DUCTWORK DESIGN COMPLICATES CONSTRUCTABILITY

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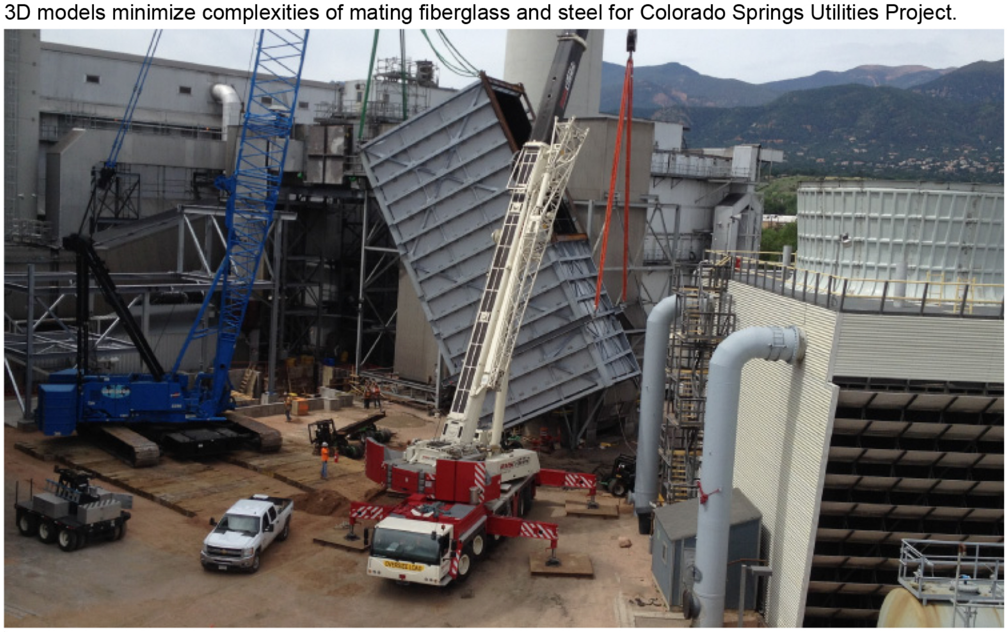
3D models minimize complexities of mating fiberglass and steel for Colorado Springs Utilities Project.



The absorber system includes six duct units between 20 and 55 feet high and weighing as much as 130,000 pounds.

In 2013, Colorado Springs Utilities began constructing and commissioning technology that would help meet regional haze regulations by drastically reducing S02 and other stack emissions at one of its coal-fired power plants. During pilot testing of the technology from Neumann Systems Group (NSG), researchers determined the best configuration of the absorber ductwork for the system was a combination of reinforced fiberglass (FRP) (designed and fabricated by Ershigs, Inc.) and a steel exoskeleton (designed and detailed by Ruby+Associates, Inc.). While there are many benefits of utilizing FRP, such as its chemical resistance and light weight, it also presented challenges that had to be overcome by supporting the fiberglass duct with a structural steel exoskeleton.

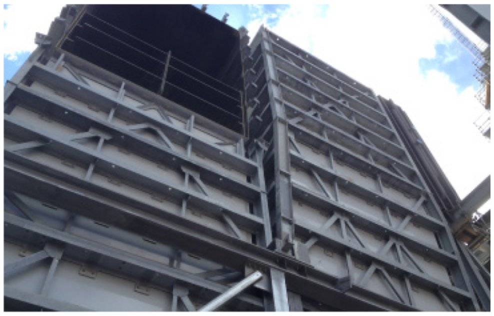
In addition, fiberglass, which expands more than steel, warms to the internal temperature of the flue gas, while steel remains at ambient temperature, or the same temperature as its environment. The engineering team had to allow for the fiberglass to slip against the steel as it expanded up to 3/4 inch, but still provide the out-of-plane resistance that would keep the shape of the ductwork.

The steel skeleton was designed to provide strength and stiffness for the duct, while at the same time allowing for thermal expansion of the FRP; but as a result, the team couldnt use internal bracing typical of steel ductwork. Unlike traditional steel ductwork that allows crews to get inside and weld in braces, the fiberglass required all of the structure to be on the outside of the duct. The only connections between the two materials were with slotted clips and UHMW shims, which allowed the FRP to expand and contract relative to the steel. The steel framework relied on a system of braced frames and bolted moment frames for stability because the FRP wasnt able to provide any shear resistance to the structure.

Constructability

The projects structural engineering firm is Ruby+Associates, a nationally recognized pioneer in constructability and well experienced in complex structures. The firm relied on Tekla Structures, Trimbles BIM software, to visualize mating the steel and the FRP, determining in 3D where the connections needed to be made, and ensuring the final ductwork design would be properly supported by the framework below.

"We needed to work at a high level of detail to provide this kind of constructability and coordination," said Drew Twarek, P.E., S.E., project manager for Ruby+Associates. "Tekla Structures was the ideal 3D BIM solution for us."


The steel skeleton was designed to provide strength and stiffness for the duct, while allowing for thermal expansion of the reinforced fiberglass.

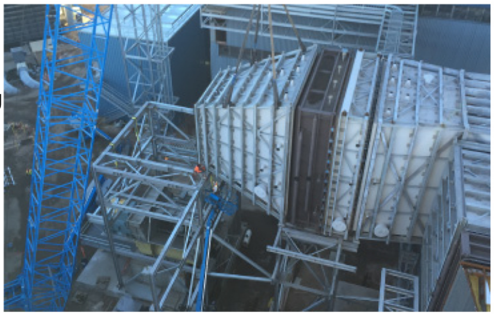
Tekla Structures also allowed the team to visualize the projects unique space requirements and geometry in 3D. Because the project was constructed on an existing power plant site, there wasnt a lot of room for the NSG system. One of the reasons Colorado Springs Utilities selected NSG was for its small footprint compared to traditional absorbers, but still, the project team was limited in the amount of room available for ductwork.

"The Tekla model allowed us to identify structural design issues early in the process," said Twarek. "We were able to discover potential problems such as places where there wouldnt be enough room to fit a person between the two pieces of ductwork to bolt in an expansion joint. So, the team made a design change to use an expansion joint that is bolted from the inside of the ductwork. The Tekla Structures model allowed us to visualize the space and make those changes in advance, which saved our client and the owner time and money."

The system is made up of six duct units between 20 feet and 55 feet high and weighing as much as 130,000 pounds. Ruby+Associates built custom Tekla components to streamline connecting the model and adding FRP attachments, and wrote custom reports to allow Tekla to easily communicate material and shipping lists in a format Ershigs could readily use.

The steel had to be galvanized to protect it from the elements, but welding galvanized material is difficult and dangerous, not to mention fiberglass is easily charred by welding. To solve this problem, Ruby detailed the structure to be entirely field bolted. Ershigs fabricated the structural steel in-house and sent it to the galvanizer in modules small enough to be dipped in the tank and shipped back. The fiberglass panels were fabricated in the same 8- to 10-foot widths as the steel modules, and were shop mounted to the steel at Ershigs facility. They were then shipped to the project site, where Ershigs field team quickly bolted each duct module together and sealed the FRP joints.

Collaboration


Space for installation of the ductwork was tight because the project was constructed on an existing power plant site.

"Our success is the result of collaboration across the project team," Twarek said. The Ershigs and Ruby+Associates teams held regular Web-based meetings during which they were able to share the Tekla Structures model and make live changes. Over the course of the project, both teams were able to share models between Tekla Structures and other solutions, and NSG was able to import final geometry into its master model. This collaboration allowed the entire project team to proactively consider all aspects of the construction process and facilitate a more thorough design. They were able to identify structural limitations, increase efficiency, and create a structure that made the most efficient use of the resources at hand.

Once the design process was complete, Ruby+Associates produced the fabrication details from the Tekla Structures model and shared it with the engineers at Ershigs, who then imported it into their fabrication software and produced assembly drawings for use in this process. The engineering team also used 3D PDFs from Tekla Structures as a communication device so that the fabrication shop could see what the modules were supposed to look like and how they would fit together.

"Seeing something in 3D and being able to rotate it and share it with the client is a huge benefit," Twarek said. "You can look at all the 2D drawings you want, but until you see a bolt clashing here or a plate in the way there, there is no good way to communicate that and resolve it on the fly. Having all of our data and our clients data in 3D and the ability to compare and contrast our models in a Web meeting is what made the project run smoothly and efficiently."

Information provided by Tekla Structures (tekla.com/products/tekla-structures (http://www.tekla.com/products/tekla-structures)).