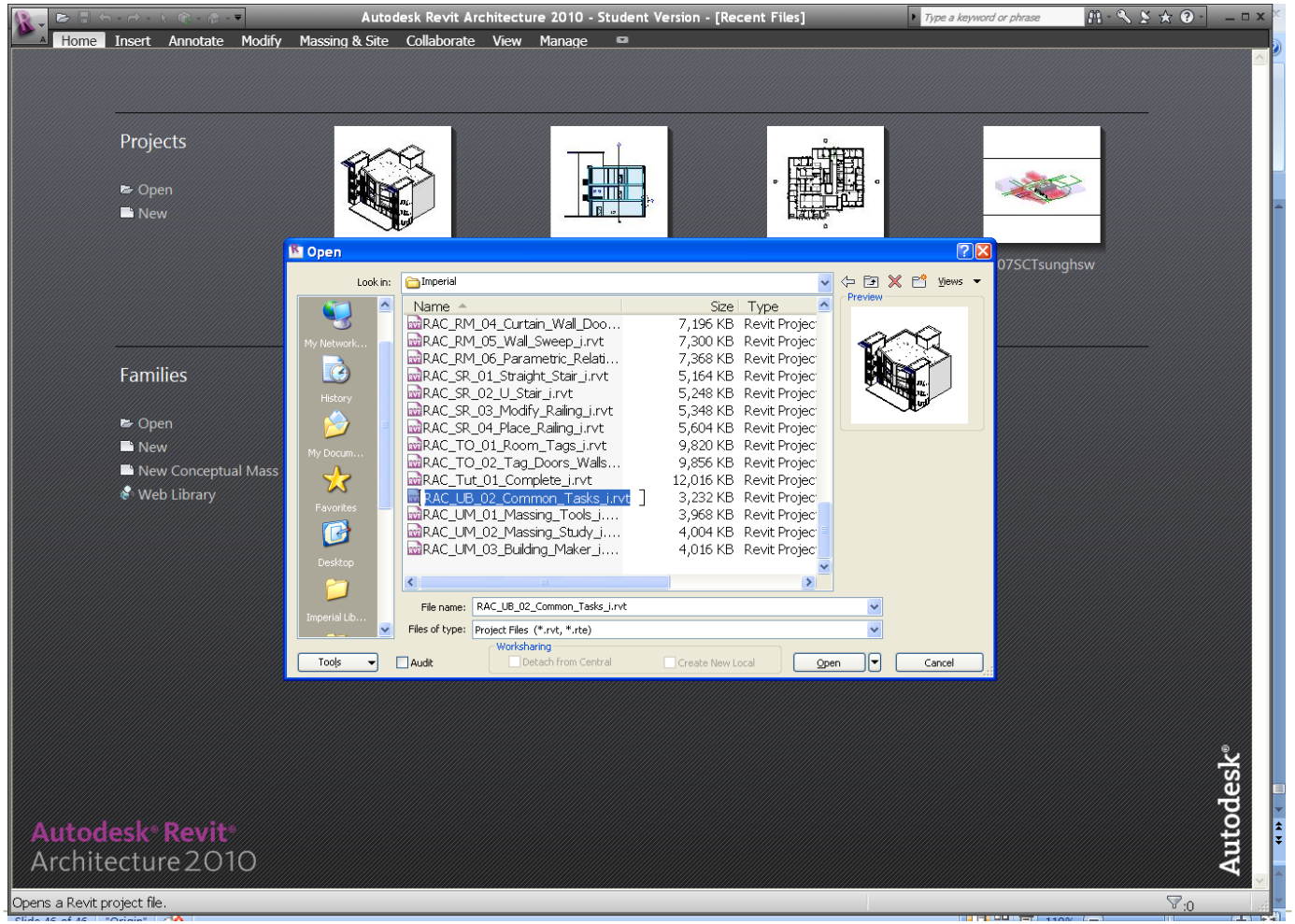


Revit 2010 Lesson1

- **Exercise 1- 3**
  - Open, Save, and Close an Existing Project
- **Exercise 4**
  - Creating a New Project
- **Exercise 5**
  - Using Zoom & Pan to View Drawings
- **Exercise 6**
  - Using Revit's Help System

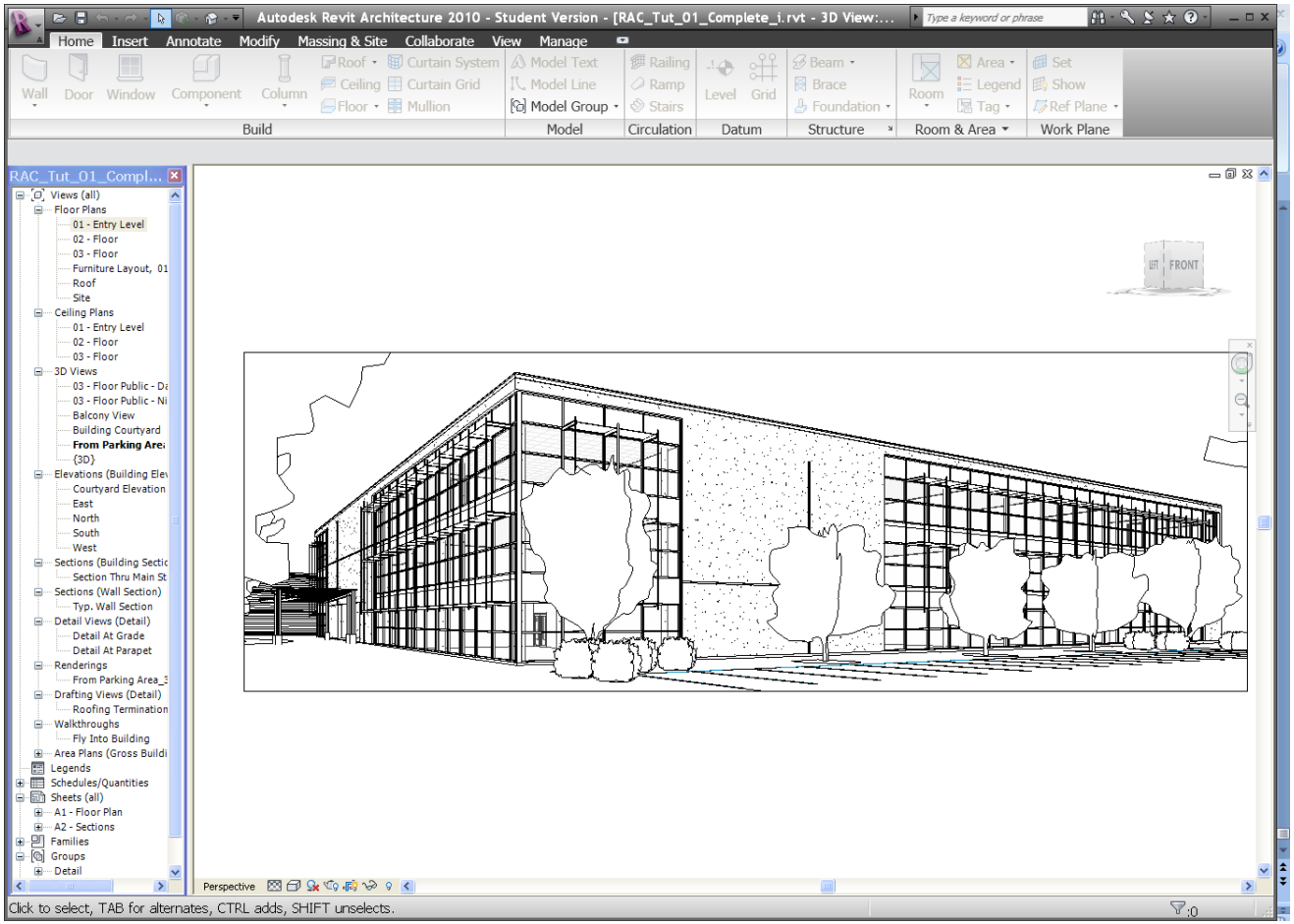
Exercise 1-3

Open Project RAC_UB_02_Common_Tasks_i.rvt



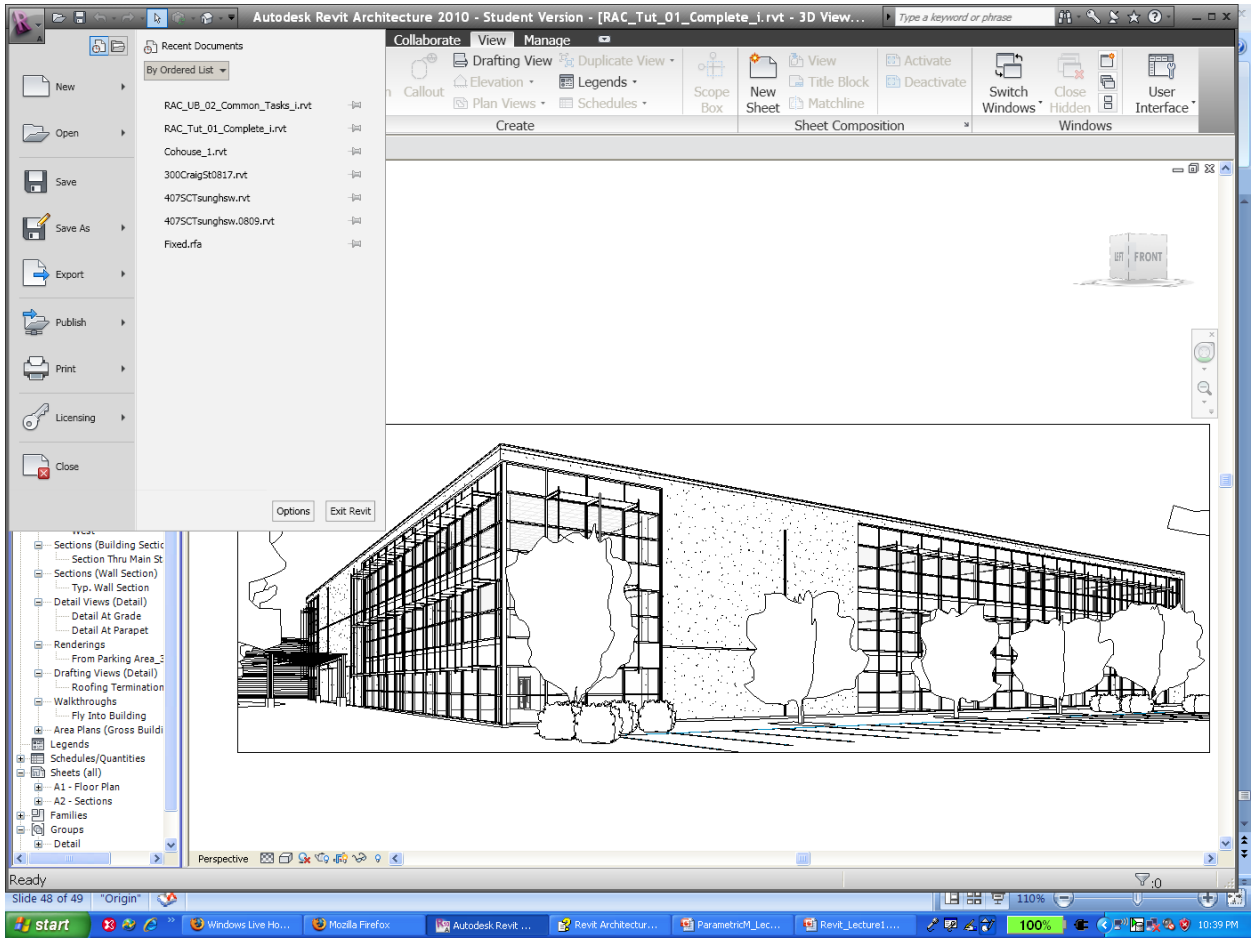
Exercise 1-3

Open Another Project



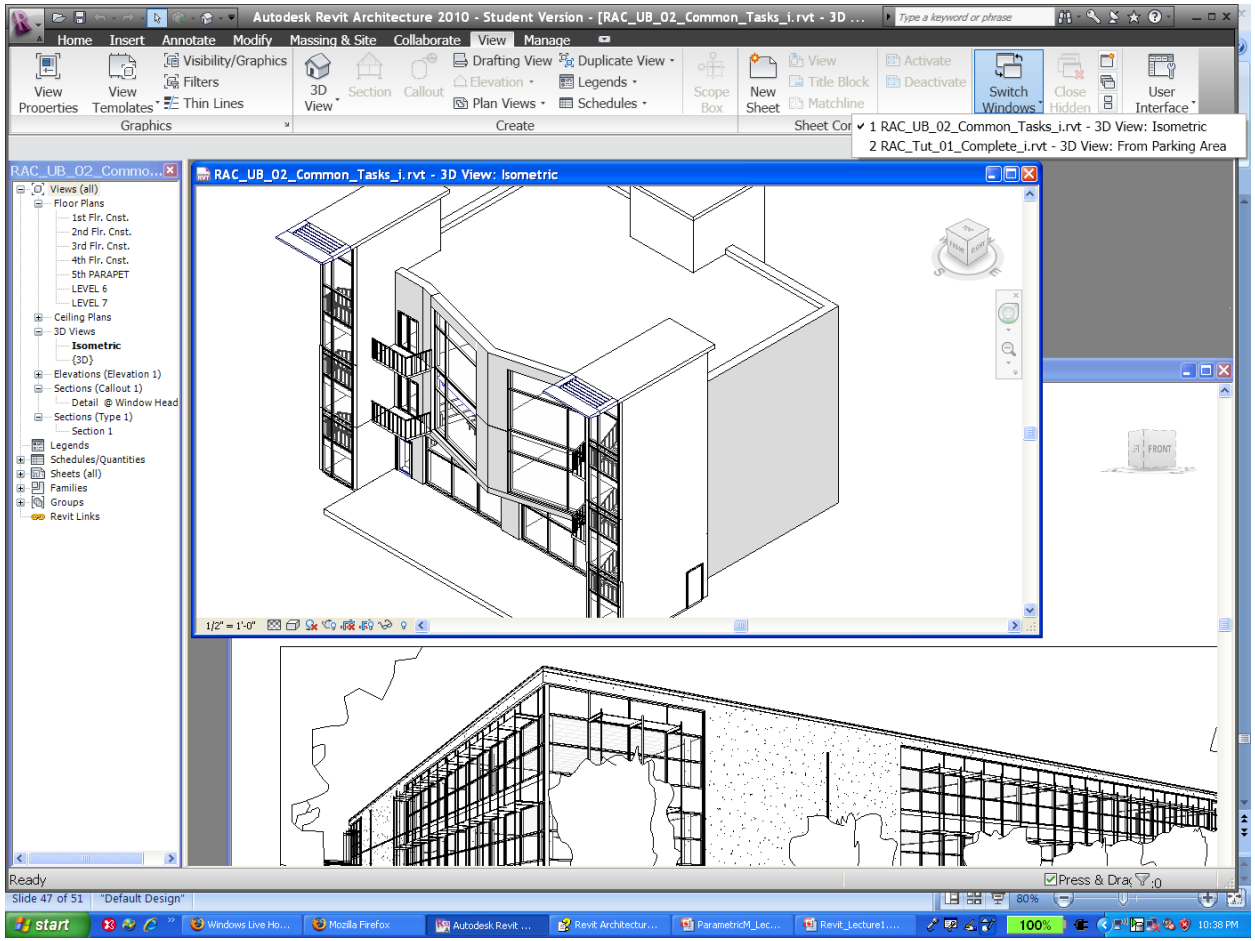
Exercise 1-3

And another project



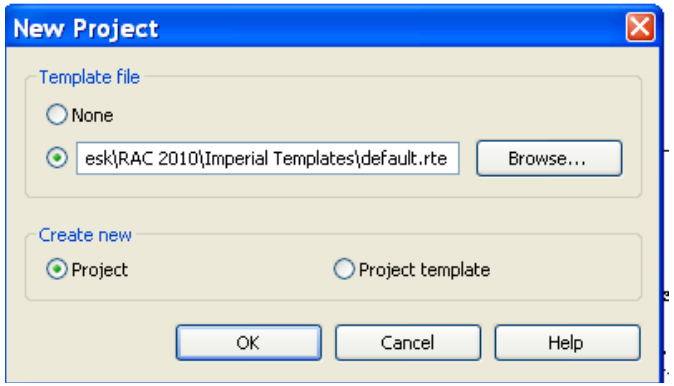
Exercise 1-3

Toggle between projects



Exercise 4

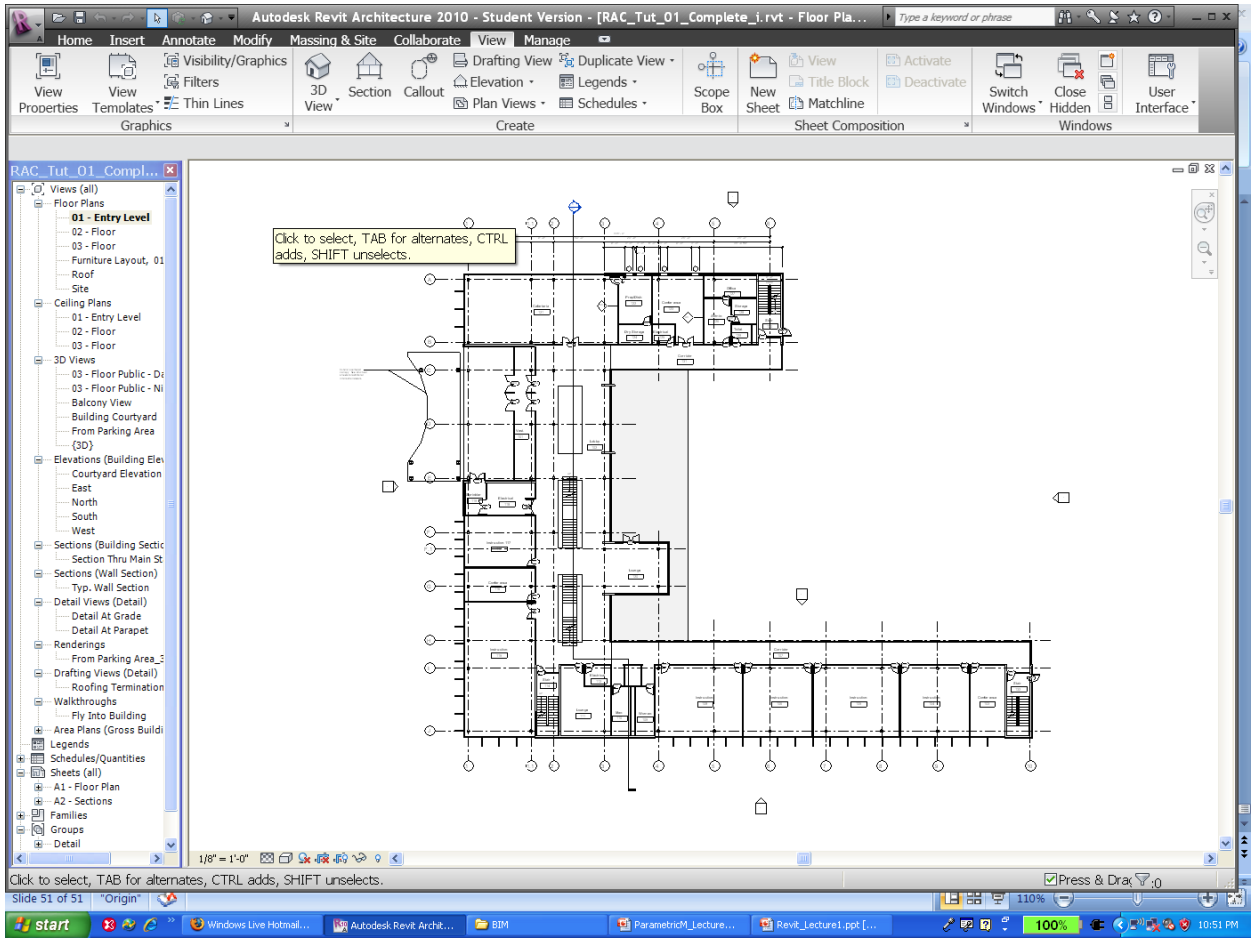
- Create a new Revit project



- Template Files
  - Units set (e.g. Imperial or Metric)
  - Wall, door, and window family styles defined
  - Title blocks inserted

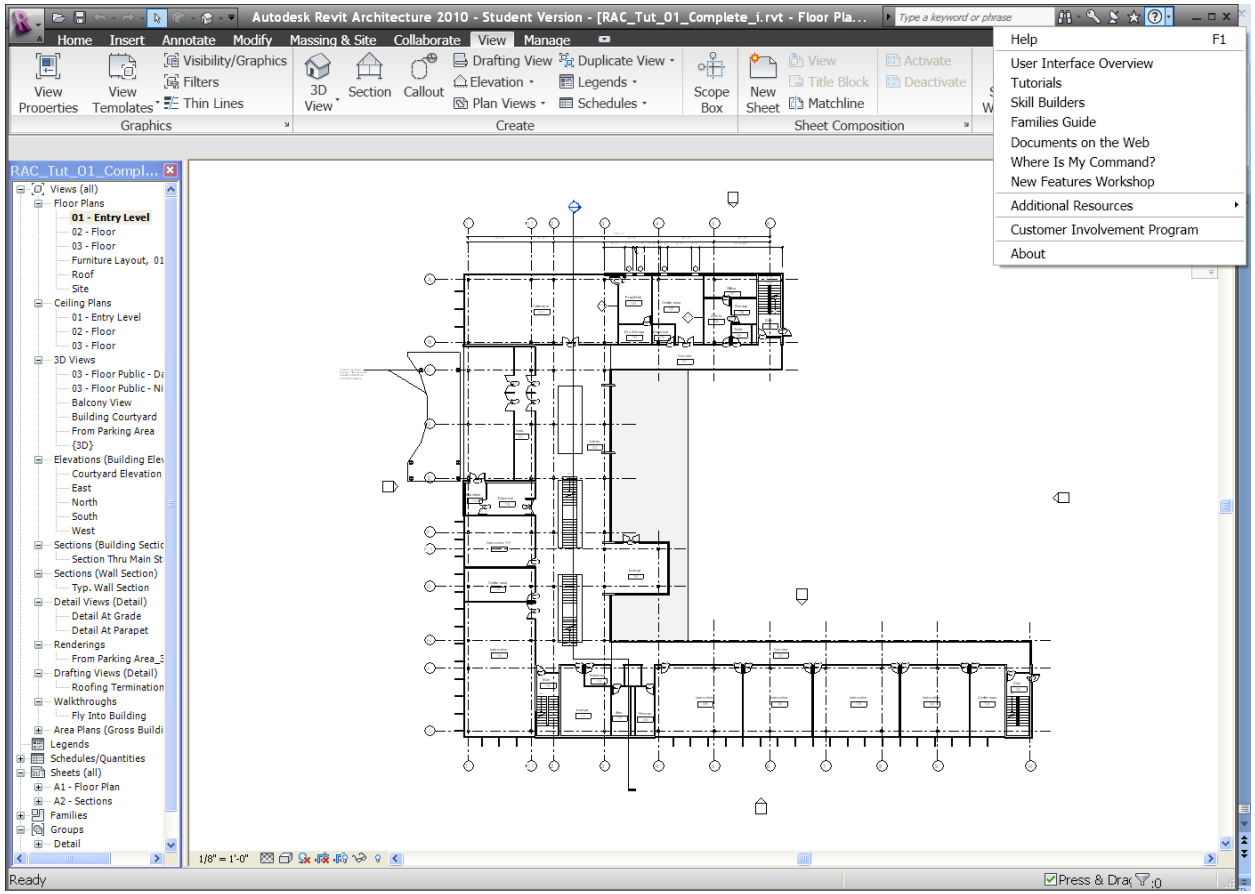
Exercise 5

Using Zoom and Pan to View a Drawing

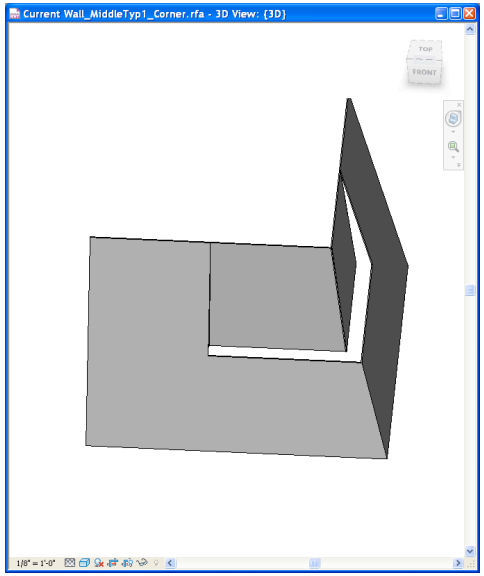


Exercise 6

Use Revit's Help System



Family Creations & Manipulations (ex01)



Wall Family _ Coner

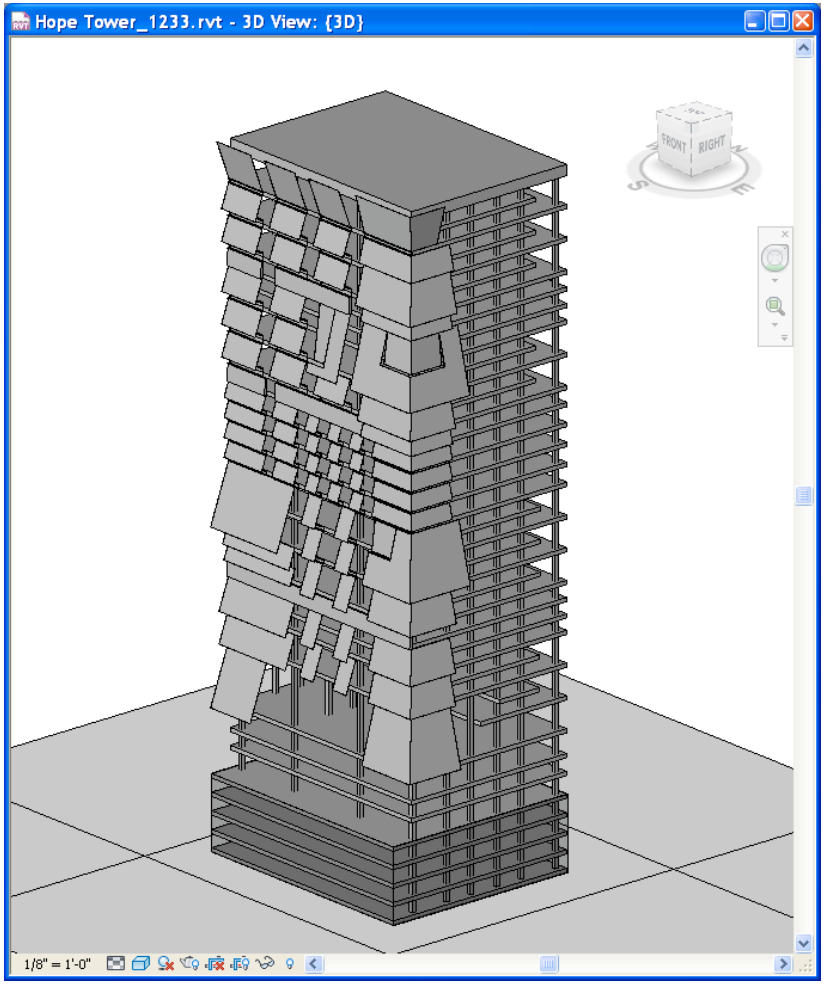
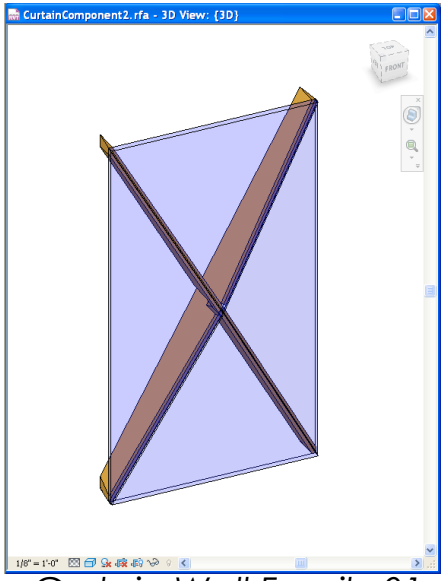
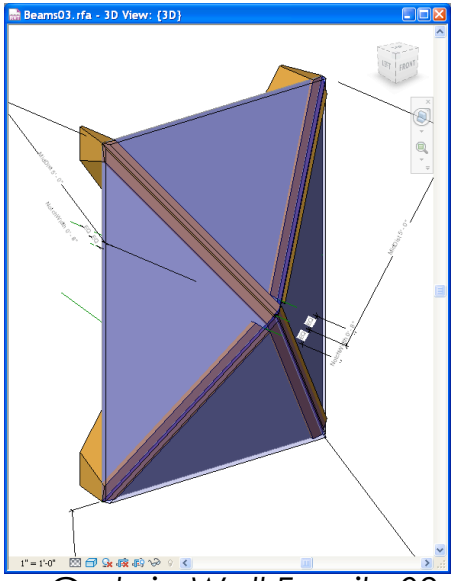


Image by Taihung Chen & Chingyi Chou, GSAPP, presented at NYV Revit User Group Meeting (designReform.com)

Family Creations & Manipulations (ex02)



Curtain Wall Family 01



Curtain Wall Family 02

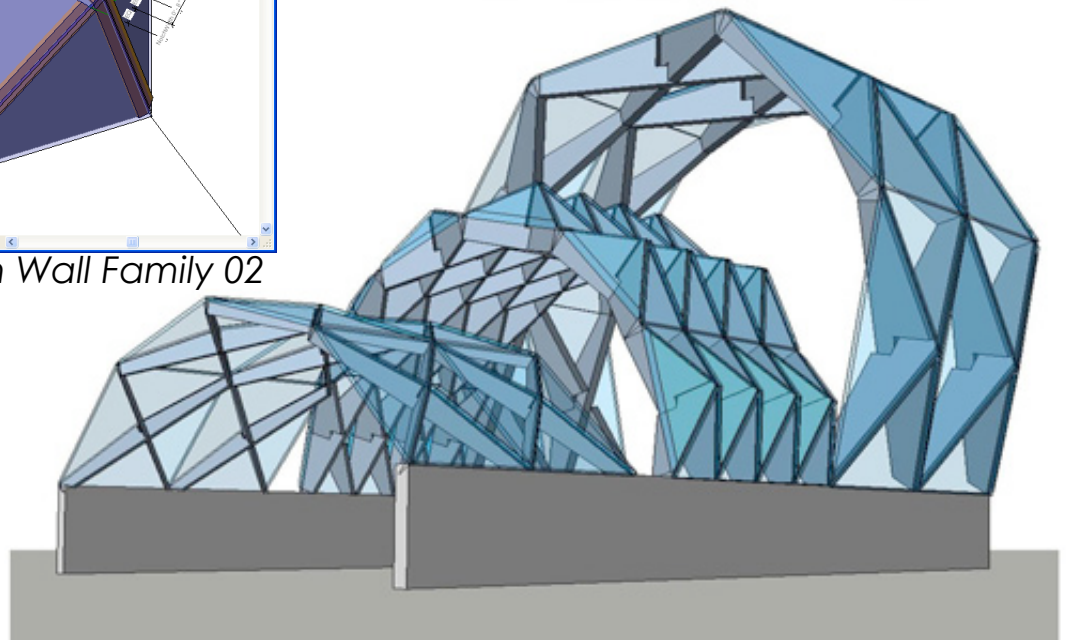
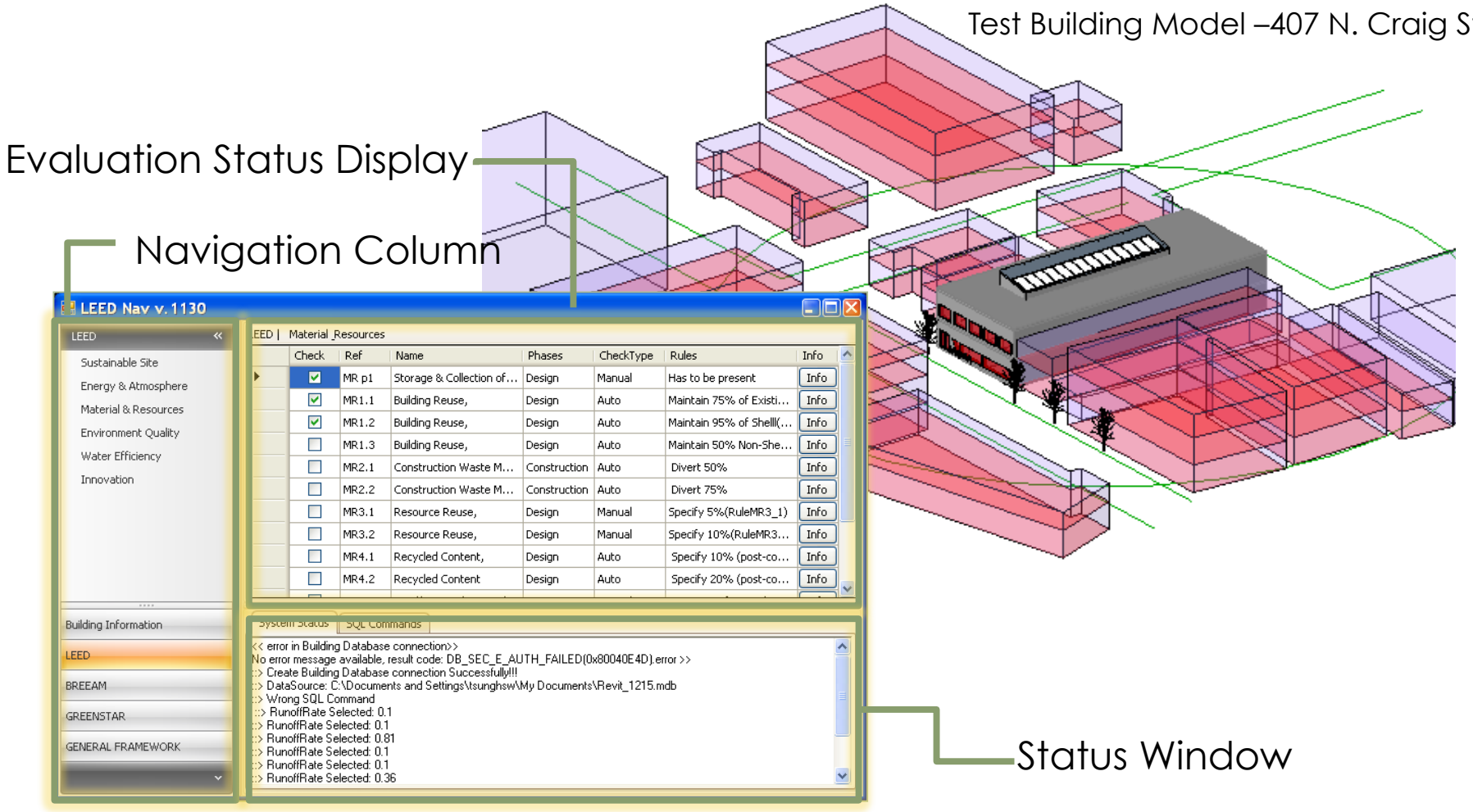
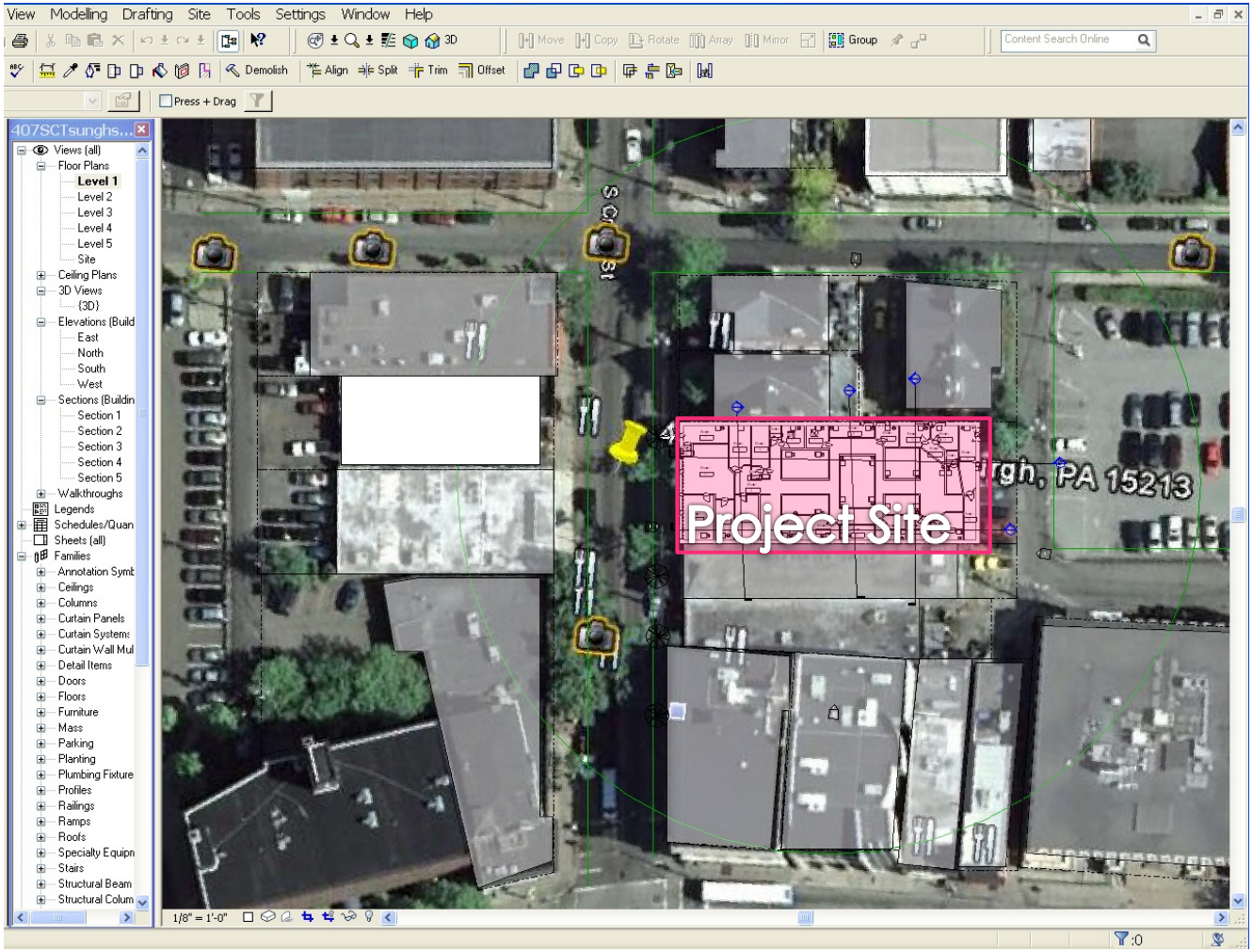


Image by Milan Dale & Micah Roufa, GSAPP, presented at NYV Revit User Group Meeting (designReform.com)

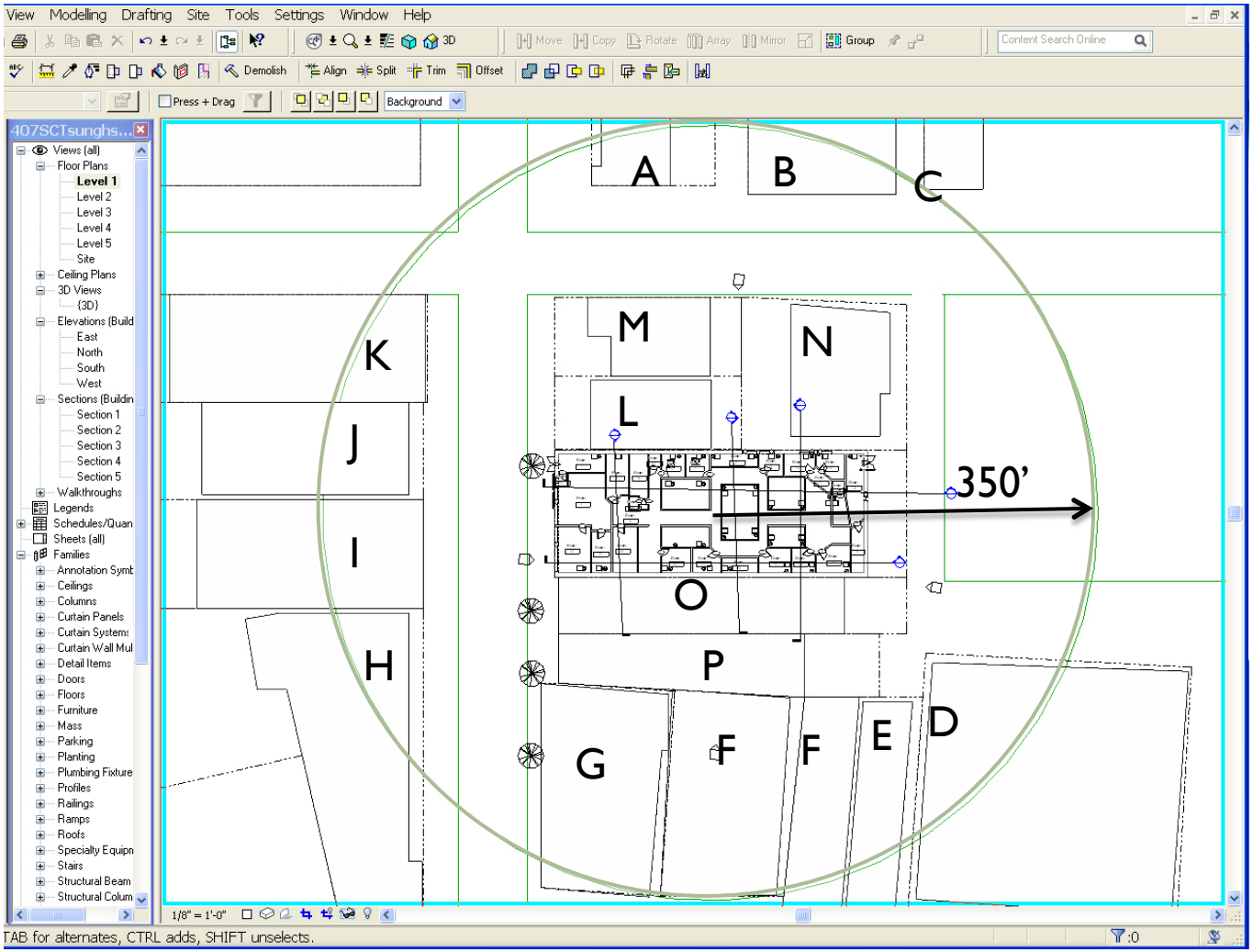
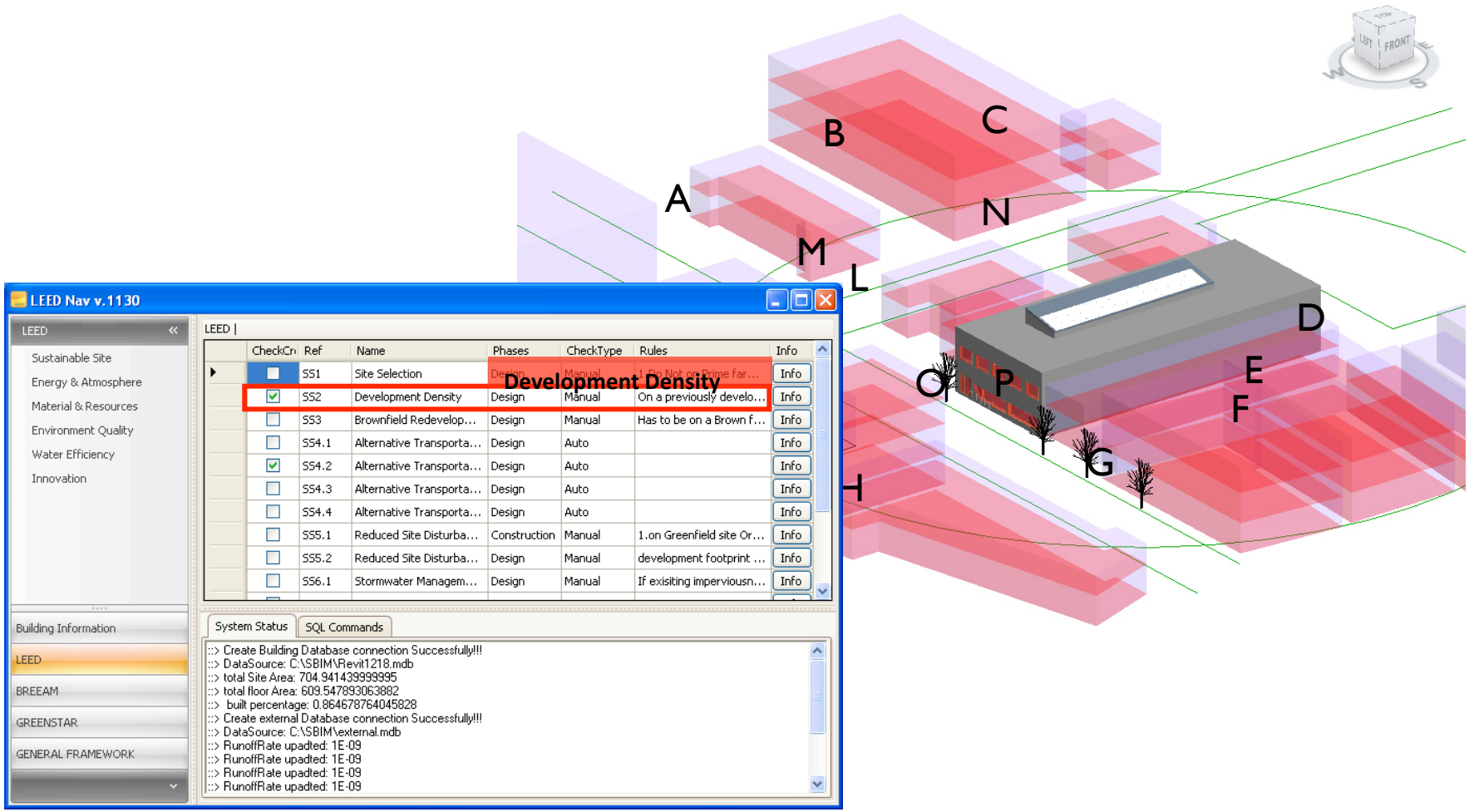
Dot Net Application (Automating LEED Evaluations)



Evaluation example- calculating LEED SS 2
(site density)



Evaluation example- calculating LEED SS 2 (site density)



Ongoing Evaluations- calculating LEED SS 2
(creating mass model for site density)