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The Next Steps in BIM: Civil and Construction Coordination with BIM Models

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AB5074 BIM as both a process and a type of software has been utilized for architectural and engineering design and documentation for some time now, and its use continues to spread to more facets of the AEC industry. This class will focus on the BIM process as it applies now more than ever to both the civil and construction trades. Using real world examples and core design concepts, we will explore strategies for how the civil and construction trades can best coordinate with the other trades' BIM models and data. We will also discuss the benefits of improving civil engineering collaboration with the other BIM models during the design and documentation stage, and later incorporating the construction and subcontractor models. With increased collaboration at every stage comes improved design efficiency, reduced costs, and the potential for a more interactive model deliverable that can be leveraged by owners for operations and maintenance.

Learning Objectives

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

- Describe what information is typically needed from a BIM model for construction and civil use
- Describe useful techniques for sharing relevant data between the architectural, MEP, structural, and civil trades
- Create a BIM model for construction management from a documentation model
- Identify the process for keeping a BIM model coordinated within the construction process

About the Speakers

Peter Marchese is a senior consultant with Microdesk, providing support to national architecture firms implementing Revit®. He also specializes in implementation, custom content creation, consulting services, customized training, and leading firms through the process of creating standards and workflows based on building information modeling technology. Prior to joining Microdesk, Peter worked at firms working on residential, institutional, liturgical, pharmaceutical and commercial projects. He has managed projects throughout all phases from design through construction documentation. He holds a Bachelor of Science degree in architecture from Drexel University in Philadelphia, Pennsylvania.
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Andrew Thoma is a BIM manager with HITT Contracting, Inc., where his primary focus is on the implementation and use of building information modeling technology within the AEC industry to enhance efficiencies throughout the design and construction process. HITT Contracting Inc. is an award-winning "turnkey" construction company performing a wide range of services from small jobs, service and emergency work, to full base building renovation and shell construction. Prior to working with HITT, Andrew worked with Microdesk Inc. as a solution specialist, where he provided consulting services, training, and implementation support for civil engineering, construction, and BIM technology. Andrew has also worked as a designer at a variety of engineering firms, where he was responsible for commercial and residential land development submissions, preparation of roadway and site designs, construction inspection, and managing CAD standards. Andrew holds a degree in civil engineering from Drexel University in Philadelphia, Pennsylvania.
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Louise Buchanan is an architecture solutions specialist with Microdesk, where she provides technical support, training, and standards development for companies using Revit® Architecture, AutoCAD® Architecture, AutoCAD, and Navisworks®. She has over 10 years of experience working as a CAD designer, drafter, and analyst on a wide variety of residential, commercial, and institutional projects. Prior to joining Microdesk she worked at Brooks Pharmacy's corporate headquarters, where she served in a dual role as CAD manager and designer; before that, she was a CAD/GIS drafter at Brown University. Louise holds a bachelor of science degree in architectural/building engineering technology from the New England Institute of Technology in Warwick, Rhode Island. Louise is a certified professional Revit User, certified Google SketchUp trainer, and certified Autodesk® Seek content creator.
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Class Summary

The goal of this class is to help show that BIM is not just about the building. Depending on who you talk to, BIM can stand for Building Information Modeling or Building Information Management. The key to understanding this process , isnt in the Modeling or Management, it's the information and the fact that it's a process. Its more than just a software package or a specific part of a construction project; BIM is about creating a model of a building or other project that can be communicated to all the parties working on it, from initial design and development through to the actual construction. But in order to get the most out of BIM, it's important that every step is included in the BIM process. If any one party or any one phase of the project is left out, the entire collaboration suffers. Today we will go over some real-world examples of how companies have put a BIM process in place -- where things went wrong, where things went right, and how we can more readily take advantage of the programs that are available to help implement a BIM process, covering tools that are available now as well as tools that are coming soon.

How are we using BIM for civil and construction now?

At the moment BIM is being used on large-scale civil engineering projects or for infrastructure projects rather than smaller work. Like other new technologies, adoption of BIM has been slow because many engineers previously did not need to model projects in 3D, or to utilize software that could do certain calculations or analysis for their work.

Those that are utilizing BIM for civil engineering have found some issues when coordinating with other companies, but they have also found new solutions and methods to make the collaboration work.

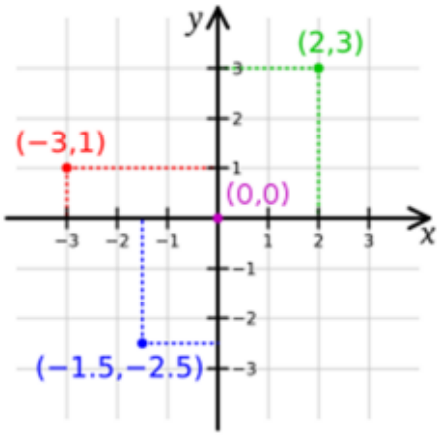
With more projects being fast-tracked, companies being pushed to incorporate LEED standards in their projects, or contracts stating that coordination errors will not be paid for by the client, the usage of BIM tools will become more widespread. As that happens, clients will come to expect the output and level of performance these tools can provide, and this in turn will only increase the need to coordinate electronically with other contractors, vendors, construction companies, and the clients themselves.

Problems we want to avoid

The issues we want to avoid are the ones that probably everyone in this room has run into at some point in their career. It could be as simple as elevations not being coordinated, or part of a building getting moved accidentally on a sheet but no one catches it. It can even be something as simple as a conversion issue. These seemingly simple issues can cause major problems, including financial losses, schedule delays, and damaged reputation.

Let's not forget that NASA's Mars rover failed due to a metric conversion error.

Many of these issues can be alleviated with software, but just using the computer to fix or coordinate some issues without understanding why they come up in the first place will not truly solve the problem. A simple example of this is setting the origin point for a project. An architect or structural engineer might set the origin point of their work to a grid intersection, or possibly even a point on the site boundary. But the civil engineers will typically use something called the state plane system. This was created in the 1930s to provide a common reference system for surveyors and mappers. What it does is break the US up into 124 geographic zones for consistent location points. It is still used today because it's very accurate within each zone (moving outside of a zone degrades the accuracy) and based on a simple Cartesian coordinate system.



This is important for architects to know so that we realize that the civil team is not using "our" origin for a reason: they are making sure that the project is sited correctly in terms of its geographic location. The site plans, with their world-based locations, then locate the building within that space. The other trades may use a different origin within that space because they are more focused on where items are located within the building, and less on, for example, where a particular duct is located in relation to the overall site plan.

These images, while funny, are things we want to avoid. They probably could have avoided with just a little more care, communication, and cross-checking.

When the two groups do not coordinate, though, or fail to realize that they need to coordinate, problems can happen. And if those problems are not caught early enough they can be VERY expensive. We will talk about one such example later.

A cautionary tale

The images above may be funny, but they point to some issues that we run into far too often. Up to the point when the photos were taken, the project might have been perfectly coordinated; they could have used BIM, they could even have had frequent team meetings. But if small errors are allowed to occur and snowball, or if people let things go because it's not their responsibility, then things like this can make it into the actual building construction. Unfortunately, when that happens, all the good work prior to that can be forgotten, and all that is remembered is the problem. This is exactly what happened with the case we're about to describe. The project was built and coordinated using BIM, but a small issue that snowballed caused the building to be constructed in the wrong location.

In this particular project, the surveyor set the benchmark for the project and the civil team used this benchmark for their site design, but when the architect rubber-sheeted the civil plan, they shifted the benchmark. The civil team had no way of checking the model, since they were not yet BIM or 3D integrated. The benchmark was then given to the construction surveyor for the stackeout from the architect's construction drawings (with the shifted benchmark) and the foundations were poured 4' off in the XYZ coordinates. The construction supervisor noticed the location was wrong relative to the site as the structural columns were being placed, because the BIM construction visualizations showed the correct locations and his 'gut' told him he was wrong.

The takeaway from this is that BIM is not perfect. It is a process that allows and helps us to have a better project, but it still requires effort and knowledge of the tools to keep a little error from snowballing to become a big one.

Examples of what we want to achieve

What we want is a true BIM project that isn't just focused on the design model or the building, but is focused on the entire construction process and the area around the construction. The goal is to create a model that takes into consideration the construction model and how it relates to the design model, the fabrication model as it relates to the construction model, and an as-built model as an end product that could be used by the owner for facilities management, maintenance, or other needs, including marketing and promotion.

This does not mean that each leg of the process absolutely needs a new model. However, when a new model is needed, a good BIM process allows one to be created without having to remake or adjust the previous model.

Using BIM to coordinate civil engineering and sustainability requirements: A case study

The project is the HITT general contracting headquarters building in Falls Church, Virginia. This project reflected HITT's development, growth, and success in utilizing technology to expand their business. As a result, they were certified for LEED Platinum. The site consisted of a 147,000-sq. ft., Class A building with a 36-car garage structure adjoined.

Located in a park-like setting, 2900 Fairview Park expresses HITT's commitment to sustainable construction in many ways. They have managed to consolidate four separate buildings into one. The convenient location encourages the use of public transit to reduce their carbon footprint. Amenities like a fully-equipped fitness center, café, salon, ATM, and dry cleaning service on-site reduce the number of trips employees make each day to run errands. Thanks to waterless urinals, low-consumption water closets, and low-flow fixtures in the showers and sinks, the facility will use 46 percent less water than most buildings of this size. Other sustainability features include the lighting design, which uses more than 50 percent fewer light fixtures than HITT's existing location, and a white roof membrane that reflects light and heat away from the building. These measures and others, in conjunction with higher-efficiency HVAC equipment, will save HITT over 20 percent in electrical costs for operating the building.

To achieve a sustainable design with the civil part of this job, they utilized tools available in the software they were using. One of the focuses was LEED points from storm water runoff. Due to the LEED requirements and Virginia local regulations, the building could not increase existing site runoff by more than 25 percent after construction, and had to have equal on-site water retention and filtration. This meant that the civil engineer had to model the existing site from survey info to account for storm event water flow/flooding.

The civil team then created a storm water analysis, both inside and outside of the building. They already had a 3D model from the survey data, and it wasn't hard for them to insert the architect's building model into the site. However, the site picture is not complete until the building landscaping, sidewalks, parking, and any other features designed by the architect or landscape architects are given to the civil team to use in creating the analysis model.

Once this was completed, they used programs like Autodesk's Storm and Sanitary Analysis (SSA) with Civil 3D to study existing conditions and water runoff amounts, which in turn allowed them to calculate the changes needed to design green water features. This led to a number of improvements, including decreasing the size of the pipes in the storm sewer systems, which

translated to smaller and lighter components that saved money in transportation and installation. The analysis also revealed that the parking garage lay in the 500-year flood zone, which led them to optimize the location of the building in relation to the surrounding landscape.

Working forward from these sustainable choices, they looked at ways to make the construction of the building and its site utilities efficient and coordinated. To do this, they ensured that all utilities that tied into the building, such as storm water systems, would be modeled so they could be included in clash detection models utilizing Autodesk Navisworks Manage.

Using BIM to coordinate civil and construction: Two case studies

This example is a 140,000-sq. ft. convention center on a research campus setting. This new building was going to replace three existing structures on the site. The biggest issue in planning the demolition and analyzing existing conditions was a planned tunnel for the central plant of the campus that needed to pass through the foundation and basement space of the new building. Since this research campus was functioning at the time, this meant that the delivery of construction materials had to be staged to prevent traffic and workflow issues.

Adding to the complexities from an environmental perspective was an area to the north of the new building that was environmentally sensitive and required protection. The design and construction required strict erosion control and storm water runoff management. These issues were managed by coordination and careful use of the BIM data. The civil model was used to analyze the site, thus minimizing the SSA effect.

For the construction issues, Autodesk Navisworks Manage took in the Autodesk Revit files, Autodesk Civil 3D, and even the Google SketchUP content and helped the teams work out the 4D timeline for construction staging. They also used Navisworks to confirm that the deep excavation would not interfere with the nearby Metro line and its Pepco vaults or require the line to stop operating during the construction process.

Civil, Construction and BIM

The second example of using BIM to coordinate civil and construction we will talk about here is a $54 million apartment complex. This project included the following:

- The demolition of existing buildings, paving, and roadways
- New paving and utility structures
- A new 327-unit, 327,431-sq. ft., 11-story apartment building with a pool, bath house, and associated site work
- A 4-story, 140,000-sq. ft. garage with a 3,000-sq. ft. attached commercial space

The location of the project necessitated an intersection change and road realignment, as well as a change to the traffic pattern on an existing road. The road redesign needed to happen before the owner could get permits to build the complex. Redesigning the road, in turn, required land to be taken from neighbors as well as county and city approvals.

The model level of design that was agreed upon was 100 (as per the AIA E202 documents), and this was critical to understanding the design and setting the basis for coordination. When integrating the garage model into the site design in order to optimize the location of the building, they were able to minimize the road redesign. Once the design was modeled, they could

analyze the surrounding landscape, improving the way they managed storm water. These 3D models allowed the engineers to change the design quickly and easily, so when the building layout changed, the site update could follow and adjust accordingly.

When time came for apply for approval for the site alignment and the permit to build the garage, the visualizations based on the models were key. Since the design was one the city had never dealt with before, they needed proof that the garage would look like an office building as per local zoning, and that the nontraditional openings would provide adequate ventilation. Since the engineers didn't have to create a separate presentation model alongside the documentation model, they could keep the visualizations up to date with any changes in the designs.

In terms of scheduling, all these related aspects of the project were occurring together -- the garage, apartments, and the road were all to be built or renovated at the same time. The intent was that the garage could be open and ready when the first tenants moved into the lower floors of the building. This would allow them to lease out the lower portion of the building to start bringing in revenue while the rest of the building was being built out. This tight schedule necessitated a 4D timeline to coordinate the construction, and having that already modeled in Autodesk Navisworks Manage made the data easier to work with and keep up to date.

Current BIM technology

There is a large assortment of technology out there right now that can help coordinate projects like this. The primary software for implementing BIM in civil trades is Autodesk Civil 3D. However, we have and will be talking about several different programs and tools that can be used to achieve a coordinated and well-analyzed project. To help with this, Autodesk is now packaging its software in suites to make access to the different tools much more affordable than they would be if purchased separately. The Infrastructure Suite contains Civil 3D as well as Autodesk 3DS Max for visualizations and Autodesk Navisworks for reviewing files from many different program sources. Autodesk is actively working to help its customers with programs that will better coordinate with each other.

With regard to specific applications, the tools we have spoken about the most include Navisworks Manage, 3DS Max, Revit, and Civil 3D. The Revit applications are predominantly used for architecture, structure, or MEP, but there are add-ons that will take advantage of the site tools that are already there and take them further for site design. There are also tools available to those on subscription with Autodesk Revit Structure that give them the ability to work with some of the information from a Civil 3D file. Civil 3D includes the SSA software, which will allow for things like water quality modeling for sustainable stormwater management, as well as design of detention ponds and outlet structures and storm water drainage systems.

In truth, the software available is limited only by budget and willingness to learn and utilize it. Again, the software is a tool and not the BIM process itself, but it can contain intelligence and

help analyze or coordinate data that in turn can be analyzed with another tool. Most importantly, the software is not a black hole where information is entered but cannot be shared.

Future BIM techology

For many it might seem that the future is never going to be here. I mean, we still don't have flying cars. But if we look at what we have available to us now, and more importantly what is coming soon, we can see that many of the things we used to consider sci-fi have become just a day-to-day, normal accessory.

The radar in the James Bond movie *Goldfinger* seemed amazing when the movie was first shown in 1964. Now you almost can't find a car without a built-in GPS and touchscreen, let alone a mobile phone without a map application. Looking at the movie *2001*, which was filmed in 1968, they were already predicting a world where tablets and touchscreens were commonplace.

These examples are relevant because more and more often these futuristic devices are appearing in our daily lives and being used in amazing ways. The phones with GPS can take photos of places and remember where they were when they were taken, and then software can come in and piece those photos together to make a model of the space. This isn't sci-fi. Microsoft did it with its Photosynth software using photographs of Rome from the Flickr website. And if you take a look at the Autodesk Labs booth at the show or the Autodesk Labs website, you will see a program called 123D Catch that can do similar things.

From a civil perspective you may say that it's too time intensive to take photos of a site for existing conditions modeling, and for large sites that response would be understandable. In that case, you have something like Pix4D. They have a UAV (Unmanned Aerial Vehicle) that can fly a pattern on its own, taking photographs and then piecing them together to produce a 3D model of a location. If that kind of modeling isn't feasible, then point cloud scanning is becoming more available to the masses. Microsoft's Kinect is being developed for many, many applications using program tools that are already out there. From the perspective of architecture, engineering, and construction, some of the most interesting ones will allow the user to scan a space much more quickly and easily than ever before. These models can then be utilized for some of the things that we spoke about above -- water runoff, clash detection, getting things in the correct location on the site. Things that can pay dividends with their results.

Autodesk also has hardware-intensive initiatives in the works. We have seen some of their videos showing a person on a site with a tablet; they are looking at the ground through the tablet, but they aren't seeing the grass or the road. They are seeing the pipes, cables, and other elements that are not visible to the naked eye. Things that it knows are there because of the precise coordinates it has access to, combined with scanned data or an accurate as-built BIM model. Couple that with the continuing development in coordination and collaboration between their respective applications, and augmenting that with key acquisitions like the fabrication

software company Micro Application Packages Limited (MAP Software) we can see that that this aspect of BIM going to be a very important piece of the whole puzzle.

Key points

The main thing to take away from all of this is that regardless of what discipline you are, or what portion of a project is your responsibility, communication, collaboration and coordination are key. These are core principles of a BIM or IPD process, but more importantly, they are good practice. It's an old saw that when you have a project, you can pick two of the following: on time, under budget, or coordinated/correct. This just is not acceptable anymore. Shrinking budgets, tight timetables, and increased expectations mean we need to take more advantage of the tools available to us.

The great thing is we don't need to have a PhD in computer science to do this. Many of the tools that help us achieve this are easy to use or based off of programs that we are already familiar with. Remember: BIM is the process; the software is a tool, and many tools can be used for many different functions.

To take advantage of these functions some will require more training, but this isn't any different from what many licensed professionals already go through to maintain their license status. How many of those who attended this session submitted for AIA credits? Many classes for utilizing software to its fullest can count for some of the continuing education credits that you already need to maintain your credentials. And just like the other classes you might take for these, they can really be put back into what you do to make you and your practice more complete and more competitive in today's marketplace. Thank you again for the time you gave us and enjoy the rest of Autodesk University.

For more information:

For information related to construction:
HITT Construction
http://www.hitt-gc.com/

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On the State Plane System:
http://geology.isu.edu/geostac/Field_Exercise/topomaps/state_plane.htm

Tool to convert location points:
http://www.earthpoint.us/StatePlane.aspx

Microsoft and the University of Washington's Photosynth of Rome
http://grail.cs.washington.edu/projects/rome/index.html
http://photosynth.net
http://blogs.msdn.com/b/stevecla01/archive/2009/09/17/building-rome-in-less-than-a-day-with-photosynth.aspx

Autodesk's 123D Catch
http://www.123dapp.com/catch

Pix4D: Aerial image processing
http://pix4d.com/index.html