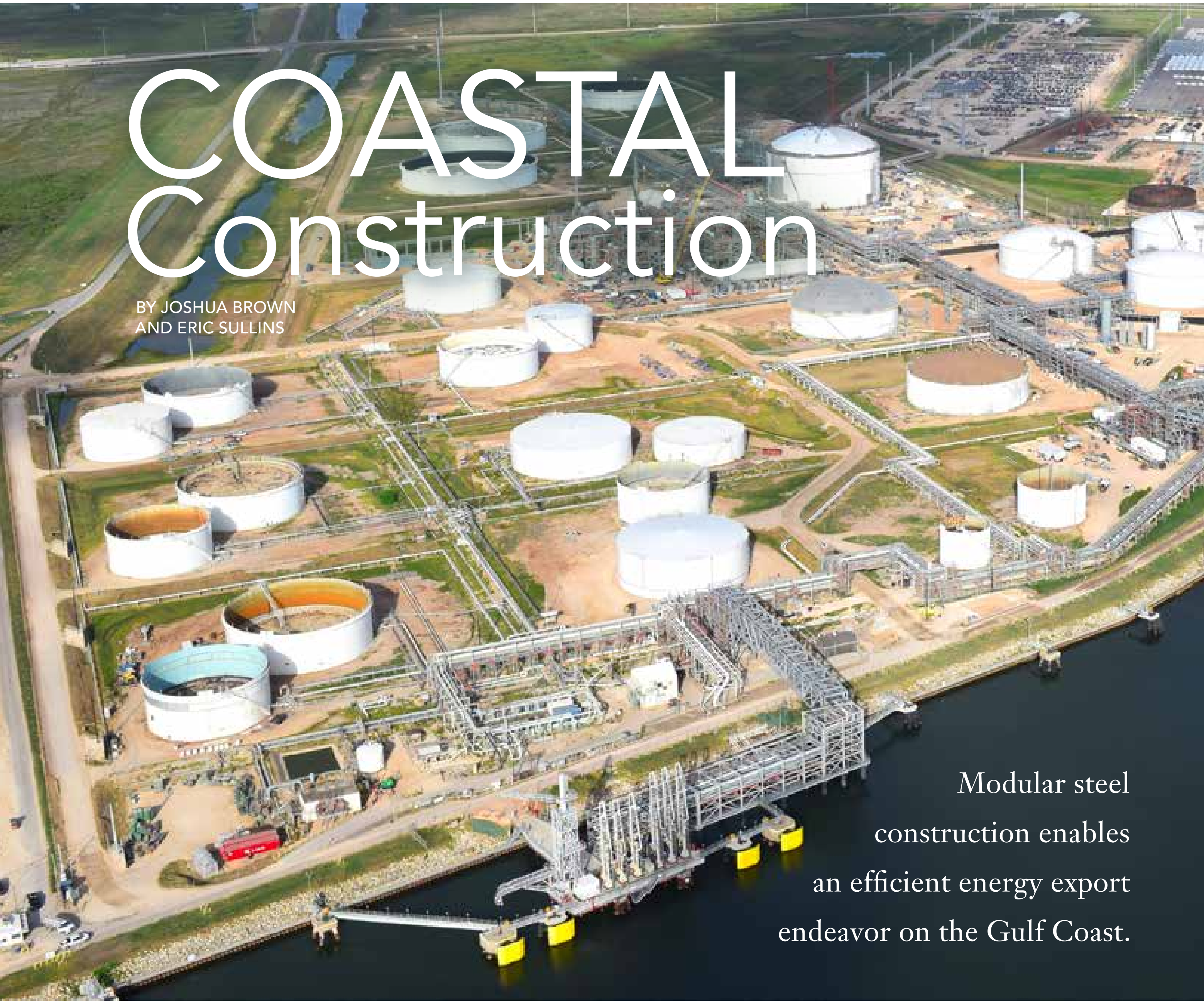
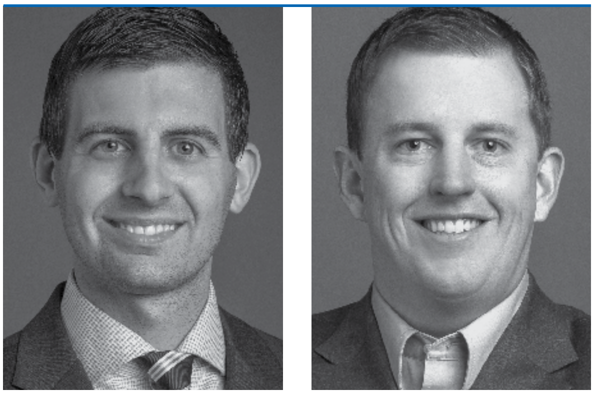
COASTAL Construction

BY JOSHUA BROWN AND ERIC SULLINS



Modular steel construction enables an efficient energy export endeavor on the Gulf Coast.



Joshua Brown (joshbrown@burnsmcd.com) and **Eric Sullins** (esullins@burnsmcd.com) are both senior structural engineers with Burns and McDonnell.

A NEW INDUSTRIAL PROJECT in Freeport, Texas, illustrates a portion of the energy industry that is sometimes overlooked but nevertheless crucial to the conversation.

While oil—particularly in terms of imports—renewable energy and even coal have dominated the current narrative, liquefied petroleum gas (LPG, often referred to as propane or butane) is a big part of the energy puzzle. And the new Phillips 66 Freeport LPG Export Terminal, due south of Houston on the Gulf Coast, is now exporting over 4 million barrels of LPG per year to Europe and Asia.

But to accommodate this new capacity, the existing 100-acre facility required 36 miles of new piping, the majority of which was installed on steel pipe racks. When it came to designing the system, structural engineer Burns and McDonnell (BMcD) determined that the project's compressed construction schedule and project site removed typical built-in-place or stick-built framing as feasible options. Luckily,

Photos courtesy of Phillips 66

The new Phillips 66 Freeport LPG Export Terminal, due south of Houston on the Gulf Coast, exports over 4 million barrels of LPG per year.

Lifting a steel bridge module into place.

BMcD had success with modular steel framing in the past, and that's the approach it took for the terminal project.

Process Unit Modules

The BMcD design team knew in needed to think big when starting design on the modules to be used for facility's new processing unit. The typical 12-ft-wide modules that BMcD had grown accustomed to using in past projects would simply not be practical for the amount of pipe required. And due to the facility's location on the water, the finished modules were shipped in on barges and could therefore be larger than what trucks can typically accommodate. In all, there are 24 new processing unit modules, varying in size and weight. The largest modules measured 40 ft tall, 32 ft wide and 110 ft long and weighed 170 tons.

Once the module sizes were determined, the next challenge BMcD faced was how to move and set them. Plot space for the modules was limited due to an existing tank farm on one side of the process unit and protected wetlands on the other side. As this limited crane access to the area, the modules were instead transported on-site via self-propelled modular transport (SPMT), with the lower support columns being erected with small cranes in the process unit area. The SPMT transported the modules from the barge to the construction site (at a blazing speed of 3 mph). Once in position, they were jacked up to a few inches above their final height then rolled into final position above the erected columns, lowered to the splice elevation and bolted into place. The entire process was completed in a single work day, per module.

Barging in a process facility module.

The modules themselves were designed in RISA 3D and Tekla, with the connections being designed in RAM Connection. Multiple RISA models were created for each module: one to simulate the loads being transferred to the steel frame during shipping on the water, one for the modules during transportation and jacking on the SPMT and a final model for the finished design where the module was connected to the stick-built columns. The framing scheme for the modules involved moment frames in the transverse direction and a single braced bay in the longitudinal direction.

Levee Bridge Modules

In order to transfer LPG from the facility to the loading docks, new pipe bridges were needed to span the levee; the United States Corps of Engineers (Corps) required all new piping crossing the existing federal levee to be supported by an elevated pipe bridge. No structures or foundations could be constructed within 25 ft of the toes of the levee, resulting in clear spans ranging from 220 ft to 260 ft. The terminal project required three pipe bridges to be designed, one at each existing loading dock. The pipe bridges were designed as modules; each one came fully assembled with pipe and cable tray.

Levee Bridge Modules

Module	Clear Span (ft)	Lift Weight (Tons)	Steel (Tons)
Dock 2 Pipe Bridge	222.5	255	194
Dock 3 Pipe Bridge	260	417	282
Dock 4 Pipe Bridge	230	238	185

Transporting a module via SPMT.

Setting a process module in place.

The three modules were approximately 25 ft high by 22 ft wide, and the final design incorporated field-erected support towers at each end, using slide bearings at one end and a fixed bearing at the other end. Each module also had a field-erected block valve access platform.

The top and bottom chords of each bridge were preassembled to assure that the required camber was provided, and a trial fit of the splice connections was also performed prior to shipment to the module assembly shop. Splice lengths were fixed early in design so that chord members could be preordered to length and help minimize cutting the members in the shop. The steel was galvanized and shipped to the module shop where

the modules were fully assembled and piping installed, and the bridges were built on cans and transported from the yard to a barge via SPMT.

The bridges were set using a land-based crane and a marine crane. The marine-based crane lifted the entire bridge into position at Dock 2, but at Dock 3 and Dock 4, the reach was too far for the crane to set the bridge with one pick. For these two docks, the marine crane lifted the entire bridge to a "resting" position on land while the land-based crane rigged up. The bridges were then lifted using both cranes into final position on the support towers.

Modular Advantage

For this particular project, which used 6,150 tons of steel in all, modular construction provided several advantages over standard stick-built erection, including a reduced schedule and the subsequent monetary savings—but the most important advantage was safety. Construction sites are busy and congested, making them a potentially hazardous work environment. By designing the pipe racks as modules, it allowed for a significant number of the steel and piping construction hours to be removed from the job site and shifted to the module shop where ironworkers and pipefitters could work in a more controlled environment. Multi-level modules were erected, filled with pipe and cable tray, insulated and fireproofed at ground level, then shipped to the site and installed in their final locations. ■

Owner
Phillips 66, Houston

General Contractor
Zachry Construction, Houston

Structural Engineer
Burns and McDonnell, Kansas City

▲ Erecting a bridge module at night.

▼ The project used 6,150 tons of steel in all.

➤ A bridge module, set in place.