**Introduction**

Large construction projects often exhibit cost overruns and delays due to unforeseen events or design changes during construction. As is well known, a judicious balance between cost, time and quality needs to be maintained in any construction project in order to have the resulting product as profitable, safe and sustainable as possible.

In a construction project, the architects and structural engineers first need to come up with a conceptual design that is appropriate for the intended function of the structure. Potential structural loads need to be identified, and the conceptual design needs to be guided by the efficiency of how these loads get transmitted within the structure and distributed to the foundations. Any errors or inappropriate design choices at this stage can have significant time and cost implications on the final outcome. If the structural components are pre-fabricated, then these and the final structure need to be designed based on the ease of manufacturing the pre-fabricated parts, which can often contain specially designed new materials. Also, the transportation of these parts and the final assembly processes need to be considered. A complete study on how early design choices affect the construction process, time and costs is, therefore, necessary. Moreover, such studies need to be done quickly and also need to provide comprehensive data in order to enable architects and engineers to make proper comparisons between different conceptual designs. Therefore, we clearly observe the need for simulation.

**ROLE OF SIMULATION**

In architecture, virtual or graphical simulation models can help in arriving at conceptual designs, taking into account wide ranges of criteria, such as layout, positioning, landscaping and lighting. Also, realistic rendering can be used to help make depictions lifelike, adding to their value for clients.

In engineering, virtual representations can be used to idealize structural geometrical configurations. These configurations can then be used in computational analyses to predict structural deformations and stresses resulting from applied loading and support conditions. Subsequent to such simulation analyses, the predicted data values can be visualized and examined. Based on these data values, engineers can ascertain the strength, stability and safety of the proposed structure, and can then finalize the structural design.

In construction, the finalized design is then used for material estimation and ordering, planning the construction sequence and managing the construction process using appropriate simulation tools. As one can see, simulation helps in all three phases of any civil engineering project—conceptual and architectural design, engineering design and construction. Although individual tools are available to simulate these three phases separately, the use of such tools may result in potential loss of information when passed between different phases of the project. Civil engineering projects, hence, need simulation tools that seamlessly connect the architecture, engineering and construction phases.

**Implementation of simulation in construction**

1. ***Dassault Systèmes***

The Structure Design for Fabrication process on the 3DEXPERIENCE® platform from *Dassault Systèmes* has been specifically developed to provide engineers and architects with a unified capability to virtually represent conceptual designs, perform engineering analyses, analyze construction sequences and manage construction projects all together, while keeping track of individual components. It provides a unique representation of the project as a whole, one which several users can remotely access in order to obtain information according to their individual needs. Any change in any component can be reflected throughout the project, including the effects on project schedule, and also likely implications on the structural loading and response.

In addition to the Structure Design for Fabrication process on the 3DEXPERIENCE platform, Dassault Systèmes also provides solutions using Abaqus® simulation software for complex simulations and analyses, including for pre-stressed and reinforced concrete, for simulating the altered behavior of damaged structures, for geomechanics analyses for tunnels and foundations, and for seismic response analyses of complex structures.

**SIMULATION FOR BRIDGES IN *Dassault Systèmes***

Starting with a Dassault Systèmes’ CATIA® model, one can use physics apps on the 3DEXPERIENCE platform to create simulation models and perform analyses for events such as the movement of trains on bridge decks.

**The benefits of simulation**

* Simulation provides a tool to measure the benefits of implementing a productivity solution before investing in it.
* Simulation sometimes is the only appropriate tool for modeling complex systems with many interacting random elements.
* By using simulation, designers can see the impact of a change on an entire system, rather than on just one element.
* To pre determine the quality of the construction.
* For accurately calculate the cost.

**Example for benefits of simulation**

Shanghai Xian Dai Architectural Design Group (SXDA) has been using the solutions provided by Dassault Systèmes for designing innovative structures. The solutions have enabled SXDA to achieve quality and excellence in their projects, along with minimizing costs. SXDA has designed several innovative structures including Shanghai’s World Financial Center, the CCTV building in Beijing, the Zendai Himalayan Art Center and the Taihu Pearl Hotel.

The Zendai Himalayan Art Center’s shape is bionic, with curved surfaces. The curved geometrical shapes were represented by SXDA using CATIA software, and the structural integrity was simulated using Abaqus simulation software, from Dassault Systèmes’ SIMULIA® brand. Abaqus simulation software helped SXDA locate regions where additional reinforcements were needed and where reinforcement could be reduced. Using these types of optimization studies, SXDA was able to achieve 10 percent savings in the steel requirement for the structure. For skyscrapers such as the CCTV building, and the World Financial Center, SXDA used Abaqus simulation software for performing simulations taking into account geometric and material nonlinearity, material damage, and the effects of material damage on the structural response due to seismic excitations.

**CONCLUSION**

Modern architectural designs involve innovative shapes and new materials. The structural behavior of such structures needs to be predicted accurately in order to achieve and maintain structural safety, reliability and utility. The 3DEXPERIENCE platform provides a seamless way to model and analyze buildings and bridges. Models can be created, meshed, and analyzed using connected tools available in the setup. For more complex cases, the available Abaqus simulation software capability can be used to perform sophisticated analyses, such as nonlinear elasto-plastic analysis including damage, coupled pore-fluid flow computations for foundations and tunnels and multi-physics studies including thermal and diffusion effects.