Code Analysis in AutoCAD® Architecture

James Upton – Grimm + Parker Architects

AB4739 Do you need to track occupant loads on spaces? Do you want to track egress through doors? Would you like to visually check which walls and doors are rated and which rooms require additional exits? In this class, you will learn to leverage property sets, schedules, tags, and display themes to assist in code reviews of your buildings. If you are looking for additional ways to streamline your workflow and leverage your model, this class is for you.

Learning Objectives
At the end of this class, you will be able to:

• Use property sets to extract and process data from a model
• Use display themes to graphically represent any data stored in a property set
• Create tags for construction document code analysis
• Use schedules to present model data

About the Speaker
James Upton works for Grimm + Parker Architects in Calverton, Maryland. He has worked on a range of projects, including single and multi-family residential, and K-12 and collegiate educational. He is currently responsible for research, training, implementation, and support of design software. He has worked with AutoCAD® for over 20 years, AutoCAD Architecture (Architectural Desktop) since 2003, and Autodesk® Revit® Architecture since 2009. James received his BS in architecture from the University of Maryland and is currently working toward his architectural registration.

Email: jupton@gparch.com
Introduction
The basis of code analysis is data. We add data to our models with property sets. We visualize the data with display themes, tags, and schedules. Each is dependent on an accurate model. Thus, the first step in any code analysis is an accurate model.

Once an accurate model is achieved, the data attachment and extraction can begin!

Four basic elements of a building that can be examined with ACA are:

1. Travel Distance
2. Fire Ratings
3. Occupant Loads
4. Egress Loads

Each will utilize a combination of some or all of property sets, tags, display themes and schedules.
Property Sets

“A property set definition is a group of related properties of the objects and object styles to be reported in the schedule. Once attached to an object or its style, a property set becomes the container for the property data associated with the object. Values for properties are obtained directly from the object or are entered manually for the object or the style.”

-ACA 2012 Help File

Figure 1 - Out of the Box DoorObjects Property Set Definition (PSD)

Property sets are the key to tracking data. Each of the techniques for code analysis starts with properties. Property sets can be applied to objects or styles and can be filtered by classifications. The majority of the sets I use for code analysis are object based,

Types of Properties

There are 9 types of properties that can be added to ACA objects or styles: Not every type of property is useful for code analysis. The main ones I am manual, automatic, formula, classification, project and anchor.
The 9 property types are:

1. Manual

   Manual properties are those that must be entered rather than obtained directly from the object. Object numbers (for tagging) and notes or remarks are manual properties. The value entered for a manual property in an object-based property set is saved with the object. The value entered for a manual property in a style-based property set is saved with the style and is available to all objects using that style. You can define a list of manual property values to use in property definitions. For example, you could predefine the values for paint color or manufacturer to avoid repeatedly typing the information.

   Uses in Code Analysis:
   a. Occupants egressing through doors
   b. Overriding a room occupancy
   c. Wall Fire Ratings

2. Automatic

   Automatic properties cannot be edited directly because they are obtained from the object or other source. For example, the physical characteristics of an object, such as its dimensions or material, are automatic properties. To change the value of an automatic property, you must modify its source. The change then appears in the property set data for the object.

   Uses in Code Analysis:
   a. Door width
   b. Room area
   c. Travel distance

3. Formula

   Formula property values can be computed based on the values of other property data. For example, width and height are automatic door properties, which you can use to compute the perimeter of the door. Defining \(2 \times \text{[Width]} + (2 \times \text{[Height]})\) as a formula for a 36" x 84" door results in a value of 240. A formula property definition is a type of automatic property, because the value it displays is determined automatically, based on its definition, and cannot be edited directly.

   Uses in Code Analysis:
   a. Actual door egress width
   b. Maximum allowable egress through door
   c. Door ratings based on wall rating
   d. Code violation notifications

4. Location
Location property values are obtained from property data on AEC polygons or spaces in or near an object. When a selected object has a property set that contains a location property, a Data Location grip is displayed along with its other grips. If the location property is defined to retrieve property data from a space object, for example, and the property data comes from the space underneath the grip, then the grip moves when the object is moved. If an MvBlock representing a piece of furniture is moved from one space to another, it has access to the space’s property data, which might include the occupant of a room.

5. Classification

Including classifications or classification properties in a property set definition for schedules enables you to report classification data for the objects in a schedule table.

Uses in Code Analysis:
   a. Door egress type (single leaf, double leaf, opposing leaves)
   b. Room occupancy classifications

6. Material

Material property values are obtained from an object’s component materials or from property data specified for an object’s component materials.

7. Project

Use this procedure to add a project property definition to a property set definition. Project property values are obtained from the project navigator project in which an object is located. Project properties let you collect and display specific project details in a schedule table.

Uses in Code Analysis:
   a. Code standards (width per egress occupant, maximum travel distance)

8. Anchor

Anchor property definitions allow one object to get data from another object to which it is anchored. For example, an anchor property of a door in a 2-hour fire-rated wall could display the 2-hour fire-rating of the wall with an anchor property definition specified. The information displayed cannot be edited directly.

Uses in Code Analysis:
   a. Sourcing wall fire rating for a door

9. Graphic

Use this procedure to add a graphic property definition to a property set definition. Graphic property values can be blocks in the current drawing or image files, such as BMP, GIF, JPG, PNG, or TIF. The image displayed cannot be edited directly.
Exercise 1: Maximum Travel Distance Property Set

1. Open the Style Manager and browse to Documentation Objects -> Property Set Definitions and create a property set definition named “TravelDistance” that applies to Polyline objects.

2. Add an Automatic Definition

3. Choose Length from the list of available properties

4. Set the format to “Length-Nominal”

5. Click Ok to save and exit the Style Manager.
6. Draw a polyline, select it and open the properties palette. Click on the extended data tab. In the lower left corner click the button with the orange star, this will allow you to add the property set to the polyline.

7. Click Ok and now you have a property that reports the length of the polyline!

8. Why is this so special? You can see the length right on the design tab, correct?

Yes, but for the information to be in a tag, or used in an intelligent, data driven formula it must be in a property. We’ll put this data to use in the Tags section.
Tags

Exercise 2: Maximum Travel Distance Tag

1. To create an annotative tag (one that will scale automatically with the annotation scale), set the annotation scale to $1'-0"=1'-0"$.

2. Create geometry or text that will become the tag. In this case text for the label "Maximum Travel Distance" and the property "Distance". The text needs to be on a non-annotative style and 1" high.

3. On the Annotate tab of the ribbon, on the Scheduling panel, click the drop down arrow and choose Create Tag. (Keyboard Command: DEFINETAG)
4. Select the 2 pieces of text, and set Distance to the property created in the TravelDistance PSD. Type in a name for the tag (TravelDistance), Click OK and select an insertion point for the tag. The tag will be created as a multi-view block.

5. Change the Annotation scale to 1/16"=1'-0"
6. Select the new tag, right click and choose Tag Anchor->Set Object and pick the polyline.

7. The length of the polyline is now reported in the tag.
Exercise 3: Door Egress Tag

Using formulas in a property set allows for more advanced tags, such as a door egress tag that will display egress width, allowable occupants, actual occupants, and required minimum width.

To determine the actual egress of a door, we’ll create a classification, which will be used in a formula.

1. Create a classification named “Egress Type” that applies to doors.

2. Create a PSD that applies to door objects and the Egress Type classifications, named “DoorCodes”
with the following properties:

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Type</th>
<th>Source</th>
<th>Default</th>
<th>Units</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual Occupants</td>
<td>Actual Occupants</td>
<td>Integer</td>
<td>Egress Type</td>
<td>0</td>
<td></td>
<td>Standard</td>
</tr>
<tr>
<td>Egress Type</td>
<td>Egress Type</td>
<td>Classification</td>
<td>Egress Type</td>
<td>Standard</td>
<td></td>
<td>Standard</td>
</tr>
<tr>
<td>Egress Width</td>
<td>Calculates Egress Width</td>
<td>Formula</td>
<td>SELECT CASE [Egress_Type,...]</td>
<td>Length - Inches</td>
<td></td>
<td>Standard</td>
</tr>
<tr>
<td>Max Occupants</td>
<td>Calculates Maximum Occupants</td>
<td>Formula</td>
<td>[Egress_Width]/[Width_Factor]</td>
<td>Whole Number Round Down</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Req Width</td>
<td>Required Egress Width (Check for Minimum)</td>
<td>Formula</td>
<td>IF [Actual_Occupants_A]*[W,...]</td>
<td>Length - Inches</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Width</td>
<td>Width</td>
<td>Automatic</td>
<td>Door/W</td>
<td>Standard</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Width (Formula)</td>
<td>Inches/Occupant by Code</td>
<td>Real</td>
<td>[Width*]</td>
<td>0.200000</td>
<td>none</td>
<td>Standard</td>
</tr>
</tbody>
</table>

a. Width (Automatic)
b. Width_Factor (Manual)
c. Egress_Type (Classification)
d. Actual Occupants (Manual)
e. Egress_Width (Formula)
Subtracts out the door panel and stops from the door width.

**Formula:**

```
SELECT CASE [Egress_Type] =
CASE "Double" RESULT = [Width]-6
CASE ELSE RESULT = [Width]-3
END SELECT
```

g. Max_Occupants (Formula)

**Formula:**

```
[Egress_Width]/[Width_Factor]
```

g. Req_Width (Formula)
Calculates if the required width is greater than 32”, and displays that width if it is. Otherwise it displays 32”.

**Formula:**

```
IF [Actual_Occupants]*[Width_Factor] > 32 THEN
RESULT = [Actual_Occupants]*[Width_Factor]
ELSE
RESULT = 32
END IF
```

3. Create the geometry for the tag and create the tag.
Display Themes
Another method of visualizing properties is with display themes. Once properties are assigned to objects or styles, display themes allow them to be colored by those properties. Additionally, an anchor property can be used with a formula to automatically assign ratings to doors when in a fire wall.

Exercise 3: Fire Rating Display Theme
Everything necessary for visual analysis of fire ratings is available out-of-the-box.

1. Starting with an existing plan, import the out-of-the-box wall schedule from the content browser, which will also import the PSD.

2. Create a new wall style with a 1HR rating, and a style with a 2HR rating.
3. Set the Display Configuration to Presentation
4. Import the Fire Rating display theme from the content browser.

**Exercise 4: Door Rating by Wall**

Use an anchor property and a formula property to set the fire rating of a door based on the rating of the wall that the door is in.

1. Import the Door Schedule from the content browser.
2. Create a new Anchor Property in the DoorObjects PSD named WallFireRating, and check the WallStyles->FireRating property.
3. Delete the existing FireRating property.
4. Create a new Formula property using the Select Case formula.

5. Edit the Fire Rating display theme for the new property set values.
6. Now the doors will color properly by rating also.
Schedules

Schedules are a quick way to summarize code data from a model. First, create the necessary PSDs and tags.

Exercise 5: Create Occupant Load PSDs
The first step for a new schedule is creating the properties.

1. Create a space style for each occupant load

2. Create a Property Data Format for rounding up to the nearest whole number
3. Create a SpaceStyles style based PSD with an integer property.

4. Add the property set to each space style and set the value to the proper load factor.

5. Create a SpaceCodes object based PSD
6. Insert a space, and add the property sets to verify the calculations.
**Exercise 6: Occupancy Tag**

Now that we have the necessary data for a tag, we can create a tag. The tag will contain Room Name, Area, and Occupancy.

1. Change the annotation scale to 1'-0"=1'-0" and create the geometry for the tag.

2. Use the DEFINETAG command and create the occupancy tag.

3. Change the annotation scale back, anchor the tag to a space and verify the tag extracts the data correctly.
Exercise 7: Occupancy Schedule

Once all the rooms have the proper data attached, it’s time for the schedule. Then select the schedule, right click and choose “Copy Schedule Table Style and Assign” to create an occupancy schedule.

1. Start by creating the out of the box room schedule, selecting all spaces.

2. Rename the style to “Occupancy”, then on the columns tab, delete all the columns after ROOM NAME and add the Odd_Load_Calc column from SpaceCodes, and change the name to OCCUPANTS, and check the Total box.
3. Click OK to see the completed Occupancy Schedule, including the total occupants for the building.

### ROOM FINISH SCHEDULE

<table>
<thead>
<tr>
<th>ROOM NAME</th>
<th>OCCUPANTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLASSROOM</td>
<td>23</td>
</tr>
<tr>
<td>SPACE (6)</td>
<td>24</td>
</tr>
<tr>
<td>SPACE (4)</td>
<td>1</td>
</tr>
<tr>
<td>SPACE (3)</td>
<td>11</td>
</tr>
<tr>
<td>SPACE (2)</td>
<td>11</td>
</tr>
<tr>
<td>SPACE</td>
<td>1</td>
</tr>
</tbody>
</table>

### Conclusion
Combine it all together, and you can achieve a great deal of automatic code information for free from your model.