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Technologies That Will Dominate The Construction Industry 2020

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How Can Drones Be Used In Building Projects?

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Drones are used across many industries and commercial fields, but one of the main adopters of this technology is the construction industry. Incorporating drone technology in construction has redefined the way buildings are designed, constructed and maintained. It is commonly thought that drones can only be used to take photos and videos. However, they benefit construction companies and developers by improving design accuracy and overall quality, while simplifying maintenance during the building lifespan.

Project managers, supervisors, technology managers and contractors are taking advantage of drones to fulfil their roles more effectively. Drones have transformed the way the construction industry operates, and those changes will have lasting effects. Here is an overview of some applications and key functions of drones during various stages of a building life cycle.

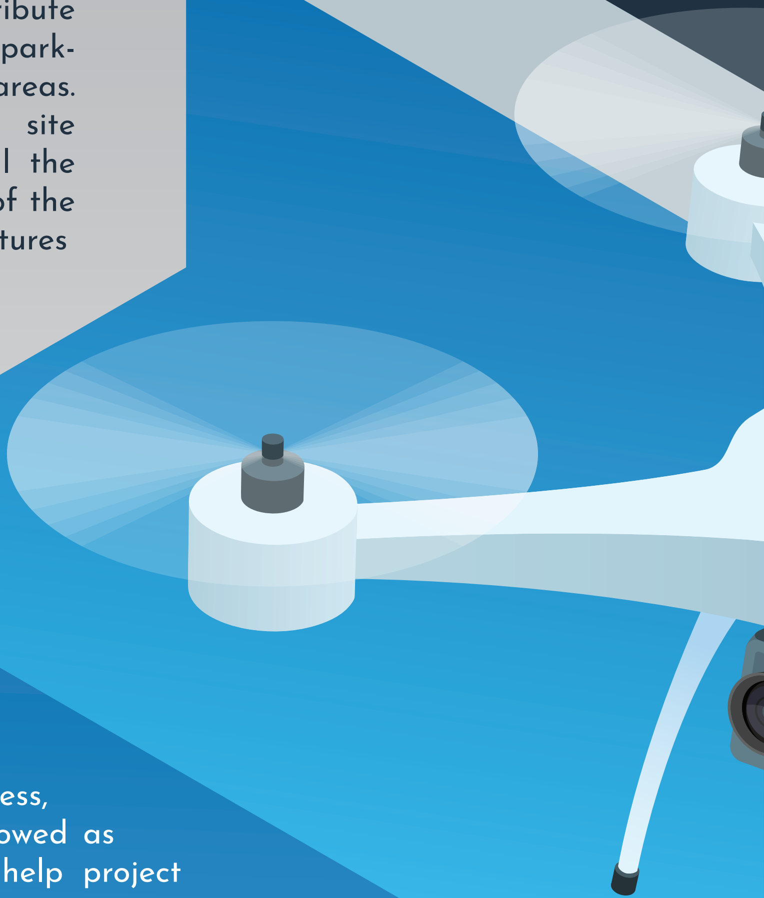
Evaluating Site Conditions

When purchasing land, it may be difficult to fully understand the terrain and land distribution. Therefore, drones can be used to capture images and give landowners a better understanding of their investment. Airplanes can be used to complete this task, but drones have become a more efficient option for many reasons:

- When using planes, information may take longer - companies must wait to have several projects to photograph, in order to make the flight time worthwhile. On the other hand, drones can easily fly and capture images when necessary.
- The operating costs of drones are considerable lower than those of planes.
- Drones fly at a lower height than planes, and the presence of clouds does not affect the quality of photographs.
- Data acquired by drones can be used by engineering software to measure dimensions, elevation changes, and estimate material volumes for earthworks.

Site Planning

Images and data captured by drones can be used in combination with site plans, to create layouts that provide more information and a better understanding of the site. Plans and drawings can be superimposed over site photographs in order for designers to distribute the different elements such as buildings, parking lots, sidewalks, and landscaping areas. These layouts can help builders and site owners to visualize and understand all the features of the site plan in the context of the land, also to determine geographic features that might affect the distribution.



Supervision and Progress Checkups

The most common application of drones in construction is using them to inspect progress, and verify that the schedule is being followed as established in the contract. Drones can help project managers with the following functions:

- Setting weekly predetermined flight paths to develop consistent images that can be compared throughout the project.
- By monitoring progress images and overlaying them on designs and drawings, builders can corroborate that the project is moving according to plans, and also supervise construction quality.
- Drones provide high quality images that can be easily compared to the plans. For example, if a structural element is misplaced or misaligned, this can be easily identified with overlaying.

In a few words, drones can detect issues that tend to remain hidden with conventional supervision methods. With their small size and hovering ability, drones can observe work-in-progress from any viewpoint.

Maintenance and Damage Assessment

Drones can also be used in buildings once they are completed. For example, the information obtained by drones can be used for maintenance planning. Also, drones can be used when working on as-built drawings and models, which simplify decisions for owners during future renovations and upgrades. Drones are also useful in situations like the following:

- Damage assessment after a hurricane or tornado: Drones can easily fly around structures and identify the extent of the damage caused by the natural disaster.
- Drones with thermal imaging equipment can detect air leakage and poorly insulated areas in the building envelope.

3D Scans

Another application of drone technology in construction is photogrammetry: scanning existing structures to create 3D models. This application is helpful especially in retrofits and renovations, since it allows the creation of a detailed model with actual conditions.

BIM software can be used to import the model and use it as a reference. Drone data can also be converted into virtual building models that can be "walked" using ER goggles. This allows clients to observe the final outcome of renovations, and have a better understanding of spaces, before construction even starts

Marketing

Nowadays there is no other device that captures videos and images like drones. They are capable of reaching viewpoints that are inaccessible for humans. The high-quality images and videos obtained with drones can be used for marketing purposes in websites or social media.

PREFABRICATION: HOW CHINA BUILT TWO CORONAVIRUS HOSPITALS IN TWO WEEKS

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According to the World Health Organization (WHO), the current fatality rate for confirmed COVID-19 coronavirus cases is 3.4%. In the past two decades, there have been outbreaks of deadlier diseases like Ebola (25-90% fatality), SARS (14-15%) and MERS (34.4%). However, COVID-19 is dangerous due to its infectiousness, even with a relatively low fatality rate. If allowed to spread without control measures, COVID-19 can overwhelm healthcare systems.

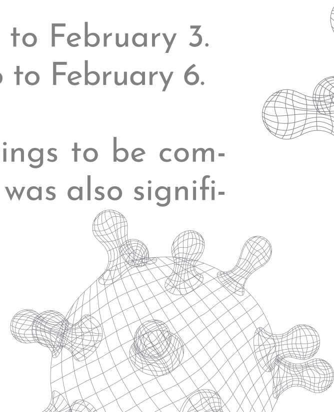
China had already deployed an emergency hospital within days, in 2003. The Xiaotangshan SARS Hospital in Beijing was built in only six days, to treat patients affected by the SARS outbreak. It is important to note that SARS was caused by another strain of coronavirus, deadlier than the current one but less contagious.

A 3.4% fatality rate may seem small, but consider how fast coronavirus can spread a population. For example, if a country has 10,000 confirmed cases, the case fatality rate reported by the WHO results in 340 casualties.

When the coronavirus outbreak started in Wuhan, the Chinese government quickly concluded that local hospitals would be overwhelmed. In response, two hospitals were built in Wuhan in less than two weeks, exclusively for COVID-19 patients:

- Huoshenshan Hospital (Mount Fire God Hospital), built from January 24 to February 3.
- Leishenshan Hospital (Mount Thunder God Hospital), built from January 26 to February 6.

This engineering feat was possible thanks to prefabrication, which allows buildings to be completed in a fraction of the time required by traditional methods. The labor input was also significant, with three shifts and over 7500 workers involved.



Building Temporary Healthcare Facilities with Prefabrication

Traditional construction methods are slow because they follow a linear approach, where many activities depend on the completion of earlier tasks. For example, structural components cannot be installed until the groundwork and foundations are completed. In turn, building envelope components cannot be installed without the underlying structure.

With prefabrication, structural components and building systems can be manufactured offsite, even if the groundworks and foundation are not complete. In other words, prefabrication transforms construction from a linear process to a parallel process. If a country must expand its healthcare system to contain a pandemic like coronavirus, prefabricated emergency hospitals are a viable solution.

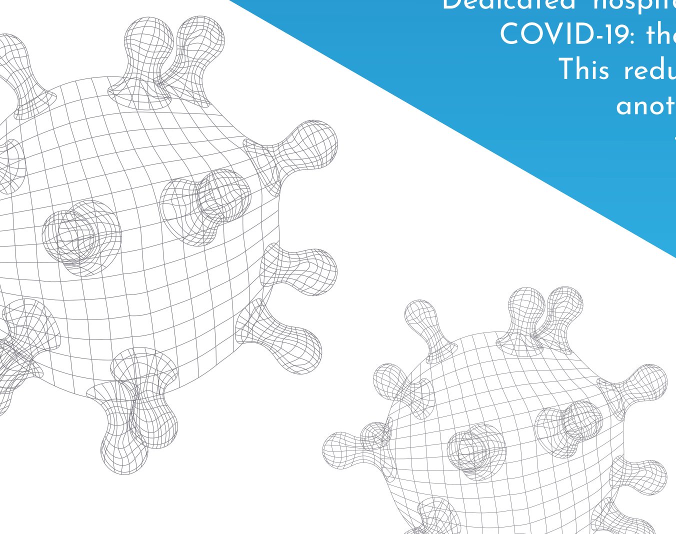
The Huoshenshan Hospital is located in the Caidian District of Wuhan. The facility has 1,000 beds and 30 intensive care units (ICU), with two floors and over 269,000 sq.ft. There are multiple areas and quarantine wards to treat coronavirus patients with different symptoms: unconfirmed cases, mild cases, and severe cases that need life support. The hospital also has medical equipment rooms, and an isolated command center where protective equipment is not needed.

The Huoshenshan Hospital was built with prefabricated units, each with an area of around 100 sq.ft. and designed for two beds.

- A specially designed ventilation system creates negative pressure in patient rooms, to prevent air leaks that could carry the coronavirus outside.
- The rooms have two-sided cabinets, allowing the delivery of medical supplies without opening the door.
- The hospital is run by a medical staff of over 1400, which includes military medics who have experience with previous outbreaks like SARS and Ebola.
- Medical robots support the staff with tasks like testing patients and administering medication.

The Leishenshan Hospital is located in the Jiangxia District of Wuhan, 25 miles away from the first hospital, with a capacity of 1,600 beds. This hospital is divided into 32 zones, where 4 zones are exclusively for severe cases of COVID-19. The Leishenshan Hospital is larger, with an area of over 322,000 sq.ft.

Dedicated hospitals provide a key benefit during a global pandemic like COVID-19: they isolate patients from those affected by other conditions. This reduces the chance of exposing a patient to coronavirus and another medical condition simultaneously Prefabricated hospitals can be used to boost the US healthcare system, and help contain the coronavirus outbreak.



USING DATA SCIENCE IN MEP ENGINEERING

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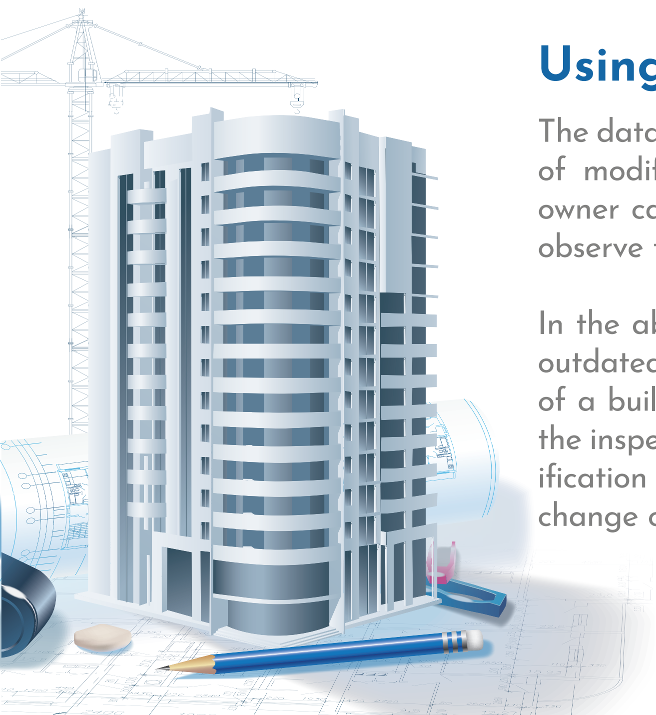
Data science has promising applications in business fields, and this includes MEP engineering. Buildings use many systems for functions like space heating, air conditioning, water heating, electric power distribution, ventilation and fire protection. All the equipment and components that compose these systems are potential sources of data when equipped with sensors. Data also has promising applications in research and development: it can be used to develop building technologies that improve performance.

The value of data science lies in processing large volumes of information and extracting useful insights. Since humans cannot process information with the speed of computers, large amounts of raw data have little use by themselves. However, when information is processed with adequate algorithms, it becomes useful for business decisions. Data science can be complemented with graphics and other visual aids to make information even easier to understand.

In MEP engineering, a promising application of data science is creating a "digital twin" of an existing building. A digital twin can be considered a more advanced version of a BIM model. Typically, a BIM model is finalized with "as-built" information when a project is completed. However, a digital twin constantly updates itself by collecting measurements from the building. This provides a constant stream of data, which can be analyzed to manage the building better.



Using Data to Plan Building Upgrades

The data collected from a building can be used to predict the effects of modifications such as energy retrofits. This way, the building owner can simulate many possible projects in a virtual model, and observe their impact before an investment decision.

In the absence of data, a building upgrade must be planned with outdated documents and visual inspections. Due to the complexity of a building, key pieces of information may be missed even when the inspection is conducted by professionals. Once the building modification project is started, the lack of information may result in change orders and unplanned costs.

During a building upgrade, there are often several upgrade options for the same building system, and many of them are mutually exclusive. Consider the following examples:

- Heating systems can be designed to use a mix of electricity and combustion, or only electricity. The most economic option may vary depending on the local price of electricity, and the availability of natural gas and other fuels.
- HVAC systems can use different heat-transfer fluids to deliver or remove heat inside a building. Direct expansion systems use air ducts, hydronic systems use water piping, and VRF systems use refrigerant flow. The best option may vary depending on the conditions of each project.

With so many variables to analyze, finding the best upgrades for a building is a technical challenge. However, the use of data science in MEP engineering allows a much quicker decision. Comparing many designs with spreadsheets and conventional CAD software can take plenty of time, which is not always available.

Data science can also be used to analyze behaviors that are invisible for humans. For instance, a promising application of data science is energy disaggregation: breaking down the electricity consumption of power meters to estimate the individual consumption of each device. Energy disaggregation allows virtual submetering, while only using one power meter physically. This information can then be analyzed, identifying the most promising opportunities to save electricity.

Data Science During the Building Design Process

MEP engineers can apply data science even when a building does not exist yet. In these cases, the building model uses only design specifications instead of measured data. However, the same principle applies: data science allows the comparison of many options in a fraction of the time required with spreadsheet calculations. Simulations are more complex when there is no measured data from an existing building, since the model must be based fully on physics. However, simulation is a powerful design tool for both planned buildings and existing buildings.

Data science is also a powerful troubleshooting tool when a building has performance issues. Measurements can be processed to find hidden interactions between problems, allowing a faster and more effective solution. Data can be used to avoid time-consuming inspections, and consultants can focus on analyzing information and making the best decisions.

HOW DIGITAL TWINS CAN MAKE BUILDINGS SMARTER

Author
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Digital twins can be considered an enhanced version of Building Information Modeling (BIM). Sensors, drones and other inputs are used to collect information about a building. This data is then used to update a digital model automatically. Visualizing computer models is much easier than inspecting actual buildings, and this makes digital twins very useful.

A digital twin can use advanced data analysis and artificial intelligence to constantly learn about a facility. This provides insights on how to better manage the building and its equipment. The concept can also be used to analyze how building modifications will affect performance, allowing better investment decisions.

The use of digital twins is already common in aviation and manufacturing, but the concept is relatively new in the building sector. Having a digital copy of a real-world asset is useful for operation, maintenance, and investment decisions.

Creating a Digital Twin of a Building

The first step to create a digital twin is like any BIM procedure. The building and its systems are modeled in 3D, and enhanced by adding the properties of individual components. This procedure varies depending on the stage of the building life cycle:

- There is design freedom in new projects that are not built yet. In this case, BIM engineers can modify and optimize the layout of building systems.
- In existing projects, the goal is replicating the current installations as accurately as possible. Laser scanners are very useful for this task.

Once the digital model of the building is completed, the next step is adding the data acquisition technology that will allow automatic updates. Initially this represents a technical challenge, but complex facilities become much easier to manage.

Applications of Digital Twins

Digital twins bring two benefits that are very useful when managing assets like buildings and equipment. They can be inspected more easily than the physical objects they represent, and they allow tests and modifications without real-world consequences.

If a decision has a negative effect on the digital twin, the changes can simply be rolled back. On the other hand, a decision that affects a building or piece of equipment will hurt the bottom line. When building owners have many investment options available, they can use the digital twin to test them. The results can then be compared, finding the option with the highest return on investment.

Digital twins also simplify technical documentation. Instead of dedicating many hours to gather information about the facility, the digital model can provide live data automatically.

- During expansions and major renovations, the digital twin becomes a useful tool for design and planning.
- The data collected by a digital twin is not only useful for property management purposes. In commercial applications, the concept has also been used to improve customer service and increase sales.

When creating a digital twin, the main challenge is the initial engineering effort. The concept combines diverse technologies like BIM, sensor networks and cloud computing. In other words, there is no such thing as a "digital twin software".

Conclusion

A digital twin provides significant benefits when managing a complex facility. Better investment decisions are possible, and building maintenance can be programmed more effectively. Sudden equipment failures are easier to prevent, since sensors can detect the early warning signs.

The successful application of a digital twin also depends on adequate training. As the digital model of a facility is developed, the engineering and maintenance teams must receive the corresponding training. A learning curve can be expected, but the technical personnel will work much more efficiently after mastering the concept.

HOW MODULAR CONSTRUCTION CAN HELP PREVENT DISRUPTION IN PROJECTS

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Construction is the largest industry in the world, representing 14% of global GDP according to the business consulting firm McKinsey & Company. However, building projects can be disrupted by several external factors, and risk management becomes critical to protect investments. External threats for construction projects include extreme weather, volatile material costs due to geopolitical issues, and health emergencies like the COVID-19 pandemic.

Modular construction is promising, since it brings many advantages of the manufacturing industry to building projects. Most of the construction process is taken to a factory floor, isolated from external factors like traffic and the weather.

A controlled factory environment also increases quality while reducing waste. Personnel can also be monitored more easily in a factory, which improves safety. This includes the implementation of coronavirus prevention measures such as social distancing.

How Modular Construction Reduces Project Delays

When modular construction is used, most man-hours of work happen in a manufacturing facility. As a result, the amount of materials and equipment at the project site are greatly reduced. Most of the sitework consists of assembling the prefabricated modules. These procedures can be scheduled for days with favorable conditions, while prefabrication continues regardless of the weather.

On the other hand, when traditional construction methods are used, many activities must be suspended when the weather is unfavorable. If two building projects have similar scope, but one uses modular construction while the other doesn't, the first one is less likely to experience delays.

Consider that modular construction also isolates the project from day-to-day disruptions, such as heavy traffic around the project site. Procedures that involve heavy materials and equipment are also isolated from the public, which helps prevent accidents.

Improving Work Safety with Modular Construction

Another advantage of modular construction is taking workers to a factory floor, where managers have more control compared with a building site. For example, work at height is greatly reduced, since modules can be manufactured at ground level. Assembling the modules at the project site may still involve some work at height, but the time and staff involved are reduced.

During an emergency like the coronavirus pandemic, a factory environment also simplifies the use of prevention measures. This has been a major challenge for construction managers in project sites.

- Some construction methods make social distancing impossible, especially when they involve teamwork in reduced spaces.
- PPE such as face coverings can be very uncomfortable for construction workers, particularly when the weather is hot. PPE can also interfere with the gear worn in some skilled trades, such as welding helmets.
- Due to the layout of construction sites, monitoring all the personnel can be impractical. As a consequence, situations that increase the risk of COVID-19 infection may go undetected.

These issues are reduced or mitigated in a manufacturing plant. Social distancing can be enabled with an adequate working layout, indoor conditions can be controlled to reduce the discomfort caused by PPE, and the staff can be monitored more easily. Modular construction is also better suited for the use of robots, in cases where social distancing is not possible. Robots can also be used for tasks like welding, where the PPE that is normally required interferes with the PPE for coronavirus prevention

Adapting Financing for Modular Construction

Modular construction offers many advantages, but one of the main barriers is finding adequate financing for building projects. If you compare how cash flow is distributed throughout a project, there are important differences between traditional construction and modular construction:

- In traditional construction, expenses are spread more evenly throughout the building process. For example, if a project will take several months, materials are normally purchased in batches. Purchasing all the materials upfront requires plenty of cash, and storing them for a long time is risky and impractical.
- In modular construction, activities that would normally follow a sequence can be completed simultaneously. For example, modules from different floors can be fabricated at once. As a result, modular construction consumes a larger fraction of the project budget upfront.

Banks and other financial institutions normally provide the funds for construction as the project is completed, instead of releasing the full loan upfront. However, this must be adapted for modular construction, where upfront expenses are higher than in traditional projects. With access to more financing options, modular construction would be possible in a larger number of projects.

BIM LEVEL OF DEVELOPMENT: AN OVERVIEW

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When Building Information Modeling (BIM) is used in construction, the detail level can range from a broad geometric representation to an accurate as-built model. However, some elements of the building model are developed at a faster pace, and custom-made components need additional fabrication details.

The Level of Development (LOD) framework is used to specify how much a BIM element has been developed, and this helps with communication and coordination. For example, the structural design of a project may be almost ready, while the HVAC design is only 60% complete.

The term "Level of Detail" is also used, but it can be misleading. For instance, a model with a high level of visual detail but no technical specifications is still preliminary. "Level of Development" is preferred, since it gets associated with both visual and non-visual information.

The Six Levels of Development in BIM

The American Institute of Architects (AIA) defines six levels of development, which are presented in the diagram below. Each level corresponds with a different stage of the design and construction process:

As previously mentioned, the LOD applies for specific building systems and components, not the complete project. When design teams collaborate, the LOD indicates which areas of the design have already reached the construction documentation stage.

The definition of a "completed" model changes depending on who uses it and for what purposes. Construction Documentation (LOD 350) can be considered "complete" by contractors, since it provides all the necessary information for them to begin construction. For the client, however, only an As-Built model (LOD 500) represents a completed building.

As the LOD becomes higher, the level of detail and the information contained in BIM elements increase. The features of building components at each LOD stage are summarized below.

LOD 100: Pre-Design

Building elements are represented with generic placeholders that lack physical information, such as symbols. In other words, an LOD 100 element does not show features like dimensions, shapes and exact locations. General information about LOD 100 elements may be available from other components, but at this stage it is considered an approximation.

LOD 200: Schematic Design

LOD 200 elements are slightly more complex than LOD 100, using placeholders with approximate features - dimensions, shapes, locations, etc. LOD 200 elements may also have non-geometric information associated with them. Some LOD 200 elements have recognizable shapes, but others only have generic shapes that represent the volumes occupied. All information is still approximate at this level of development.

LOD 300: Design Development

LOD 300 elements are graphic representations like LOD 200, but their geometry and physical features are accurate at this stage. In other words, the information contained by LOD 300 models can be used during the construction stage

LOD 350: Construction Documentation

LOD 350 elements contain the same information as LOD 300, but they also include interfaces with other building components, such as supports and connections. An LOD 350 model indicates how the component itself will be installed, and also how it interacts with other building systems.

LOD 400: Construction Stage

LOD 400 elements include fabrication and installation details. In other words, the details and information contained by LOD 400 elements can be used by suppliers to manufacture the components being represented.

LOD 500: As-Built

LOD 500 models are accurate representations of building elements after construction, which have been field-verified. Since LOD 500 elements represent the existing installation, facility managers can use them as reference for operation and maintenance.

Using the LOD Framework Effectively

It is important to note that the Level of Development is a communication tool, used to specify the modeling complexity of building elements. In a given project, developing the entire model up to LOD 500 is not necessary. For example, standard components and materials that are commercially available do not require fabrication details (LOD 400). A building may also have aesthetic details that are determined after construction, which may be left at a preliminary stage (LOD 100 or LOD 200). By defining the required LOD for building systems or components, developers and contractors can avoid unnecessary work.

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