AS500342

Construction Sequence Animations

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Clayco Construction

Learning Objectives

- Learn how to plan out a construction sequence animation and know what questions to ask before starting
- Discover the basics of the Arnold renderer and how to effectively utilize it
- Build a quality material and model library
- Manage your teams' time with clear expectations and divisions of labor

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Description

Construction Sequence Animations are something we started a few years ago to help our project managers visualize their often times messy logistics plans and construction schedules. We've found it to be an invaluable tool for educating both the client and the design build team. There are other products out there that can create a sequence tied to a schedule. While great tools, they are usually pretty tedious and time consuming to create, and graphically they are pretty dry and don't have that higher quality polish. This class focuses on the things you need to think about as you design your process of putting together an animation.

This class is not meant to be *the* way to do things, it is simply *a* way. I wouldn't even say it's *our* way, as we continually evolve.

Speaker(s)

Ryan Taube is Director of Design Technology for Clayco Construction and its associated design firm, the Lamar Johnson Collaborative (LJC). With a background in architecture, Ryan transitioned out of the design field and into a BIM/VDC role in 2010. He has been a leader in the industry for several years, seven of those as part of the Clayco/LJC team. Ryan's overarching goal is to educate his team and assist problem solving. As he puts it, he strives to provide his team members with a "compass instilled within them" to guide their problem solving skills.

Ryan has been an advocate for digital design implementation throughout his career in both architecture and structural engineering. He led Clayco into drone technology as the first drone pilot for the firm, which itself is the first to company in the US to receive FAA exemption. In addition, Ryan's nerdy pursuits include cartography and archaeology and their interrelation with design and BIM.

Managing Expectations and Divisions of Labor

Since this class is about sequence animations, the primary concern when it comes to rendering is speed. We consider how fast we render a quality image and where can we cut time without sacrificing image fidelity. With Construction animation, we are rarely up close to the materials, and often times we are hundreds of feet away watching a building grow before our eyes. For that reason, we can just skim the surface and still produce some great results.

Gather Inputs
The importance of gathering as much information as possible cannot be overstated.

3D Models
It may seem obvious, but you can't animate what isn't modeled. Collect all of the Revit, Rhino, Sketchup, and Civil models/drawings into a project folder dedicated to your project and removed from the active project folder. Too often, things will get updated and mess up your workflow if you are working from live data.

Construction Schedules

Schedules are needed to turn 3D into 4D. If you don't have one to work from, I highly recommend creating your own in Excel, even if it just covers the very basics. The schedule is the organizing object for the entire animation.
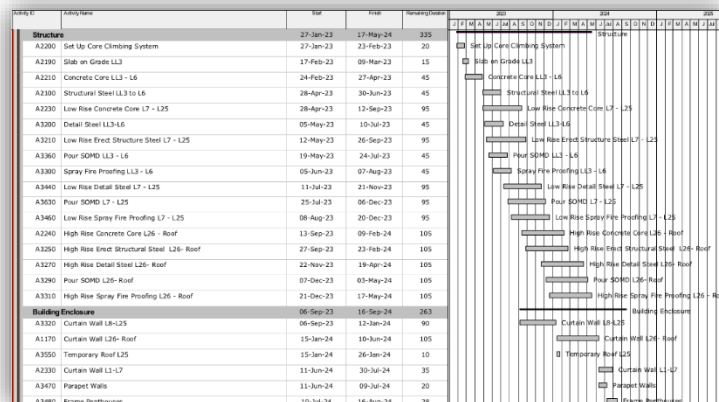
Pour/Erection Diagrams

Larger sites usually have a "flow" of construction. As long as you know the general flow moves from east to west (for example), you can orient your Slice Planes by this idea and the animation will appear correct. You don't need to know specifically which columns/beams will be erected first, nor do you need to have specific dates for each pour/beam/column.
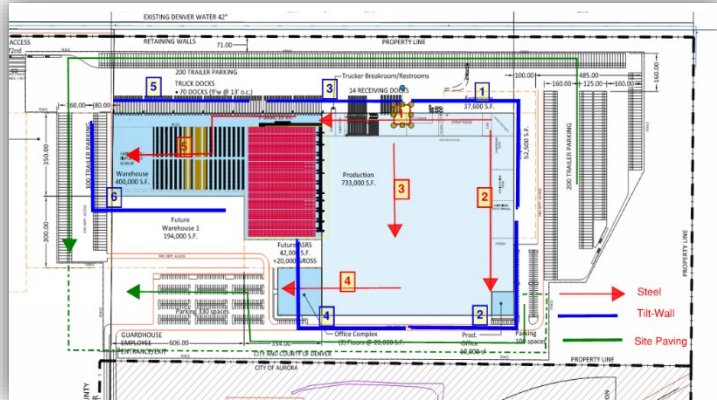
Plans that show how a slab is split into separate pours allow you to divide up your own model in a similar fashion. For slabs, it's easy to split a floor slab into parts which can be exported as separate objects. For Tilt Walls, there is usually only one or two crews that work around the building. So, knowing where they will start and which direction they are taking makes it easy to coordinate with the animation.

Site Logistics

How is the site organized? Showing fencing, cranes and hoists, material laydowns, and site access is a good way to provide both scale and an additional layer of information. It's also a good feedback loop to the builder who probably has only seen the logistics plan for the project in 2D form.
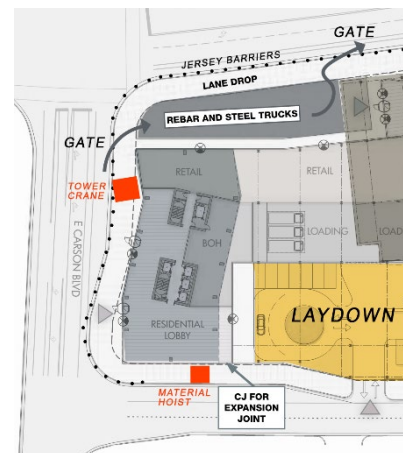
Organize your Process

It is crucial to start a master file as soon as possible that tracks what happens and on which frame. An animation is a series of frames. You need to know what is happening on which frame, but you also need to be flexible enough to change on the fly.

For this we create an excel document. This is something you only need to create once, and then just update with the new data you will be using.

Along the X-Axis we put each activity that will be animated. For instance, "Level 14 Slabs" would have their own column along the Y-Axis as it would be animated separately from Level 15 Slabs.

Along the Y-Axis we put the dates of construction. For a longer project, I typically show a line for each week. For a shorter project, I might show for each day.

These axes could be flipped with dates along the X-Axis like in P6, but for me this makes more sense when I'm working in it. I also find it helpful to show the same groupings that came out of the P6 schedule and put that in my Excel document. It's not necessary but it helps keep things visually aligned.

The power of this schedule comes into play when you start to assign formulas.

1. **Enter Dates**
   Enter dates for your project. If you put in two dates next to each other (Cells B9 and B10 for instance), select those two cells and drag the corner down. It will calculate the difference between the two dates, and sequentially add additional dates. Pull this down far enough to capture your project's dates.
2. **Enter Amount of Frames Per Week**
   Enter how many frames per week your animation will take. This number will be the one thing you change after everything is setup, so it really doesn't matter what you put. For our projects, 20 or 25 is typically a good number.
3. **Enter Activities from scheduling tool**

Enter activities from P6 or any other scheduling tool you are using. You can export this data to excel for larger projects, but I find entering manually really helps get to understand the project.

4. **Enter Starting Frame**
Type in your starting frame. In this case, we input "40" into cell B9.   In cell B10 put the formula: "=B9+B7". In regular language this is saying, "Add up the value of cell above with the value of B7". Putting dollar signs ($) in your formulas locks that cell in the formula when you fill the formula into other cells.   Select cell B10 and drag it down. This fills the same formula all the way down, so "B11=B10+B7", and "B43=B42+B7".   This creates a simple sequence that is driven by starting number, and the number highlighted in yellow.

5. **Fill In the Main Field for Each Task**
This next part is a little bit of manual work, but it's really where you start to understand the project. Use the Fill Color in Excel to start filling in the main field for each task.
    a. For instance, Activity 1, which is Mass Excavation, is scheduled to start on 8/15/2022 and end on 11/21/22.
    b. Color in the cells that correspond to those dates
    c. Since we made each line week of time, you may need to round off to the nearest week.
    d. Work your way through the project until everything is filled out.
    e. Now we need to get the numbers into these cells.
    f. In the very first upper left cell, put the formula: =$B9
    g. This locks the formula to look at column B but will keep the row free when you drag the formula down.
    h. Select cell B9 and drag it to the lower right extent. This will fill in numbers everywhere
    i. Go through and delete all numbers that are in white. (except the one that is immediately below a color block)

6. **Find the Min and Max.**
You've now tied the frames to the task. But really, we just need minimum and maximum for each task. So, in Rows 5 and 6 I have formulas that look down below and return the Minimum number: "=MIN(C9:C"108)" and the Maximum number: "=MAX(C9:C108)"

7. **Find the Absolute Min and Max**
I also want to know exactly how many frames long this excel document predicts the animation will be, so in section 7 I have another set of minimums and maximums for rows 5 and 6. In other words, what is the *minimum* minimum and what is the *maximum* maximum.
    a. I'm looking to that maximum number to tell me how long the animation will be.
    b. 2515 frames divided by 30 frames per second is 83.833 seconds of animation, or 1 minute 23.83 seconds.
    c. I can adjust this overall length simply by changing the value in Cell B7.
    d. Changing the value from 25 to 20 would save me 500 frames of rendering and cut the animation time to 1 minute 7 seconds.

Congratulations, you've now finished the Master file which will guide your animation in both
3dsmax and After Effects.

Plan the Construction Sequence

Revit	**3dsmax**	**Arnold**	**After Effects**
Modeling	Animating	Rendering	Processing
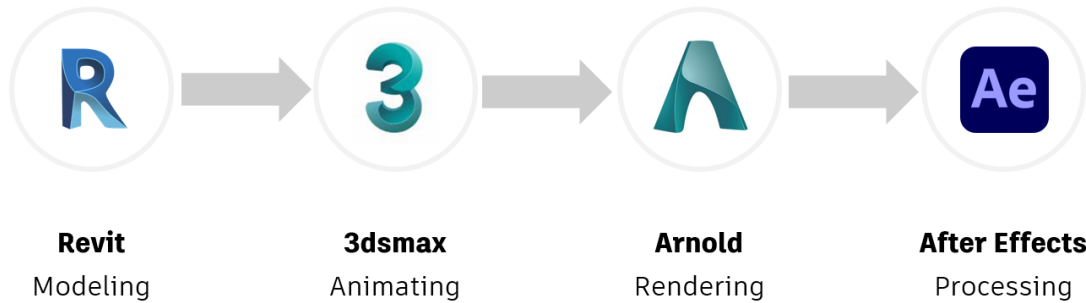
However, each of the programs have an incredible amount of depth to them. They aren't too hard to pick up and start using but when attempting to do something complicated there can be number of pitfalls. Hopefully this class will alleviate your time chasing down the rabbit holes.

Animation Process

The reality is much messier than the simple four steps above. Gathering all your inputs early is crucial because it helps you map out what questions need to be asked and what restrictions you will have as you move forward.
If utilizing an Infraworks model or GIS begin collecting that early. If utilizing drone data as your backdrop, travel to the site early and capture (hopefully the weather will cooperate).

My preference for mapping out how this information is gathered is akin to the visual programming languages like Dynamo or Grasshopper. We map out our information flow in Illustrator and as we resolve standards we make note of them here for future use.

One of the uses of a diagram like this is to help understand what will happen when changes come along. With something simple like materials, backtracking to make changes and re-render are minimal. If models need to change, however, a domino effect is in play and multiple other things need to be adjusted to get the animation right.
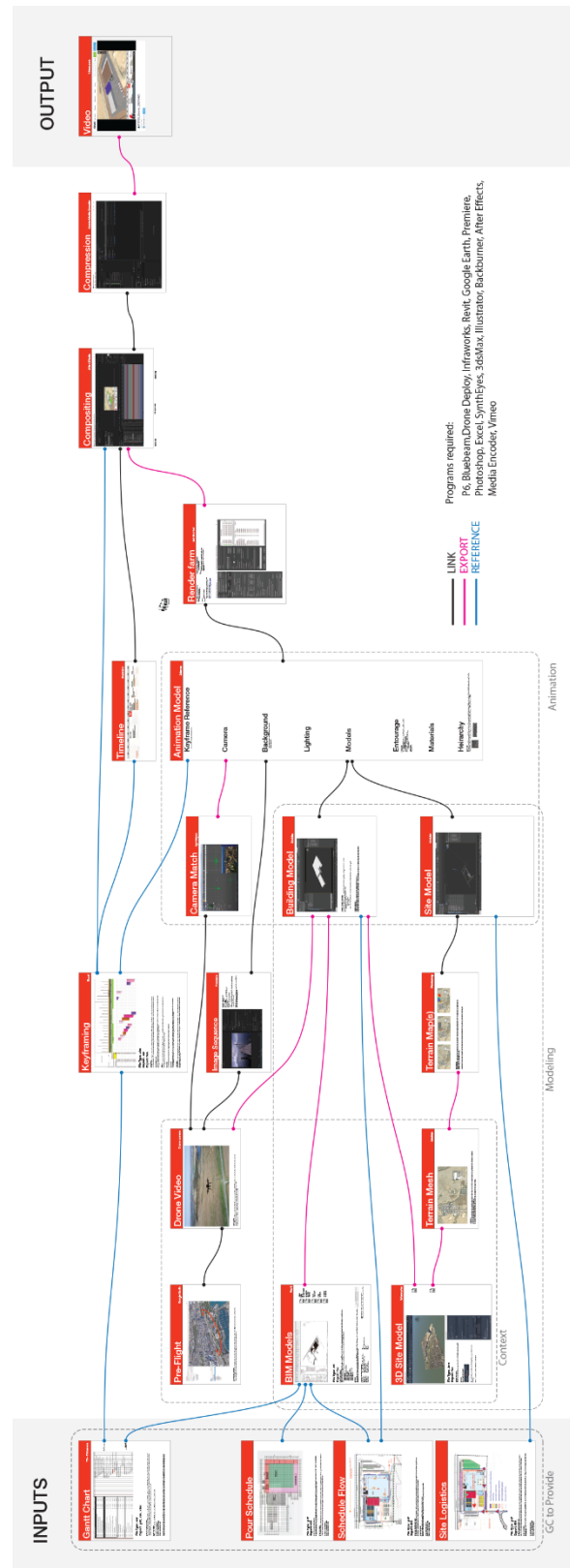
Generate Views in Revit

For Animation, it's easier to animate groups of objects at the same time. For instance, you can animate all the steel beams on a level using a single Slice plane, which we'll talk about later. To aid that effort we need a view in Revit that isolates those beams on that level so that they can be output to an FBX file and brought in as a group.

Dynamo

Revit Dynamo is helpful in this regard with generating multiple views at once. Using that same spreadsheet that we created earlier, we quickly create a list of views that are needed, and Dynamo can easily generate views and name them based on that list.
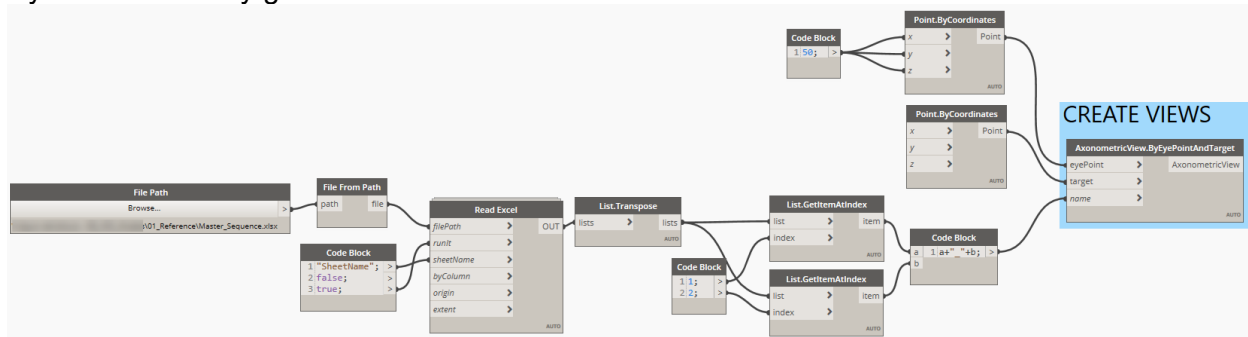
View Templates and Scope Boxes

From there it's a matter of properly using your scope boxes (which can now be applied to 3D views) as well as your view templates, to quickly control multiple views and adjust which categories/worksets/links are visible in these 3D views.
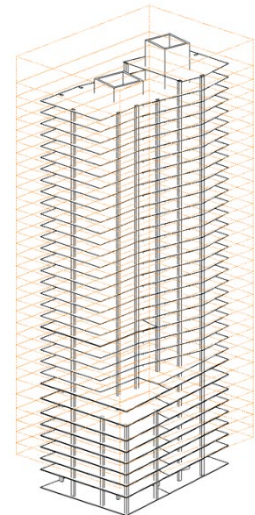
Exporting to FBX from Revit

Manually exporting a large number of views to FBX can be tedious (File: Export: FBX)
However, if you have an automation tool such as Imaginit Clarity, you can create an FBX
publish and let Clarity take care of the creation part of it. This is also useful if you need to go
back and re-export because you forgot something.

A word of caution though, when you are creating your views, you need to be very careful that an
element is only exported in a single 3D view. If it shows up in multiple views, 3dsMax isn't sure
how to handle the conflict and it doesn't position it in the proper location.

Importing FBX to 3dsMax

Importing FBX files can also be a tedious process, however
3dsmax has an open scripting platform called Maxscript and an
extensive user base that creates some really cool tools. There
are a few tools that get the job done. The one I recommend is
called Batch Export/Import which was developed by Jos Balcaen
and is available on Scripspot.com. The reason I use this script is
because it allows the user to import multiple FBX files at once,
which 3dsmax doesn't allow you to do natively. It also allows you
to put each FBX into its own group and on its own layer. This is
excellent from a project management perspective.
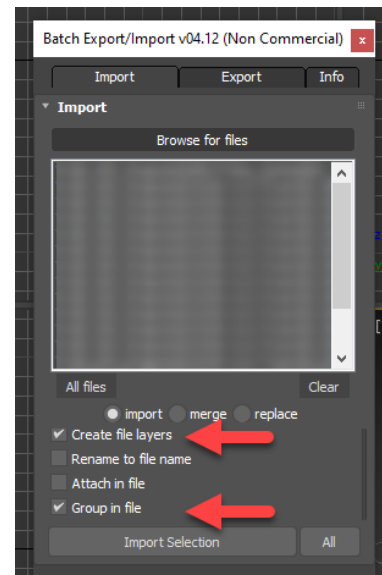
Animation Tips & Tricks

There are a few quick tips and tricks that we'll cover that will take care of most of your animation needs. To animate an object is simple.

1. Select the object and click the AutoKey button located in the lower right.
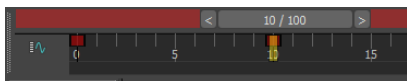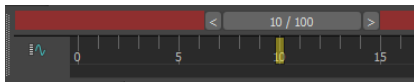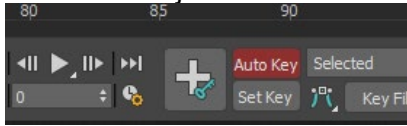
Slice Plane

The Slice Plane is a Modifier that completely slices through a selection and removes either the positive or the negative. By placing the Slice Plane in a way that completely removes the object, the object can be revealed by animating the slice plan moving across it. This tool was updated quite a bit in 2022 and you now can cap the cut area, and even apply a different material to that cut surface.

This method is great for showing slab pours, or groups of structural beams. By placing the slice plane horizontal to the ground, you animate the columns or building core rising from the ground.
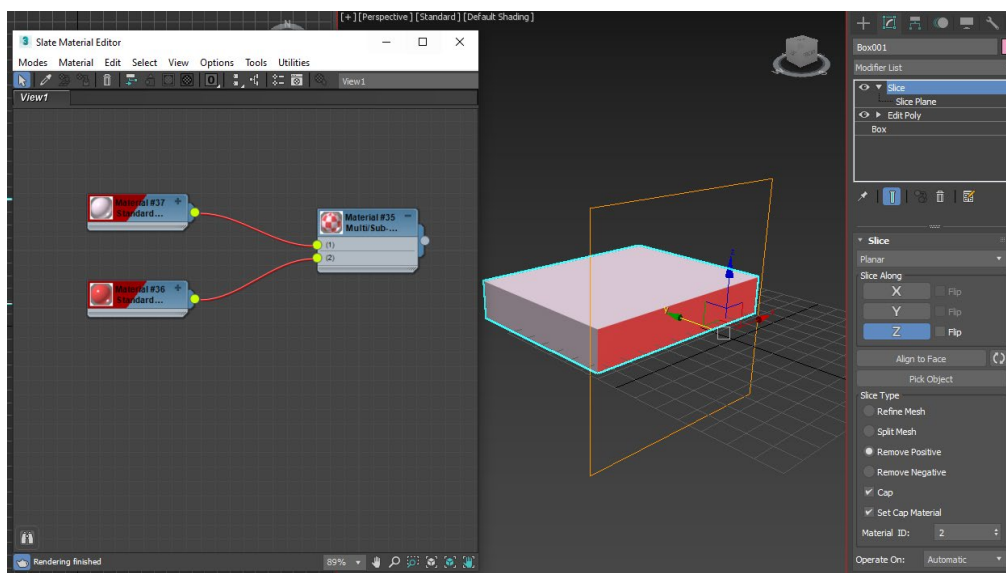
Keyframe Offset

Offsetting your keyframes is another great way to animate a building. This is another Maxscript file, this time created by Espen Kielland. If you search for his name along with "Keyframe Offset" you should be able to easily find the scrip. This tool is very simple.

1. Select a bunch of objects that you wish to offset, such as all the columns on the ground floor.
2. Animate all of them at once.
    a. A trick I use is to just hit the Auto key, move them out of position and uncheck the Auto key to stop animating
    b. You can then drag the keyframe at the 0 frame and move it to the other side of your other keyframe, thereby reversing the direction of movement
    c. This is how you can quickly drop a bunch of objects onto a scene
3. Select all the objects, start the Keyframe Offset Tool and type in how many frames between each object's start time and the Keyframes will offset.
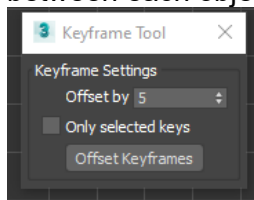
Show Selection Range

Another quick tip is to right click on the Timeline: Configure: Show Selection Range. With this selected, you can select the objects you are animating, and then select the keyframes that show up in the timeline. The Select Range appears below those keyframes and you can adjust the range by dragging the ends of that selection range to the frames that you specified in your Master schedule.
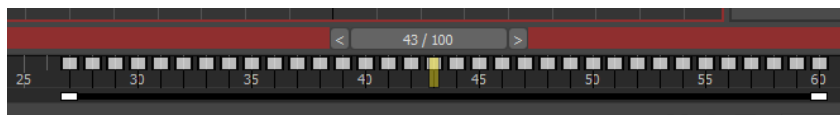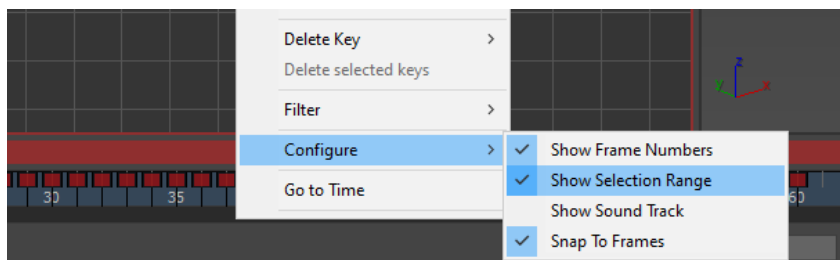
Libraries

We are always trying to find ways to make the process more efficient. Building a Library ahead of time is a great way to save some heartache down the road.

Recommendation: If you can, put your libraries on a server without a driver letter, this forces you to use the UNC path for a file which makes it really easy to move between computers or between creators as mapped drives sometimes change or are different, especially in larger offices. If you have a render farm setup at your office with Backburner or some other type of farm, UNC pathing becomes crucial.
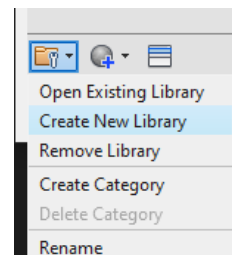
Material Library

MAT and ADSKLIB files are Autodesk specific material container files that you can either download or build to suit your need. They work across multiple programs including Revit, AutoCAD, and 3dsMax. They are incredibly useful in maintaining standards across multiple computers but also easy to expand through time over multiple projects. So not only will your projects look the same as another teams' projects, but they will look consistent over the years too.

Building an ADSKLIB file in Revit

Creating a library in Revit is straightforward. As you build your materials in your project's Material Browser, simply select Create New Library, in the lower left corner.

You can then drag and drop materials into the library and save them to an ADSKLIB file. This file can then be loaded on to other machines or saved in your library location for all to use.

Building an .mat file in 3dsMax

Within the Slate Material Editor, it's easy to create a material library by right clicking in some open room in the left-hand material browser and selecting "New Material Library…"

You can then select the scene materials in the browser, right click, and add them to a library.   For a construction sequence, you always need certain materials and having this library enables you to maintain a certain standard of consistency across multiple projects.

Typical materials needed: construction dirt, asphalt, concrete, steel, glass, stone, fencing, metal panel, bollards, grass, CMU.

You'll often find that you need a few options for each of these. Just continue to add and refine as you go and you'll have a quality library in no time.
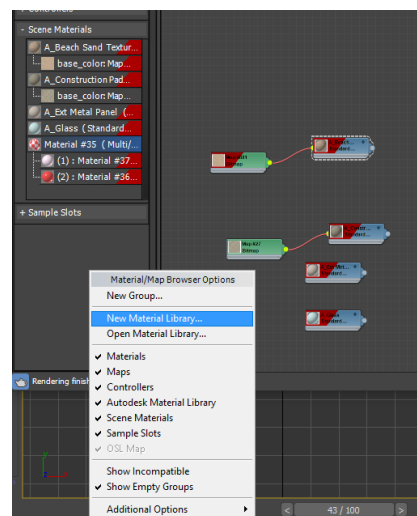
HDRI Image Library

High Dynamic Range Images (HDRI) are photos that have been taken at multiple exposure settings. By stacking these images, HDRI images can be used as a light source itself. We'll explain that process a little later, but it is very useful to create a library of HDRI images for your use. Each image as different lighting settings, some are cloudy, some are at dawn. By having multiple images, you can get the best image for your rendering.
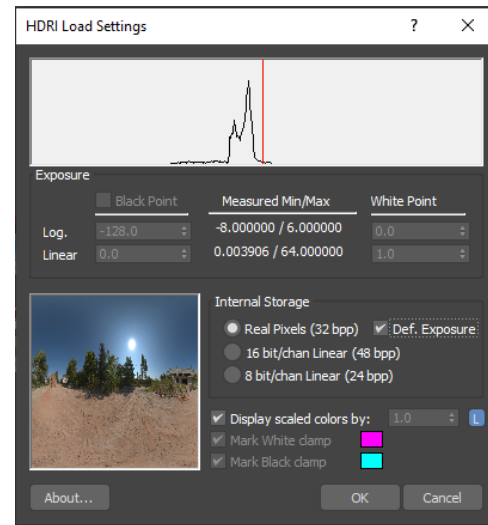
Model Library

A model library will give life to your project. Vehicles, cranes, job trailers, fences should all be saved in a well-structured folder on your server. And while it might be redundant, create a 3dsMax file with your most common objects in there so you can just merge them into your project file with a click of the button.

Build

Spend some time and get to know 3dsmax. Build out your most often used objects. Sometimes it's easier to building things in Revit and export them to 3dsmax for texturing. What gets your library built the quickest and cleanest is the way to go.

Buy

Some things are complex. You could spend days creating a cement mixer that you might only use a handful of times, or you could spend a few dollars on Turbosquid and download some high-quality stuff for a decent price.

Simplify

That high-quality content does take longer to render. Simplify these models if you can. For the most part, sequence animations are done at a bird's eye view, so nuts and bolts aren't necessary in the model.

Rig

One of the most fun parts of 3dsmax, in my opinion, is rigging a model. If you have a tower crane, you can set the rotation of the upper parts to rotate around the correct rotation point.

Using the Select and Link Tool you can create Child/Parent relationships. The hierarchy tab and Link Info tab will let you constrain movement to only certain degrees of freedom. If you're really invested, Inverse Kinematics will let you animate an entire rigged excavator simply by moving the bucket around. We're not going to go over the details here, but I've given you enough searchable keywords to get started.

Arnold Renderer Basics

Since this class is about sequence animations, the primary concern when it comes to rendering is speed. We condiser how fast we render a quality image and where can we cut time without sacrificing image fidelity. With Construction animation, we are rarely up close to the materials, and often we are hundreds of feet away watching a building grow before our eyes. For that reason, we can just skim the surface and still produce some great results.

Lights Camera Action

One HDRI Light | Basic Arnold materials | Physical Camera
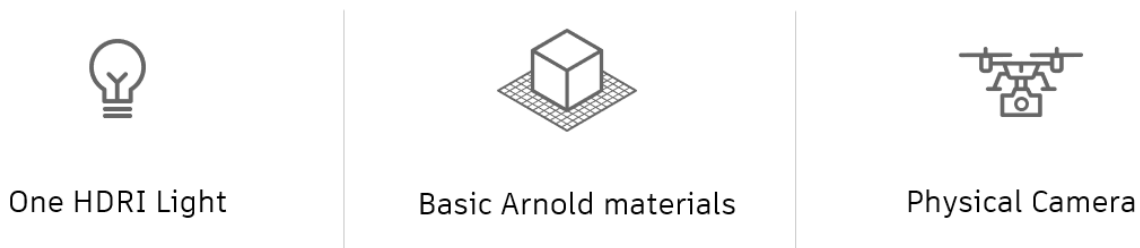
Lights – which illuminate
Materials – which reflect or refract the light
Cameras – which receive the information from the illuminated materials

It can be a discouraging maze trying to navigate these three things because as one changes the other two do as well. Arnold is intuitive when it comes to making something simple out-of-the-box, however we will help simplify it even further.

Lights
The easiest way to simplify your rendering process is to use only one light. Arnold only has one light in the menu, which makes it easy to use, however there are 8 light settings within that light which covers all lighting situations. These include Point, Distance, Spot, Quad, Disc, Cylinder, Skydome, Photometric, and Mesh.

We will only be using one Arnold light set to Skydome with an HDRI texture image. A High Dynamic Range image is one with lighting built into the data. This effectively gives you a complete light source, such as the sun, which casts shadows, and ambient light from the sky and ground which fills in the ambient occlusion and gives some realistic depth to your model.   You can find these in different sizes, usually 2k, 4k, and 8k pixels. The higher you go the longer the rendering time, so I usually stick to 2k or 4k.
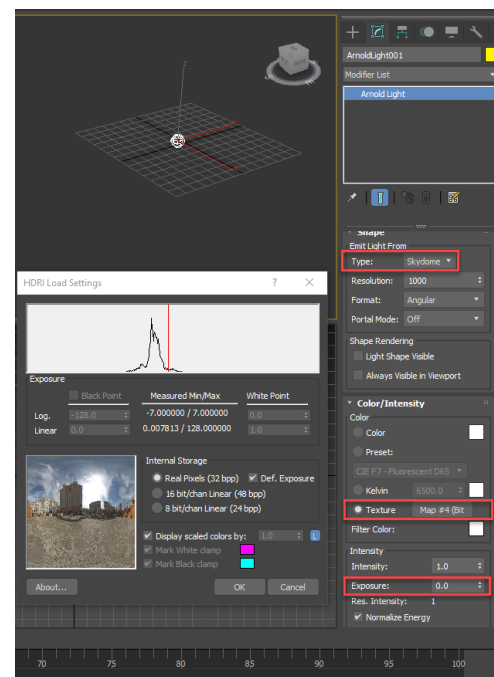
If you are using a drone image as your background, try to find an HDRI that has a similar lighting condition. You don't want to be showing shadows when it was a cloudy day.

Skydome Lights

The skydome type is great because it is super easy, has nice diffuse light in all directions, and is great with ambient occlusion to get that nice soft shadows in the crevasses. One note, when you place a skydome light in the scene, change the Exposure Value to 0 in the light. We'll be controlling exposure in the camera.

Cameras

Cameras have also gotten easier with Arnold. The Physical Camera is a great camera that mimics real world cameras. This is especially useful if you are flying a drone and have a specific camera setting, field of view, F-stop, etc.

The Exposure Gain is controlled in the camera, typically a value of 9 is the best starting point but it can be adjusted up or down to get the right results. We do need to set the file to follow the Camera's exposure value for this to work. We'll cover that later in the Render Output settings.
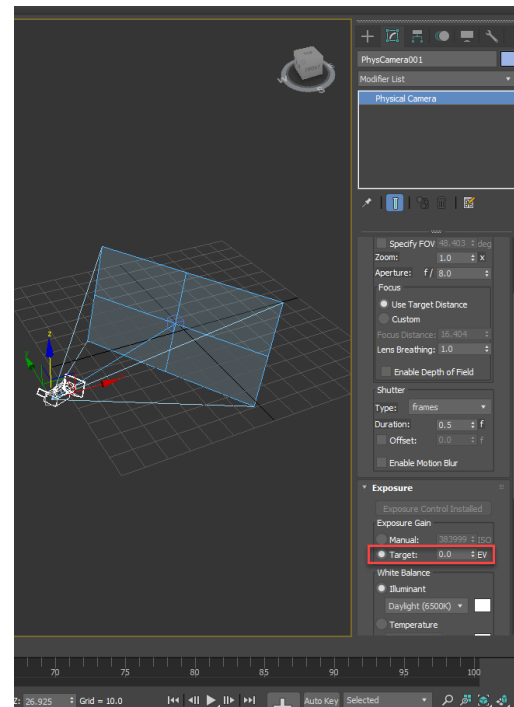
Drone Cameras

Speaking of drone cameras, using programs such as Syntheyes allows you to generate an animated Physical Camera merely by analyzing the drone footage. This drone footage is then inserted as a background in the renderings and the building fits seamlessly into the frame. It does this by creating tracker points that you can then use to align your model.
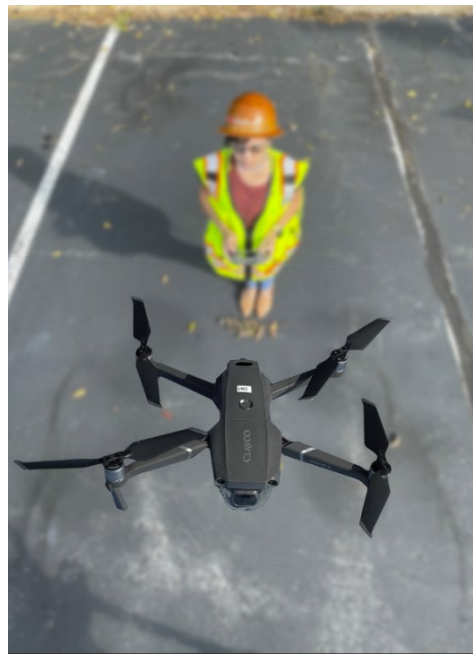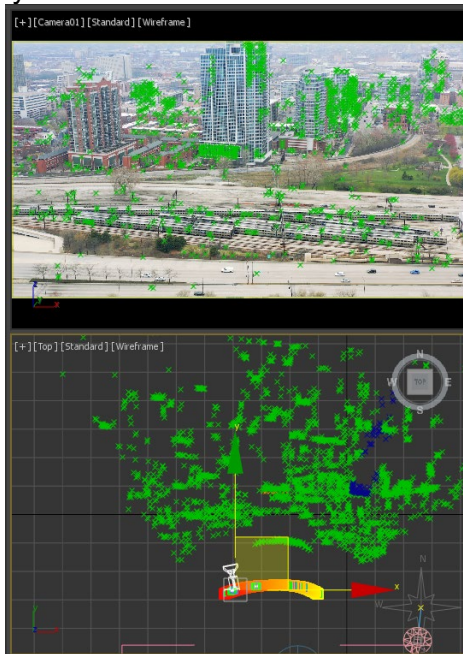

When working with background images, it's best to turn on Safe Frames. This sizes the viewport to the aspect ratio of your rendering which in our case is 1920x1080. To turn on Safe Frames, click on [Perspective] within the viewport and choose Show Safe Frames. You can also use the shortcut Shift+F. You'll notice that your viewport is now cropped down to the proper aspect ratio with a yellow border and black filling in the rest.
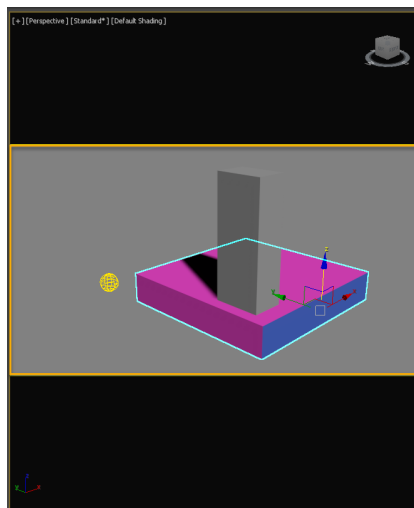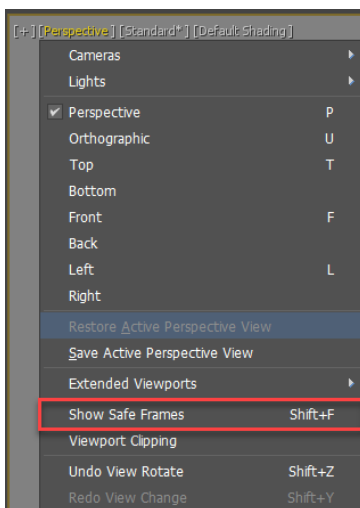
To insert a background image, whether it's a still, or a video. Click the [+] in the viewport and choose Configure Viewports. In the Background Tab, Choose Use Files and click the "Files…" button at the bottom and navigate to your image. If you wish to use a drone video as a background you'll need to first convert the video to an image sequence. A program like Adobe Premiere can do something like this, although there are many tools that can. Bring in your image sequence to 3dsMax by selecting the first image on the list, and check Sequence at the bottom to bring in the entire sequence.
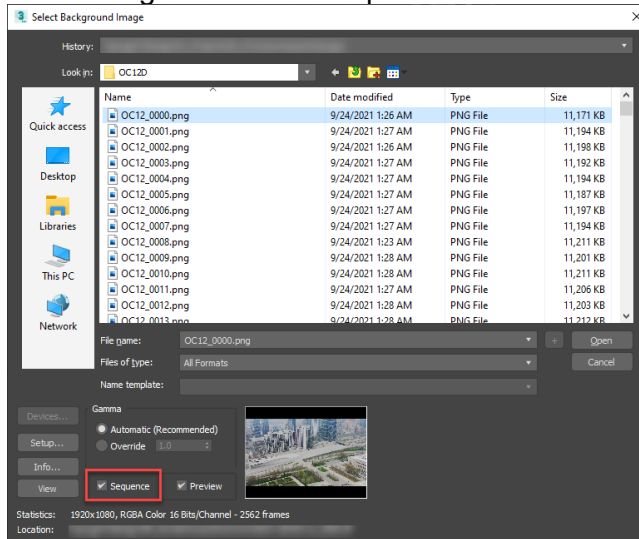

If you have gone through the process of creating a camera from the drone video, you should see the track points align perfectly with the background video.

Arnold Materials

Materials have a bit more variety and are extremely powerful. We are only going to show a few things about them to get you going, but there is a lot of depth here to really make your animation standout.

Arnold Standard Surface will be your default material to use on your renderings. Here are the settings to get these different looks:
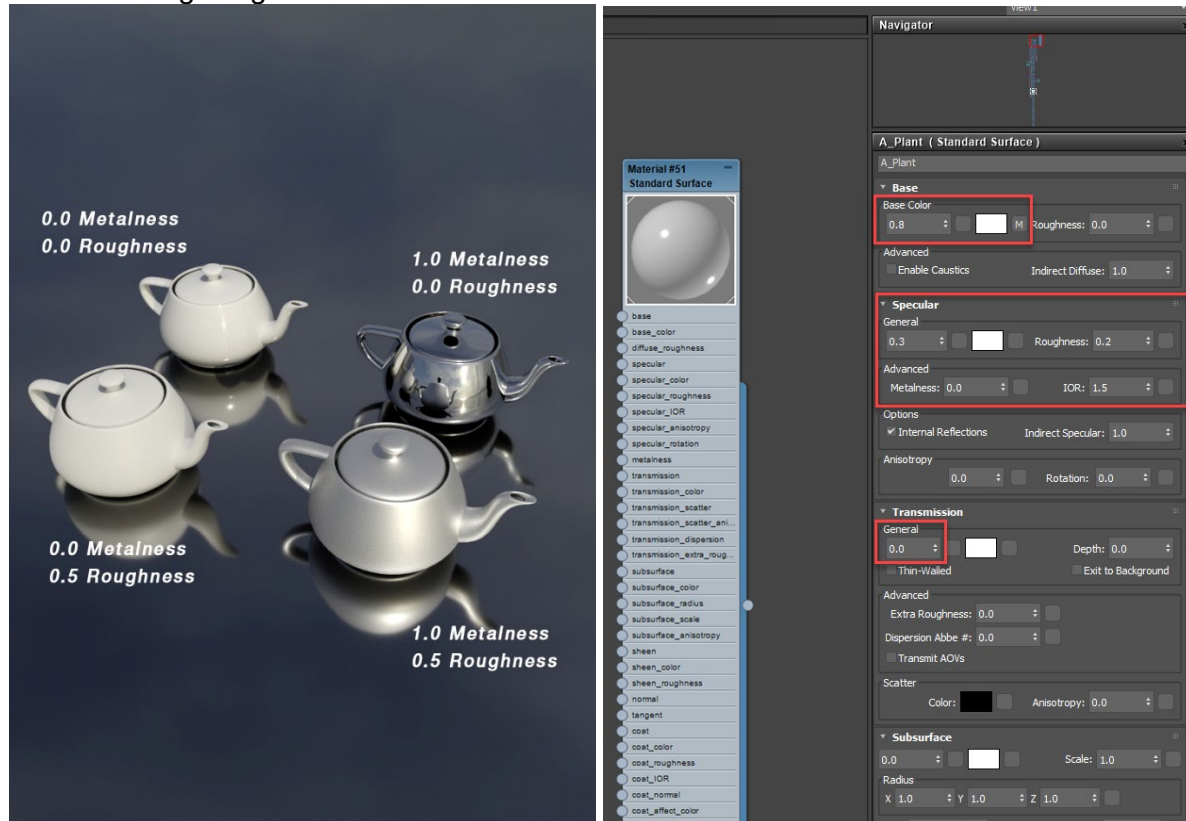

Rabbit hole for those so inclined: This can be an animated PNG sequence.

Roughness, Metalness, Specularity, Transparency are all primary controls in this material type, each one of them can be assigned a map by clicking on the empty button next to the value.

Adding Textures
To add a texture, based on an external image file. Open the Material library (M) and create a standard Arnold Material by right clicking in the Library view and choosing Materials: Arnold: Surface: Standard Surface.
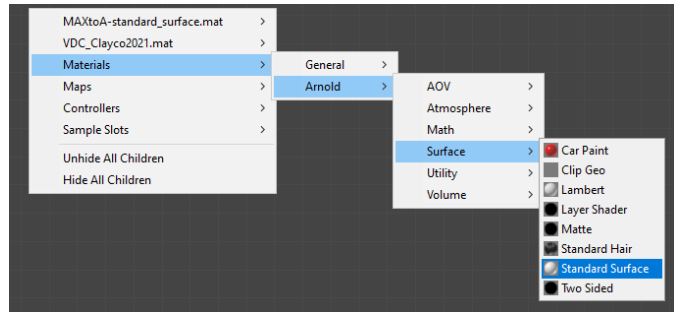
A material with a long stack of parameters will show up below the preview window, but we are only focused on one. Click on the circle to the left of the base_color parameter and drag it out and release, you should see the circle turn yellow with a red line, and then a menu will appear when you release.
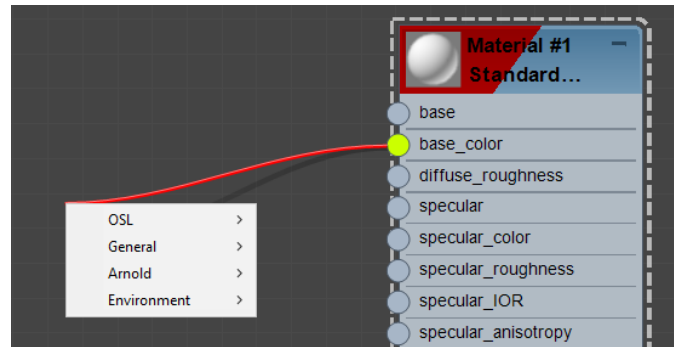
Choose General: Bitmap. An open dialog box will appear. Navigate to your image file and select it. It's important that you choose a material that is seamless so that you don't have ugly seams running through your renderings.
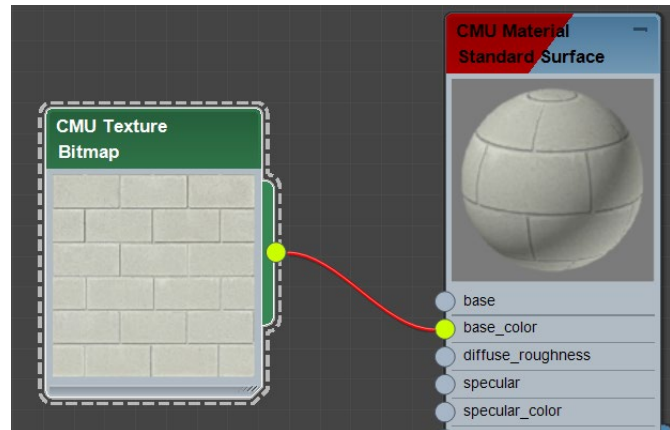
Multi/SubObject Materials

Certain objects export from Revit with multiple materials, yet still act as a single object. These would be doors and windows, which would have a glass material, frame material, possibly a hardware material. 3dsmax has a great material called a Multi/SubObject Material which allows you to apply one material to an object yet still maintain the separation. It does this by having Material IDs within the object. You can mix and match materials in different Multi/SubObject Materials as shown below. There are many tutorials online on how to best utilize this powerful feature. It can get complicated quickly, so I'll just leave it at that.
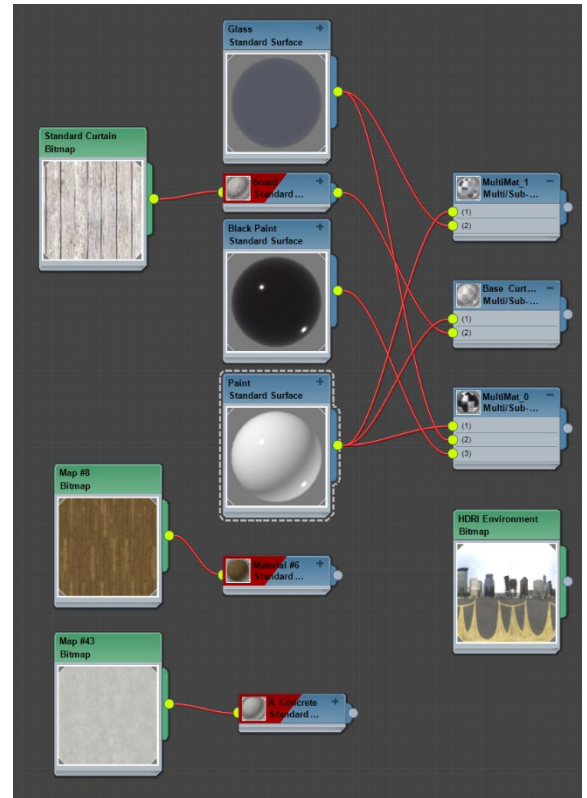
Render Output Settings

Controlling Exposure in rendering is probably the first big headache that 3dsMax throws at you. It's simple to control, however, and even though there are a variety of ways to do it, we're going to take care of it all in the Camera. To do this though, we need to open the Environment and Effects Panel (Rendering Menu: Environment shortcut is (8))

In the Exposure Control setting, change <no exposure control> to Physical Camera Exposure Control. No other settings really need to be changed here as the Exposure is now controlled in the Camera.
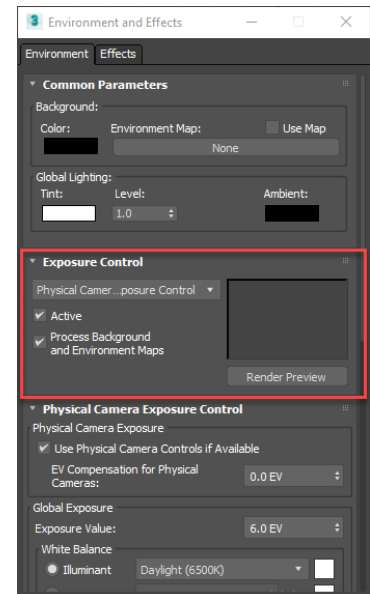
We'll now turn to the actual Output settings for the render.

When you open your Render setup [icon] you have a few different tabs. For what we're trying to achieve here, you only need to focus on the first three tabs.

Common Settings

This tab doesn't change regardless of which rendering engine you choose. For animation, we'll need to make a settings adjustment in a few places.

1. Change the Time Output to Active Time Segment (or Range, if you don't want to render the entire animation)
2. Change Output Size to your desired aspect ratio (in this case 1920x1080)
3. Select your Render Output Path and choose a folder that you will be dumping a rendering of each frame. You will also choose a file format here. A PNG file is good choice because it has an alpha channel. If that's not needed, a JPG will work as well.
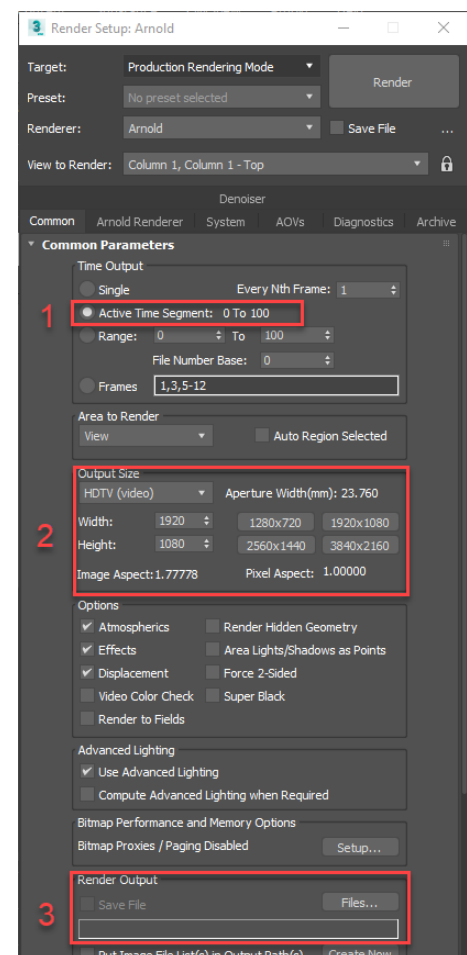
Arnold Settings

The Arnold tab only shows up when you have selected Arnold as your renderer. If you want the simplest adjustment just look to the Camera (AA). Changing this value will have the single greatest impact on your rendering. If the number is low, the rendering will be grainy and pixelated but render very fast. As you increase this number, the rendering time increases, but your graininess will dissipate. With an animation you must consider your overall animation render time, so it's better to start with a very fast render time to check your lighting quality. Often the graininess will not be as noticeable because you've introduced motion into the video.   My recommendation is to start with 1 for Camera (AA) and increase it until you find the right balance.   With our office using a render farm, we find somewhere between 4 to 6 minutes per frame works for an overnight render.
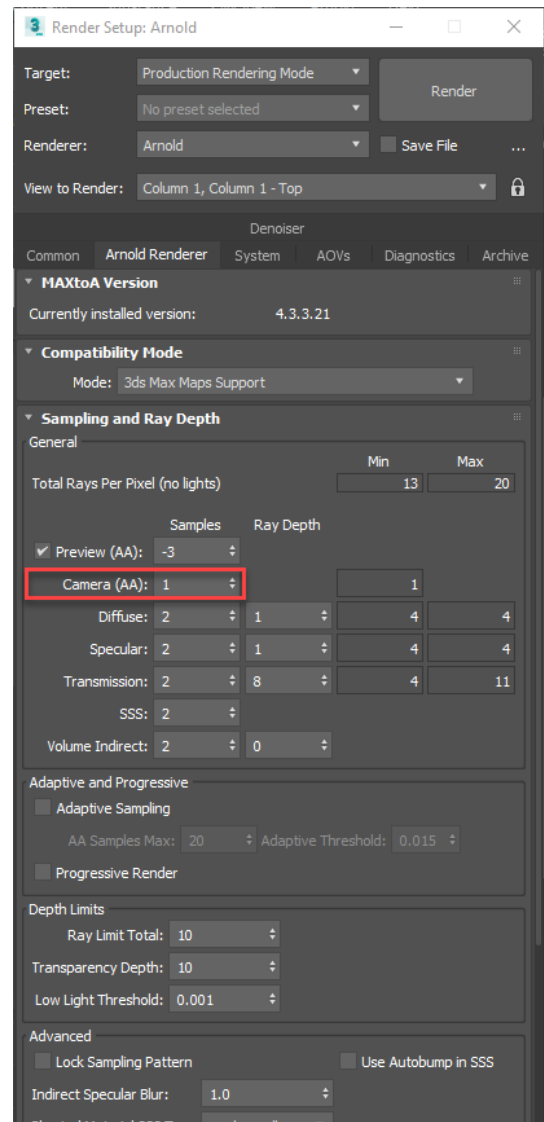
System Settings

The one thing to check in the System tab is whether you want to render using your CPU or your GPU. It's up to you to decide which one is faster. Personally, I find that the GPU renders faster at the same settings, however, the Camera (AA) needs to be bumped higher to get the same level of quality, so it's almost a wash.
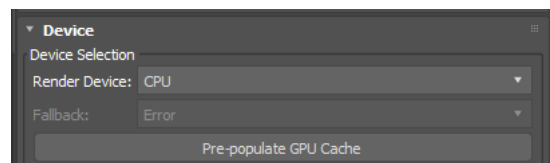
Post Processing

Post processing is what takes place after you have rendered the animation. We typically would add things like logos or titles in After Effects and render out the final composite as an MP4 video that could be uploaded to Vimeo/YouTube or just be a standalone file that can be played during a presentation.

One other thing we add is a Timeline to our construction sequences. It's basic and doesn't include everything from the P6 schedule, but it allows us to freeze the video at any point and show what activities are happening at a certain point in time.

Importing Files

To bring in your rendered images into After Effects, right click in the Project window and Import..: Files..:
Select the first image of the sequence and make sure that Sequence is checked, and it'll bring in the entire sequence of images as a composition.
In this manner, you can bring in Illustrator files with text and really anything else that helps finish off the video.
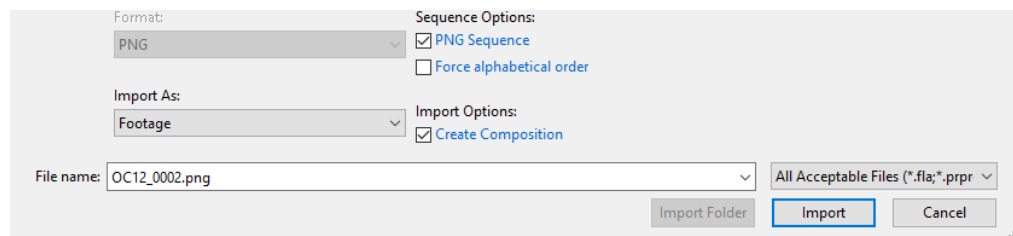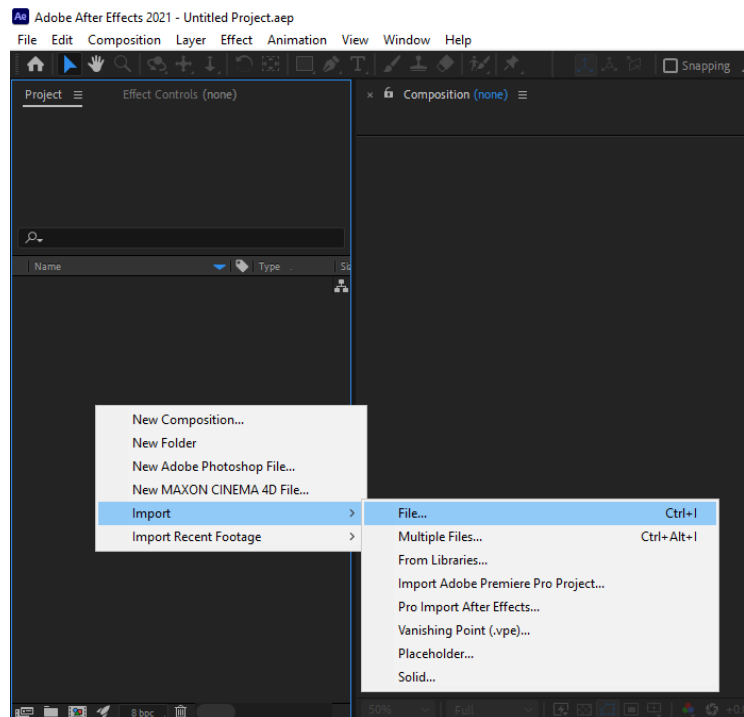
Animating Text

A simple text animation is all we use to show which activities are currently under construction. Each activity that we use is a separate layer in After Effects. The color the text is animated starts at a light gray, transitions to orange when the activity is underway, then to green when it is completed before for fading to black. It's very basic, but gets the job done.
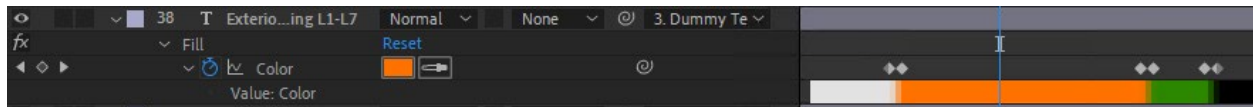

Where these keyframes occur is based on that excel file we created way back at the beginning. With all those frames clearly specified there, we're really changing the text from our template file and then sliding frames to match.

Animating Timeline

A timeline is a graphic created in Illustrator or Photoshop. Since our animation times are almost always linear, the timeline moves at a constant pace, so usually just needs a start and end keyframe to match up perfectly. Occasionally we'll insert more if the project is multi-year and we want to hit the Jan 1 turnover on the timeline.
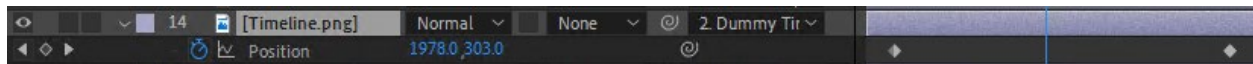
Putting this all together we get a moving timeline with text that fades in as the sequence is constructed.
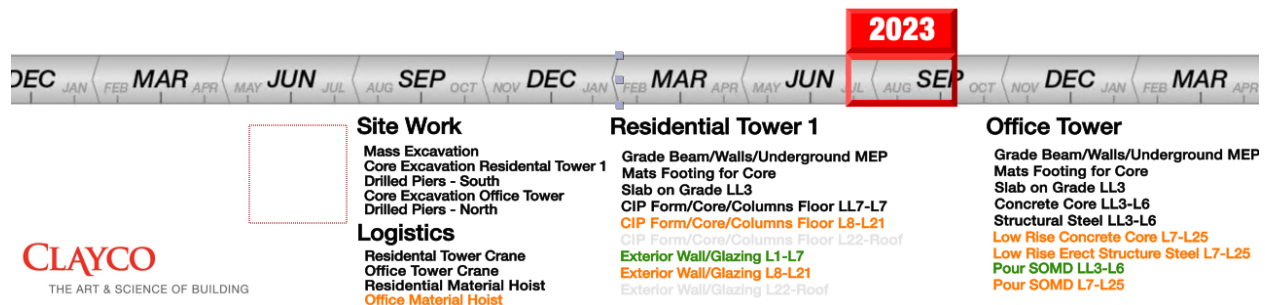

After Effects Tips and Tricks.

1. (U) is the shortcut in After Effects to open all layer parameters that contain keyframes. You can open multiple layers at once using this, and it makes it easier to line them up.
2. [Space Bar] will start/stop playing the animation, which is useful for checking timing.
3. Get to know the concept of Dummies, both in 3dsMax as well as in After Effects. It makes controlling the positions of multiple items a lot easier.

After Effects Output Settings

To export from After Effects, go to File: Export: Add to Adobe Media Encoder Queue. This will open a separate adobe program that takes care of output. Adobe Premiere uses it as well as a few others. We've found that H.264 Format with the Vimeo 1080 Full HD works well. Click the green play button and it will output everything to a final video.
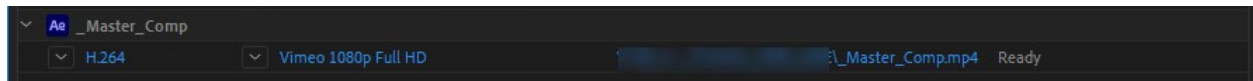
Conclusions

This is by no means meant to be *the way* to do a construction sequence animation. It's just "our way" and it probably is only our way for right now. As we hire more people and bring others with more experience in animation onto the team, we will evolve this and grow it. The purpose I'm trying to show here is waypoints on a map that cast some light on the how things are done. The process I showed is Revit -> 3dsMax -> Arnold -> After Effects. However, for you this might be Rhino ->Cinema 4D ->V-Ray ->After Effects. I'd like to encourage everyone to find their own way with these tips and even share them with me on LinkedIn so that others can grow and develop. It's been fun trying to figure out processes like this and I hope you enjoyed it.