COMMENTARY

CIMdata®

Transforming Construction with Virtual Twin Practices

Powering Modular Construction

Key Takeaways

Historically the construction phase of buildings and industrial facilities is plagued with disconnects between stakeholders pushing for changes in construction while suffering from skill scarcity.

Dassault Systèmes' Modular Construction virtualizes knowledge and know-how in a new approach, "productization," using virtual modules aligned with the objectives of general contractors that can be managed independently of projects and can be reused across many projects, improving quality while saving time and cost.

Dassault Systèmes' cloud-based modular construction solution uses virtual twin and generative design capabilities to enable general contractors and fabricators to collaborate in real-time based on a single source of data. Stakeholders can procure everything modeled in the twin as well as support construction planning and installation work packages across the extended construction ecosystem.

Generative design can be used to customize production, where each project is a unique design, while replicable production processes enable faster and higher quality delivery.

Productization reduces waste and lowers carbon emissions on construction projects enabling better energy performance and helping to better meet sustainability requirements

Introduction

Environmental regulations today mandate that buildings perform better and require less waste to construct. This shift towards sustainability demands higher efficiency in construction processes and materials. Achieving these goals is complicated by the inherent fragmentation within the construction industry driven by the lack of collaboration among the many stakeholders involved, which can change from project to project. Despite building owners' demands for compressed schedules, the multiplicity of stakeholders working within their own silos creates inefficiencies that result in projects that suffer from cost and schedule overruns.[1]

Owners also seek personalized buildings, uniquely designed by architects and engineers to meet specific needs and aesthetics. However, the design and construction processes are typically hampered by

[1] Research for this paper was partially supported by Dassault Systèmes.

disparate software tools and building information modeling (BIM) systems that are not well integrated. Architectural and engineering firms often work in isolation from developers, general contractors, and fabricators, who possess the practical know-how for construction. This lack of collaboration often leads to significant inefficiencies, as designs do not always consider feedback on constructability, resulting in further delays and cost increases.

The construction industry faces what is known as the Architecture, Engineering, and Construction (AEC) paradox, characterized by a widely dispersed and disconnected ecosystem. Unlike discrete manufacturing industries, which benefit from streamlined processes and digital continuity, the building industry comprises a unique set of partners and technologies for each project. This lack of interoperability is reinforced by contractual arrangements that maintain data silos, further exacerbating inefficiencies and making it challenging to manage construction projects effectively.

As a result, construction projects are prone to not only cost overruns and delays but also supply chain shortages, poor resource coordination, difficulties in managing the interfaces and potential conflicts between contractors, and poor construction sequencing. These inefficiencies within the construction industry are further aggravated by the retirement for skilled workers and lack of new entrants into the construction workforce, making skilled workers even scarcer. To address these issues, the industry needs to adopt more integrated and collaborative approaches, leveraging digital technologies to enhance interoperability and streamline project management. Without such changes, the industry will continue to struggle with inefficiencies, waste, and fail to meet the evolving demands of sustainability.

Solution

To address the significant challenges faced by the construction industry, CIMdata believes that leveraging virtual knowledge and know-how through virtual twins of the planned construction effort presents a transformative opportunity. Developing a virtual twin can be time-consuming and may cost as much as 10% of the overall project budget using a more traditional approach, but by leveraging productization, cost can be significantly reduced (up to 30%), and the benefits in time and cost savings across multiple projects and different lifecycle stages can be substantial. For construction execution, one of the major advantages of using a virtual twin is the ability to generate accurate quantity takeoffs for procurement and detailed drawings for fabrication, addressing historical challenges in these areas and leading to more efficient project execution.

Shifting from a bespoke, project-based design and planning method to an approach where knowledge is captured and stored in reusable libraries can significantly reduce risk and improve efficiency. Developers and general contractors can save time and costs while enhancing a project's quality by using these libraries. These repositories capture the expertise of skilled tradespeople, making it accessible to less-experienced workers through detailed work packages with instructions, which can continually be improved leveraging field experience, ensuring that best practices are consistently applied.

An example of this is FLOVEA, a prefabricated plumbing specialist, which had been challenged with finding skilled plumbers. Using the **3D**EXPERIENCE Platform, the founder, Mr. Thierry Mignot turned to using virtual twins and reusable libraries to manufacture prefabricated back splashes and other pluming elements, which are light and easy to ship and assemble. FLOVEA was able to prefabricate an easy interface between the plumbing and heating systems reducing the need for skilled laborers.

Generative design approaches that draw from highly constructible products in the library can easily be adapted to an owners' unique requirements to compose a project's construction virtual twin. This virtual representation connects upstream and downstream stakeholders, including engineering, procurement, and site supervision, fostering better collaboration and coordination.

Jet Contractors, a Moroccan-based engineering, procurement, manufacturing, and construction company creates complex shapes and architectural designs for public infrastructure, residential, industrial, and service-oriented programs, including metal works of art. Using the **3D**EXPERIENCE platform, Jet Contractors generated 4,000 unique parts to encase a double curved architecture. With CATIA's xGenerative capability, the team referenced shared geometries and parameters to generate a whole assembly. By using this generative design approach and virtual twins, they improved their manufacturing and assembly processes, which reduced risk, and increased productivity and quality. The developers were able to understand how the design performed in a virtual twin, which enabled automated processes through production and lifecycle management.

By using virtual twins, conflict resolution easily can be considered and addressed early in the process by all construction stakeholders, thereby avoiding costly clashes and on-site issues. The use of virtual twins also enhances the sequencing of construction activities, ensuring that projects are executed more smoothly. Fabricators benefit significantly from this approach, as they can save money by prefabricating modules. This not only drives down their costs but also reduces the overall project time. The integration of virtual twins and modular prefabrication offers a powerful solution to the construction industry's long-standing inefficiencies, paving the way for more sustainable, cost-effective, and high-quality construction projects.

Dassault Systèmes' Modular Construction Solution

Dassault Systèmes' Modular Construction solution provides general contractors and fabricators with the critical information needed to efficiently construct commercial buildings and industrial facilities. The solution focuses on enhancing construction processes by leveraging the concepts of modularity and prefabrication. This is achieved through a virtual twin strategy (see Figure 1), which includes Dassault Systèmes' CATIA, ENOVIA, and DELMIA offerings on a cloud-based platform. By modeling and simulating

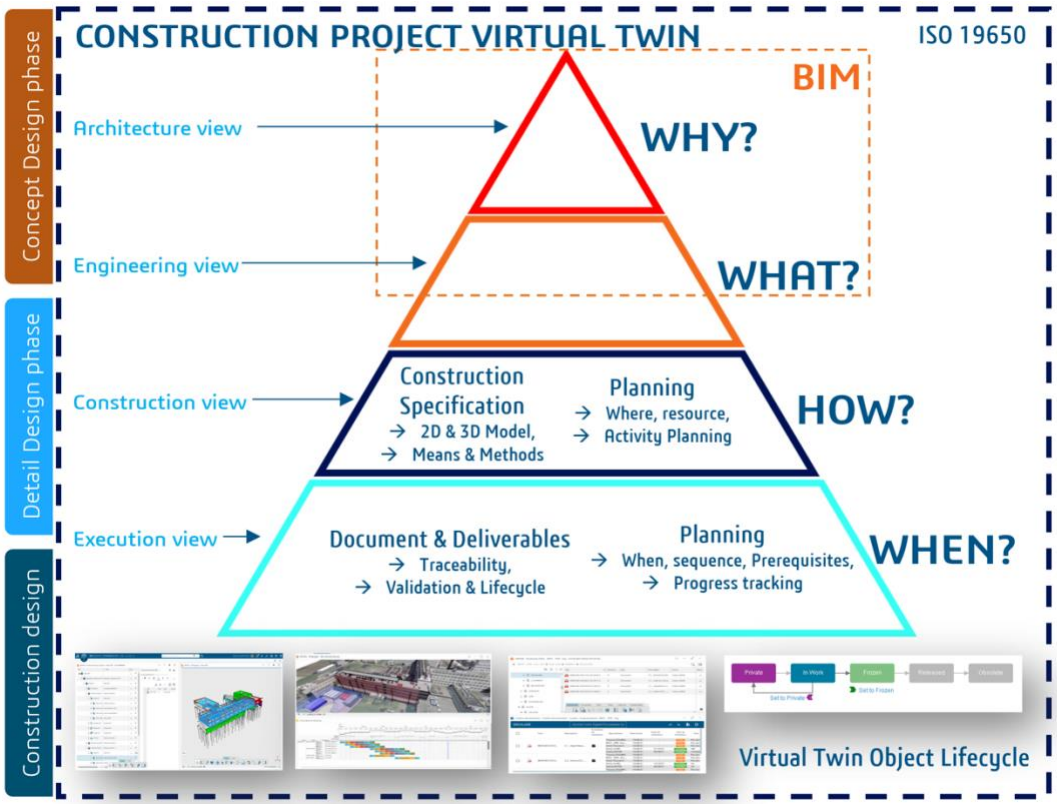

Figure 1: BIM to Construction Virtual Twin
(Courtesy of Dassault Systèmes)

the virtual twin before physical construction, contractors and fabricators can plan and execute projects with increased precision and reduced risk.

The virtual twin receives inputs from various technologies used by architects and engineering companies, integrating these inputs to create a comprehensive model for construction. Unlike traditional BIM models used primarily in design, everything that must be procured is modeled in the construction virtual twin and utilized in work packages across many partners. This approach ensures that all necessary components and materials are accounted for, enabling seamless collaboration and coordination among stakeholders. Dassault Systèmes provides a solution that empowers the field, allowing general contractors to choose their preferred construction methods, extract accurate quantity takeoff estimates, and enable them to work more efficiently within the construction ecosystem. Dassault Systèmes' DELMIA is used to model the virtual twin, detailing everything required for procurement, as well as the resources and timing needed to construct the project most efficiently. This includes supporting a "Productization" approach which virtualizes the knowledge of how things are constructed, enabling the reuse of these libraries across multiple projects, thereby saving time, improving quality, and avoiding redundant work.

By creating a detailed construction model, users can meticulously plan materials, resources, constraints, construction sequencing, logistics, scheduling, and execution. The virtual twin facilitates the creation of detailed work packages and interfaces for construction, thereby eliminating costly conflicts and delays typically encountered in large-scale projects. Rather than relying solely on a project-based approach, companies can virtualize processes for reuse, dramatically cutting project time. Dassault Systèmes estimates this can reduce project durations by up to 80%.

The solution also enhances offsite prefabrication by enabling fabricators to design prefabricated subsystems, which are then optimized for assembly. DELMIA also supports factory shop floor planning and optimization, improving manufacturing and operational efficiencies. By integrating these advanced technologies and methodologies, Dassault Systèmes' Modular Construction solution significantly enhances the overall efficiency, cost-effectiveness, and quality of construction projects.

Conclusion

Historically, the construction phase of buildings and industrial facilities has been fraught with inefficiencies due to disconnects between stakeholders that are compounded by a scarcity of skilled labor. These challenges often result in delays and cost overruns that compromise project outcomes. Dassault Systèmes addresses these issues with its Modular Construction solution, which virtualizes knowledge and know-how using a new approach called "Productization." By creating virtual modules that align with the objectives of general contractors, this approach allows independent management and reuse across multiple projects, significantly improving quality while saving time and cost.

Dassault Systèmes' cloud-based Modular Construction solution further enhances this process by integrating virtual twin and generative design capabilities. These technologies enable real-time collaboration among general contractors, fabricators, and other stakeholders to collaborate in real-time using a single source of data. This ensures that all elements modeled in the virtual twin are accurately procured, supporting comprehensive construction planning and the creation of detailed installation work packages. CIMdata feels that by fostering seamless communication and coordination across the extended construction ecosystem this solution effectively mitigates many of the traditional pain points in construction projects.

Generative design capabilities add another layer of efficiency by allowing customization of production. Each project can feature a unique design while the production processes can be replicated, achieving faster and higher-quality delivery. This adaptability ensures that each building or facility meets specific

requirements while maintaining standardized and efficient processes. CIMdata is impressed with Dassault Systèmes' "Productization" approach, which can significantly reduce waste and lower carbon emissions on construction projects, enabling better energy performance, and helping meet sustainability requirements.

CIMdata believes that Dassault Systèmes' Modular Construction solution offers an innovative approach within the construction industry. By leveraging advanced technologies like virtual twins and generative design, it bridges the gap between stakeholders, enhancing collaboration and improving overall project efficiency. CIMdata recommends those companies in the construction industry looking for a more sustainable and potentially cost-effective approach consider Dassault Systèmes' Modular Construction solution.

About CIMdata

CIMdata, a global strategic management consulting firm, provides services designed to maximize an enterprise's ability to design, deliver, and support innovative products and services. For more than forty years, CIMdata has provided industrial organizations, providers of digital technologies and services, and investment firms with world-class insight, expertise, and best-practice methods on a broad set of product lifecycle management (PLM) topics and the digital transformation they enable. CIMdata also offers research, subscription services, publications, and education through certificate programs and international conferences. To learn more, visit www.CIMdata.com or email info@CIMdata.com.