The Impact of BIM and VDC on Company Business Processes

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Abstract

The AEC industry is witnessing fundamental changes within its civil engineering and heavy construction sectors as to how projects are designed, assessed, and constructed. The goal of this change is to reduce a project's overall costs that arises from change orders and rework (15 to 20 percent of the total), and to analyze sustainable design approaches. The opportunity of reducing these costs and bringing change orders to near zero are driving the AEC industry and its stakeholders in the direction of integration. This integration is based on economics; more complexity in designs (e.g., sustainability analysis); productivity; and the nature of current owners design requirements to deliver more sustainable infrastructure more rapidly and more affordably. In this session using project case study examples, the speaker will discuss how model-based design tools, together with building information modeling (BIM) and Virtual Design and Construction (VDC) processes supported by alternative project delivery methods such as Project Alliancing (PA) and Integrated Project Delivery (IPD) are helping to reduce risk and liability in infrastructure projects and aiding in sustainable design and analysis approaches to tomorrow's infrastructure.

The Move to Sustainable Infrastructure – New Thinking

Sustainability is an increasingly common theme in the business and trade press, at conferences, and in everyday conversation with civil engineers, construction professionals and the general public. My favorite definition of sustainability is *"Meeting the needs of the present while **improving** the ability of future generations to meet their own needs*." Taking it one step further in regards to engineering design, ***Sustainable Design*** is best described as the intersection of design innovation and sustainability that accounts for the lifecycle of that infrastructure. This isn't just an energy discussion. Changes of this magnitude impact every industry in our economy and everyone else's in our world. Going "green" is a trillion dollar industry propelled not only by the energy independence but global warming solutions our customers, colleagues, investors and competitors now require. The scale and growing pace of the "green collar economy" creates not only opportunities for our business to grow revenues, but also enhance our brand in the civil engineering industry, save money and materials on projects and help solve some of the world biggest infrastructure challenges, all needed to sustain our worlds future.

The critical nature of climate change is converging with the migration of the world's population to urban environments. As a result, concern with sustainable urban environments, "green cities or sustainable communities "as they are often called, has come to the forefront and this shift in general thinking will require the expertise of civil engineers to accomplish in actual project execution . Serious challenges face our world's infrastructure and motivate new approaches and technologies to improve how we design, build, operate, and maintain our constructed physical environment – both buildings and infrastructure. How can we face these challenges and succeed in developing sustainable and economically efficient urban environments and communities?

The goal is to not only encourage civil engineers to integrate sustainability into their design strategy, but also their corporate business strategy & thinking to drive both profits and growth. And aligned to that, more modern ways of design and delivering this next generation infrastructure is required. New model based design tools and processes such as Building Information Modeling (BIM) and Virtual Design and Construction (VDC) are standards today by which many deliver this next generation of design and its increasing complexity in a more efficient and error free manner. We will discuss how BIM an integrated process built on coordinated, reliable information about a project from design through construction and operation provides the basis for a sustainable design methodology that can assist in lowering the environmental impact of any transportation project quickly and cost-effectively, with the help of advanced design software tools.

Current Process and Challenges

The current process for engineering design and construction is based on workflows going back many decades to the turn of the century when most of our infrastructure was built. Design was done on paper, and coordination was a manual process of review, redlining, and redrafting of plans. Back then the commodity of the entire process was paper. Today with the advent of advanced computer modeling tools, civil engineering has the opportunity to redefine workflows and processes to ensure it stays current with allied disciplines of architecture; mechanical, electrical, and plumbing (MEP) engineering; structural engineering; and general contracting, which have all already started to standardize on new tools, processes, and education around the next generation of design and construction. Designs today and going forward are based on more than 3D graphics, but real intelligent models and visualizations. The project managers and engineers are still involved in the same way, but they are no longer trying to

interpret paper plans, they have high fidelity models in 3D to look at. If it looks wrong it is wrong. Mistakes are found during design and quickly corrected, not discovered during construction like has happened so often in the past. Visualizations help all stakeholders including owners understand the real scope, complexity and issues with a project and allows the entire project team to make more informed decisions earlier in the process. And once decided upon, this model can be passed to and used by the contractors during construction to automate machines, people and site logistics, gaining great efficiency.

Numerous industry reports have shown that upwards of 15 to 20 percent of a project's overall costs can come in the form of change orders to the project once construction has started. Change orders result from inconsistencies in plans often generated by human error such as number transposition, or mislabeling, a lack of enough detail for contractors ending in RFI, oversights from not being able to see potential conflicts, or clashes in the design components. Construction costs are also affected by the materials being used and methods.

The following are some of the challenges faced by engineering projects today with a 2D CAD and a paper-centric approach.

Engineers:

- No incentive to optimize the design (sustainability, cost, performance) due to no easy way to analyze the design and get results real-time
- No incentive to design for constructability since CAD provides no intelligence to reflect process needs
- Delivers the first design that meets codes—since designing alternatives is hard, expensive, and not seen as valuable
- No holistic view of the entire project across all trades

Constructors:

- No input into the design process as to project delivery method or construction sequencing scenarios that could save time, materials, and money
- Construction issues and change orders, due to RFIs as a result of incomplete or misunderstood information on plans sets created for engineering approval as opposed to plans construction professionals need to build
- No holistic view of the entire project across all trades

Owners:

- Unable to realize benefits of infrastructure cost versus lifecycle performance analysis
- Lack of visibility into final product and project milestones, understanding of options, and alternatives and schedules
- Inability to specify design parameters (carbon/water footprint, energy/environmental footprint, and so forth) and see alternatives that maximize one over the other and why
- No holistic view of the project

To avoid and greatly reduce these issues, a streamlined process where design and collaboration take place on the desktop—designs are built and constructed digitally to identify errors, conflicts, or challenges, and once rectified to all stakeholders agreement then that 3D detailed model or models can be used for construction, or a clean near-error-free set of construction documentation can be created from the same model that created the approval plans, helping to ensure a coordinated approach to design and construction.

The Solution—Business and Workflow Processes built around BIM and IPD:

We are seeing dramatic costs and time savings, and change orders approaching zero on projects by engineers and contractors around the world through the use of building information modeling (BIM) and integrated project delivery (IPD). Understanding how these new approaches for design and construction utilize new model-based tools will be a critical success factor for students and professionals in order to be effective participants in the design and building of tomorrow's infrastructure.

The BIM-centric process utilizing a model-based designed approach has evolved well beyond CAD and paper-centric process. Based on trend surveys published by the AIA, ACEC, and McGraw Hill, it is clear that next year we may reach the inflection point by which it will be the standard practice in architecture, MEP engineering, and structural engineering, joining mechanical, automotive, and aerospace, which have transitioned to this approach decades ago. Industries will produce the latest in 3D designs with existing condition information coming from surveyors using terrestrial laser scanners and LIDAR and output models that are keen for contactors using construction sequencing tools for construction planning and GPS machine control for heavy construction.

Benefits of the BIM process:

- Visualizations can be generated from 3D designs that help engineers to explore a variety of design scenarios rapidly, and calculate the associated cost impacts of design options in real time.
- Engineers are better able to spot errors and omissions earlier in the process, where they can be corrected more quickly.
- By catching and correcting costly design errors upstream, money normally expended on rework or mitigation can be applied to other projects extending the reach of the money appropriated.
- Material and quantities can be accurately calculated, analyzed and selected.
- Construction can be planned and sequenced to help save on all manner of materials used and even moved around the site for optimized material management.
- Processes can be automated, including the use of automated machine guidance systems, which can help cut time and costs dramatically.
- Powerful visualization, helping to improve community relations and feedback.

Through the use of model-based design in a BIM-centric process, any mistakes or design conflicts are easily and quickly discovered where it is cheap to fix, on the computer, and not in the field where the costs go up astronomically to make changes.

BIM is also provides the basis for extracting even more value through high level of coordinated project delivery - Integrated Project Delivery, or IPD. Based on Project Alliancing (PA) a delivery method used for many years on complex infrastructure projects in Australia IPD allows project owners, engineers, and construction teams to visually share information with all stakeholders on a project up front and make critical decisions in advance, again helping to reduce change orders and costly rework. IPD is ideally suited for Public-Private Partnerships (PPP) -type projects and allows for maximum collaboration.

Why Now?

Many within the engineering community have identified the challenges that they see in the current workflow. All of them have some quantity of tools, but have not redefined their standard project design approach, to think of the problems in reverse—what is the design challenge to solve first and foremost

for the client, what outcome based parameter am I trying to solve with my design (ex carbon footprint, water footprint, lifecycle cost) and then letting the software worry about the documentation as a by-product of modeling. Today more time is spent on how do I draft and label the design to make it discipline specific. This needs to change and education will be critical to accomplishing that.

Engineers, contractors and even students are building these models today both in practice and in schools; however, rather than standardizing on a BIM process from design through construction and into operations that utilizes this rich information, they revert back to a 2D CAD-centric process and oftentimes paper when transferring the design to construction —a standard well before computers were used or even envisioned that requires them to convert the 3D information back into 2D paper based plans and processes to deliver them to other project stakeholders. There is a need for engineering and construction professions working with academia and technology providers to help remove these barriers and to help the civil engineering industry and profession standardize on a new process and design approach for providing this rich information to the project stakeholders so that the benefits seen in other allied industries can be realized.