Engineering News

3D Engineered Model for Construction

What is 3D engineered model? Can it help SCDOT's project deliveries?

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For many years, design engineers have developed projects from concept to final design in a three-dimensional (3D) CADD environment with the goals of producing two-dimensional (2D) paper record sets.

The contractors would construct the projects in a real world 3D environment based on the paper plan. Often, they have had to interpret what designers wanted, trace lines on the plan, re-enter data, and do other work to turn the design into reality. This traditional 2D paper-based process can introduce discrepancies and add time and cost to the project.

In recent years, the way contractors build projects has changed substantially thanks to an innovative technology called 3D engineered model. As part of MAP21, the transportation law signed by President Obama, and FHWA Every Day Counts (EDC) initiatives, 3D engineered model for construction has become a major point of emphasis to virtually connect design and construction teams.

3D engineered model is a mature technology that serves as the building block for the modern-day digital jobsite, according to FHWA.

The main reason for the use of 3D engineered model is the emergence of automated machine guidance (AMG) technology in construction. The AMG technology involves an on-board computer linked to GPS satellites and sensors that continually monitor directions and ground position. With the 3D model data, the AMG-enabled construction machines such as dozer, excavator, grader, or paver can run day and night via on-screen guidance and achieve accurate measurement within a quarter of an inch. AMG technologies can reduce the needs to stop construction equipment for grade checks and cut infield surveying cost (staking) by 50-70 percent. Safety can also be greatly improved as fewer workers will be onsite, and predefined "avoidance zones" can be set to alert the operators.

Projects using the combined technologies of 3D engineered model and AMG have achieved a 30-50 percent reduction in time delays, material rework, and labor costs as well as a 40 percent reduction in fuel consumption.

SCDOT District 5 construction crew took the 3D modeling for automated stakeout and inspection training at Florence U.S. 378 construction site.

Realizing the importance of the technologies, SCDOT and FHWA South Carolina Division formed a 3D engineered modeling initiative team in 2013. The 3D AMG specifications for construction were first developed to accommodate the evolving technologies, followed by the development of operation procedures to prepare Electronic Engineering Data (EED) files for construction pre-bid.

"The EED files are the key ingredient to the successful 3D engineered models. They can save time and reduce the possibility of human error due to direct data import," said **Peter Yeh**, SCDOT Design Automation Engineer, and Co-chair of the 3D modeling initiative team. "We adopted a universal file format to ensure compatibility among CADD design software, survey and construction equipment. Our goal is to prepare EED files to automate both AMG construction and SCDOT field verification."

The technologies have since been applied to let four SCDOT projects for AMG construction. The first pilot project, U.S. 378 from Lake City to Kingsburg, went out for bid in November 2013.

"It is an ideal project for AMG construction," said **Wilson Elgin**, Upstate Regional Production Engineer who was then the Design Manager for the project. "The project involves widening the existing two lanes to a five-lane section for approximately eight miles with an estimate of more than a million cubic yard earthwork volumes."

While the 3D engineered modeling was exciting, SCDOT faced many challenges during the pilot project execution.

The most critical was the field survey equipment upgrade. In 2014, over $770,000, including FHWA STIC grant assistance of $100,000, were used to procure advanced survey instruments. "A total of 44 robotic total stations (RTS) and 41 GPS rover units were set up and distributed to construction and preconstruction survey offices," said **Dr. Wei Johnson**, Engineer in the SCDOT Director of Construction office.

"The SCDOT has utilized FHWA STIC funds to purchase 3D modeling survey equipment for construction verification, which has allowed them to expand their resources to move this innovative technology forward in the state," according to Alice Travis, SC Division Operations Engineer, Co-chair of 3D modeling initiative team.

But that was just the beginning. Over the next several months, SCDOT coordinated extensive training and workshops to assist the technology implementation. Several "Just-In-Time" training classes were introduced to SCDOT field construction offices with hands-on practices in automated stakeout and inspection. Just like the AMG operators, SCDOT field surveyors could access 3D models of finished grade elevations anywhere on the construction site, allowing their advanced survey instruments to receive instant feedback on cut/fill information.

"The potential moving forward on the design front is tremendous - greater ability to evaluate alternatives, to visualize them, to make changes and quickly implement them – all can drastically change and improve the way design is done," said Elgin.

"3D AMG is the future of construction," according to SCDOT District Bridge Engineer **Jason Thompson**. "The learning curve is steep, but with patience and experience, it does indeed increase efficiency, speed, precision and yield a better product while lowering operation costs."

On Feb. 18-19, 2015, SCDOT and FHWA co-hosted a 3D Engineered Models for Construction workshop in Columbia. Acting Secretary of Transportation **Christy Hall** and FHWA Assistant Division Administrator Bob Thomas made the opening remarks and stated leadership's support of adopting the new technology. Seventy-two engineers from FHWA, SCDOT construction and preconstruction offices, consultants, contractors and other state highway agencies attended the two-day workshop and peer exchange sessions.

"FHWA invited subject experts to provide overviews on various topics of 3D engineered models," said Johnson who was also the workshop coordinator. "We have received positive feedback from the participants and will certainly tap into the resources provided by FHWA and fellow DOT's."

Workshop moderator David Unkefer, who is the Construction and Project Management Engineer from FHWA Resource Center Atlanta office, said: "It was interesting to hear from the Sitetech Inc. representative about SCDOT's Conway Bypass in 1998 being the world's first AMG project. I hope that provides some encouragement to SCDOT to move ahead with this powerful shift to the 3D engineered models for construction technology."

"The most important lesson we learned: 3D engineered model is not a product," said Yeh. "It is a combination of technologies, processes and people that could lead to a much faster, safer, cost effective and predictable project delivery."

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