PDCA PROJECT OF THE YEAR AWARDS

Associate/Engineering Affiliate Category: Downtown Juneau Floating Cruise Ship Berths

PND Engineers, Inc.

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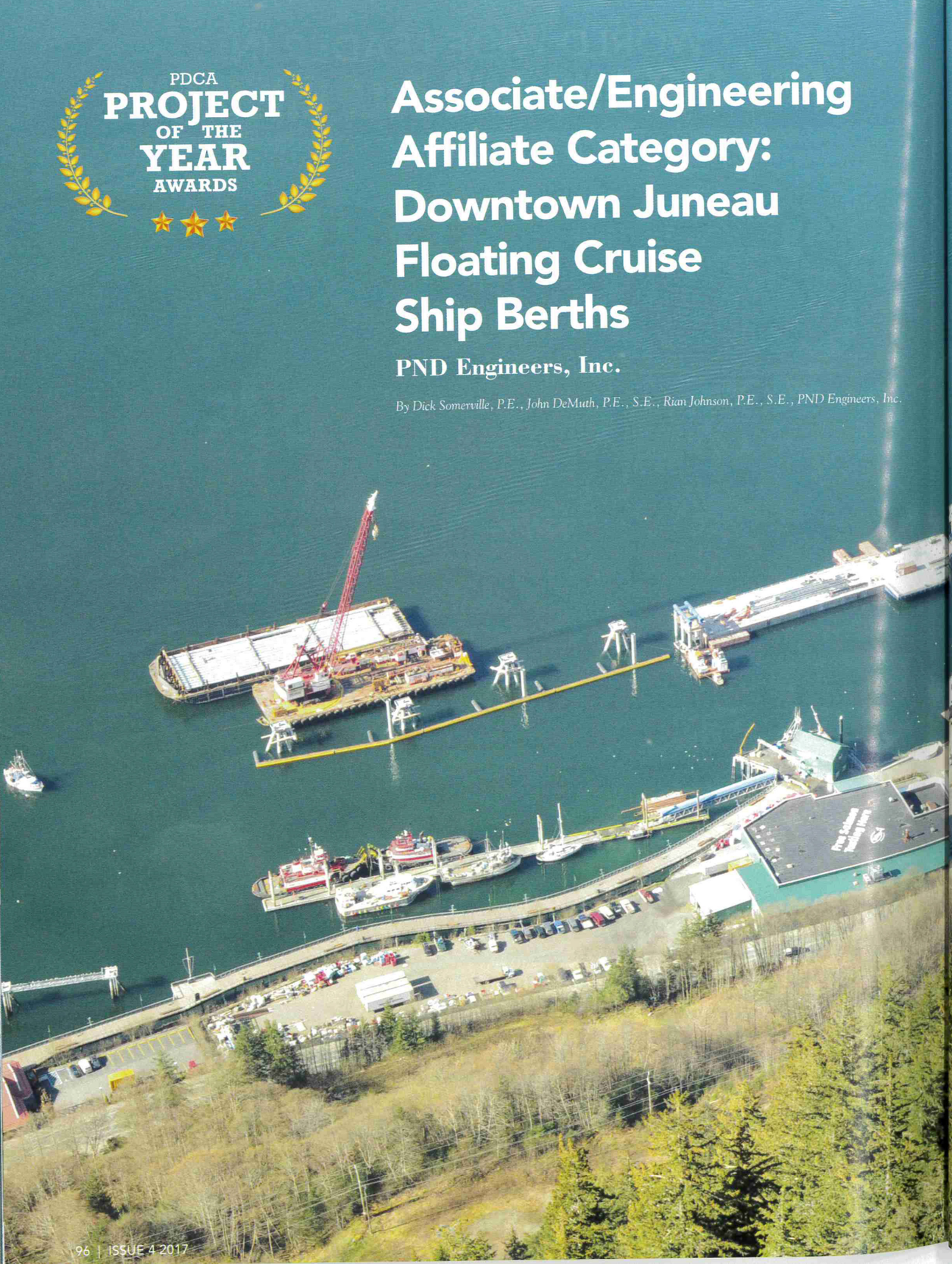


With the introduction of larger cruise ships into the worldwide market, individual ports have responded by expanding their facilities to welcome larger vessels. Southeast Alaska is no different. This rugged region is on a popular itinerary for the cruise industry and Alaska's capital city, Juneau, is the central port-of-call in the Alaska cruise itinerary.

Juneau is located in a region of deep waterways flanked by steep, mountainous and densely forested slopes with topographic elevations reaching from tide water and rapidly climbing upwards of over 4,000 feet. It is the only U.S. state capitol which cannot be accessed by road: Juneau is only accessible by air and sea. The remote and awe-inspiring scenery that attracts visitors from around the world also presents challenges for deep, marine foundation construction. The City and Borough of Juneau (CBJ) needed additional space to accommodate two new generation cruise ships in close proximity to downtown. However, limited waterfront space and natural mountain

The Juneau Cruise Ship Berths project is the largest cruise ship dock construction project of its type in Alaska state history.

Aerial view of the project site

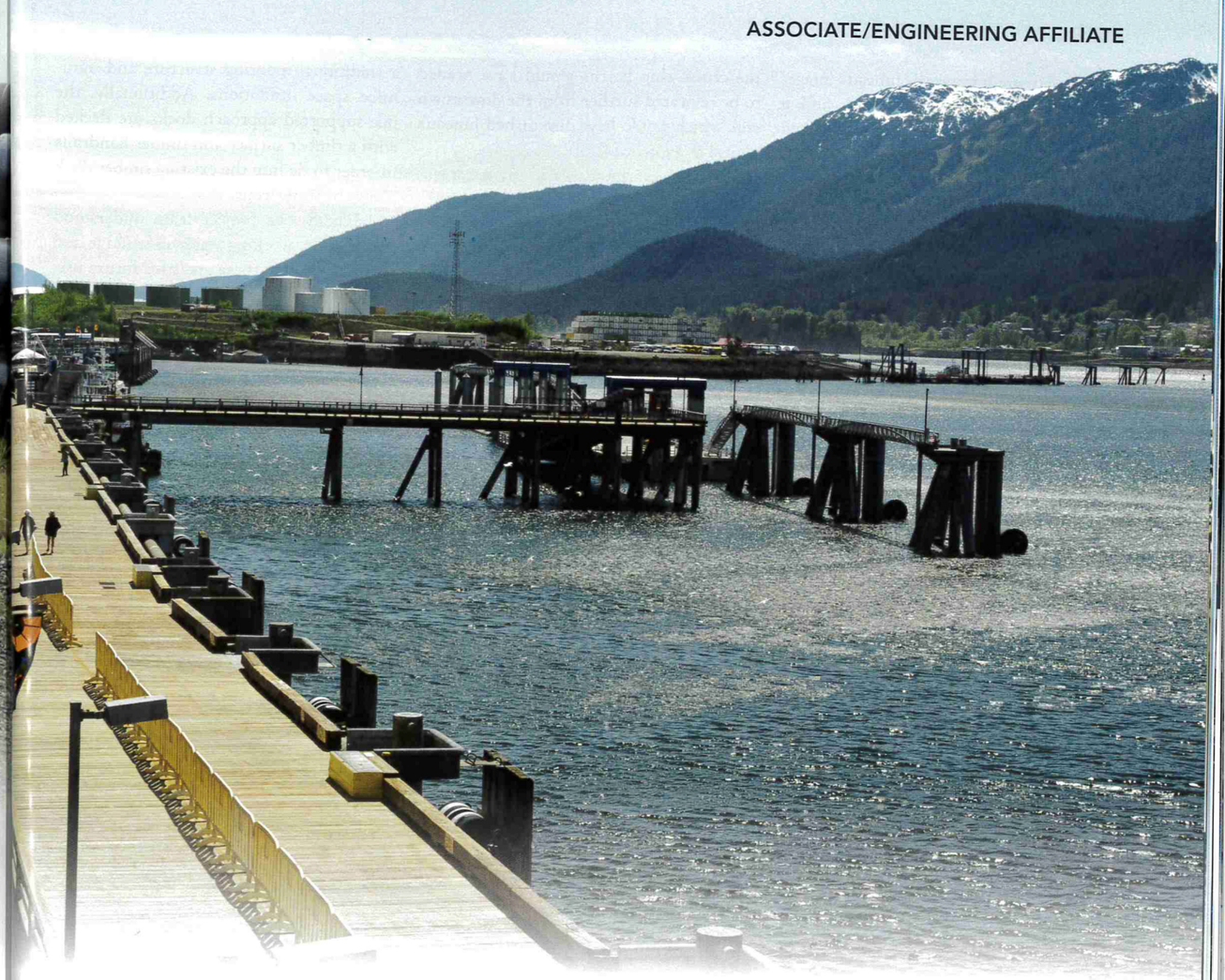
Photos courtesy of PND Engineers, Inc.

SPIN FIN® pile

barriers near the shoreline limited the available options to expand the city's cruise ship facilities. PND worked closely with the CBJ to develop project alternatives and the selected concept was two independent, floating concrete pontoons to use as the berths. The north berth pontoon measured 400 feet long by 50 foot wide. The south berth pontoon measured 300 feet long by 50 feet wide.

Since all access, mooring and breasting structures are located over deep water, a pile supported solution was the most economical method for design and construction of the floating berths. PND Engineers, Inc. (PND) developed a design using 179 steel pipe piles, which were incorporated into 24 independent and unique structures to support the two facilities. The pile sizes ranged from 24-inch by 0.5-inch pipe piles to 48-inch by 0.75-inch pipe piles and the length of pile varied from 100 to 240 feet long. PND also incorporated a variety of pile tips in order to optimize the project cost and adapt the driven pipe piles to the site conditions. PND used SPIN FIN® pile tips on piles with high tension loads and moderate overburden depths. Where there was insufficient overburden, PND incorporated tensioned rock anchors through the center of the driven piles. Where a full-moment connection was required in shallow overburden, PND incorporated rock-socketed pipe piles with rock anchors to support the new deeper water structures. The water depth at the face of the berth ranges from -60 feet to -100 feet (MLLW).

Manson Construction Company (Manson), based in Seattle, Wash., was awarded the construction contract for the project and construction of the cruise ship berths began with the pre-fabrication of elements in the Seattle/Tacoma area in the



fall of 2014. Prefabricated steel elements were produced by Jesse Engineering Inc. (Jesse) and the precast, concrete pontoons were produced by Concrete Technology Corporation (CTC). Manson began work on site in October 2015 and completed all pile driving and construction activities through the winter in Juneau. The South Berth opened to cruise ships at the start of the peak tourist season in early May 2016. Manson remobilized to the site in September 2016 and construction was completed in May 2017.

The Juneau Cruise Ship Berths project is the largest cruise ship dock construction project of its type in Alaska state history. The project team worked closely with CBJ and other stakeholders to assure the new facilities aligned with the long-range goals for the CBJ in three specific ways: The project strengthened tourism product offer-

ings downtown; it improves Juneau's images and attractiveness for investment; and it protects the existing working waterfront for the future. Using driven pile foundations and structures helped to achieve these three goals.

The project provides excellent proximity to existing retail, entertainment, residential and service amenities by locating the berths close to the downtown core. Using steel pipe piles as opposed to other foundation techniques allowed the design team to push the face of the berths into deeper water. This created more linear space for the larger vessels to use the facility while still maintaining close proximity to downtown Juneau. Without driven pile foundations, the cruise ship berths would have needed to be relocated further from the downtown core which would have diminished Juneau's appeal as a Port-of-Call.

As the marine gateway to the downtown core of Juneau, the cruise ship berths are the first view many visitors have of the city. The design team was able to incorporate the CBJ's color scheme and artwork and a variety of attractive visual elements into the berth in order to make the facility more attractive to visitors and encourage investment in the service industries in the waterfront area. The pontoons' pile-supported mooring structures were designed as all vertical pile moment frame structures in order to simplify the complex geometry of a traditional mooring structure and minimize space limitations. Additionally, the pile-supported approach docks are decked with a timber surface and timber handrails in order to tie into the existing timber dock along the waterfront.

Finally, the project team understood the existing, working waterfront usage and strove to protect these areas for future use. Using steel pipe piles to position the cruise ship berths offshore of the existing waterfront line, small vessels including work boats, pocket cruise vessels, fishing boats and float planes still maintain access to the existing waterfront and waterfront businesses operating near downtown Juneau.

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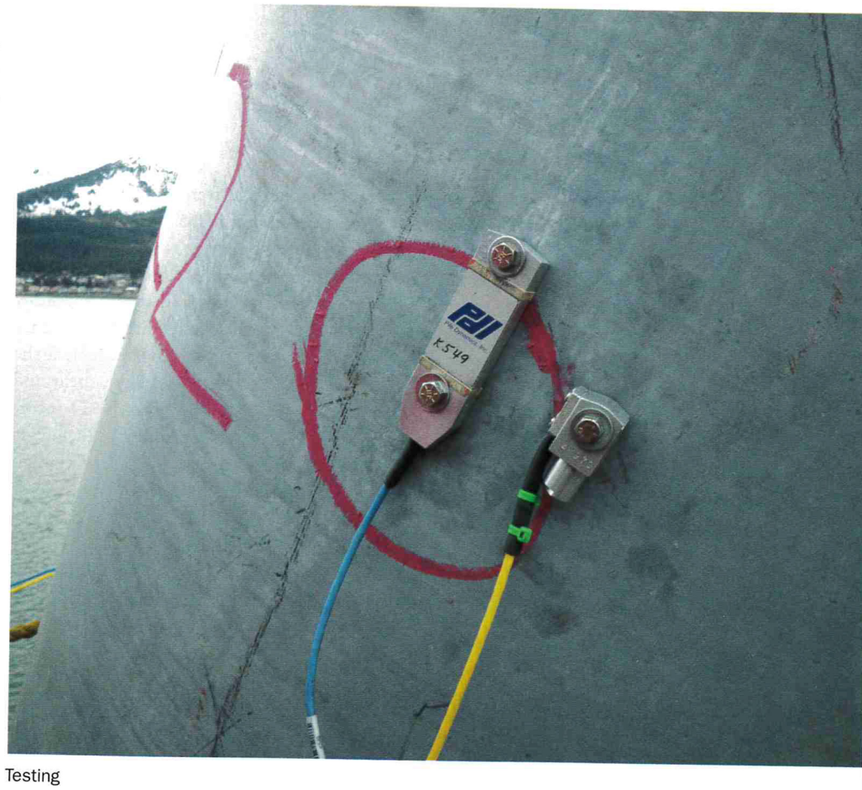
The project team in Juneau

A difficult job

The project site for the downtown cruise ship berths presents a variety of geotechnical and construction challenges that are unique to marine infrastructure design in southeast Alaska. These challenges stem from the highly variable geotechnical conditions that vary from loose marine sediment to shallow and steep-sloping bedrock and areas of underwater landslide debris.

The site is situated in one of the world's largest non-polar ice regions, and has been historically subject to multiple advance and retreat cycles of the surrounding glaciers. The primary result of this process is that the landscape is made up of deep, steeply formed channels and hillsides, including the sub-region where downtown Juneau is situated. The downtown Juneau waterfront sits at the base of the slopes of Mount Roberts and Mount Juneau. The mountains from sea level to peak measures over 3,500 feet. Yet the horizontal distance from shoreline to peak is only one mile.

The soil profile is a composite of man-made fill, mass wasting slope deposits, alluvial/deltaic deposits, native marine intertidal deposits and glacio-marine deposits. The elevation of the bedrock varies from exposed



Testing

ASSOCIATE/ENGINEERING AFFILIATE

bedrock to zones with bedrock measuring as deep as 110 feet below the seafloor and closely followed the steep profiles of adjacent Mount Roberts and Mount Juneau. Given the large foundation loads associated with the cruise ship berths, PND needed to design the foundation elements so that they could transfer these forces to the seafloor and underlying bedrock.

PND developed a geotechnical investigation program to characterize the general site ground conditions along with specific ground characteristics at the locations of deep foundation elements for the dolphin and mooring structures. PND characterized the ground conditions by taking in-situ standard penetration test (SPT) readings and vane shear tests. Additionally, test pile probes were driven at each planned dolphin location to confirm bedrock elevation.

The water depth, bedrock variability and large forces from new generation ships meant that large, driven steel pipe piles were the most economically viable way to support and anchor the marine structures because they could be supplied in the necessary length for the project and could be readily anchored to the bedrock. With the presence of shallow, steep and sloping bedrock at the site, and the need to resist large shear and tension forces with the piles, PND incorporated several different pile tip anchoring elements into the design. For piles with high shear or tension forces driven into little or no overburden, rock anchors were incorporated to resist these forces by transferring the force directly from a tensioned anchor at the top of the pile directly into the bedrock. For piles in shallow bedrock subject to large bending forces, rock socketed pile tips with rock anchors were incorporated into the design so that the full flexural capacity of the pile could be transferred to the bedrock. Finally, for piles required to resist large tension loads in locations with moderate overburden depths, PND used SPIN FIN® pile tips. These pile tips consist of a series of straight steel plates welded to the tip of the steel pipe piles in a helical pattern. When driven and attached to a structure to prevent rotation, the SPIN FIN® tips enhance the resistance to compression forces by providing additional skin friction area and bearing area for the pile to resist forces.

Construction innovation

Given the variability of soft soils underlying the project site, additional verification of driven pile tension capacities was necessary. Compression capacities of the piles were established by firmly seating the piles in the underlying bedrock with an impact hammer.

PND's engineers performed field pile driving inspection throughout construction of the project. As part of the pile driving inspection, PND performed tests utilizing the Pile Driving Analyzer® (PDA) system on pipe piles with and without SPIN FIN® tips. The PDA tests were performed on 24-inch-diameter pipe piles and 42-inch-diameter pipe piles in adjacent locations in order to compare similar sized piles in the same soil strata with different pile tip configurations.

The geotechnical testing yielded valuable information regarding skin friction resistance distribution along the shaft of the pile. The pile driving record was imported into the program Case Pile Wave Analysis Program (CAPWAP) and signal matching was performed. The CAPWAP analysis provides an added degree of accuracy to the estimated capacity of the pile and further evaluates how the capacity is developed – end bearing and frictional resistance distribution along the shaft. For the SPIN FIN®