TAIHEIYO CEMENT

PND Engineers, Inc. earns a PDCA Project of the Year

By Rian Johnson, PND Engineers, Inc.

The Taiheiyo Cement Facility in San Fernando on Cebu Island in the Philippines produces cement for distribution across the Philippines. Taiheiyo Cement needed to upgrade their existing gravity block jetty which included four outer berths (Berths 1 to 4), five inner berths (Berths 5 to 10), two RORO berths (Alpha Beach and Echo Beach) and constructing a pile-supported jetty dock.

To complete the first phases of the work, the vessel berths needed to be deepened and this could not be safely achieved with the existing gravity block wall. A sheet pile wall was required to achieve the quay wall heights required to meet the owner's operating needs. Several options evaluated included a tied-back Z-sheet sheet pile or combi-wall. Japan Port Consultants (JPC) also included the OPEN CELL SHEET PILE™ system. After considering the pile driving aspects of the different system, JPC recommended the OPEN CELL system to the owner for final design.

Pile driving of the OPEN CELL system was a critical component to the success of the project. The site consisted of sands, limestone cobbles and concrete debris. In close collaboration with JPC, the contractor, and an experienced field superintendent, obstacles were avoided or removed, and the flat sheet piles were advanced with vibratory driving to final tip elevation. To date, Berths 1 to 4, Echo Beach and Alpha Beach have been completed with future phases on track for construction.

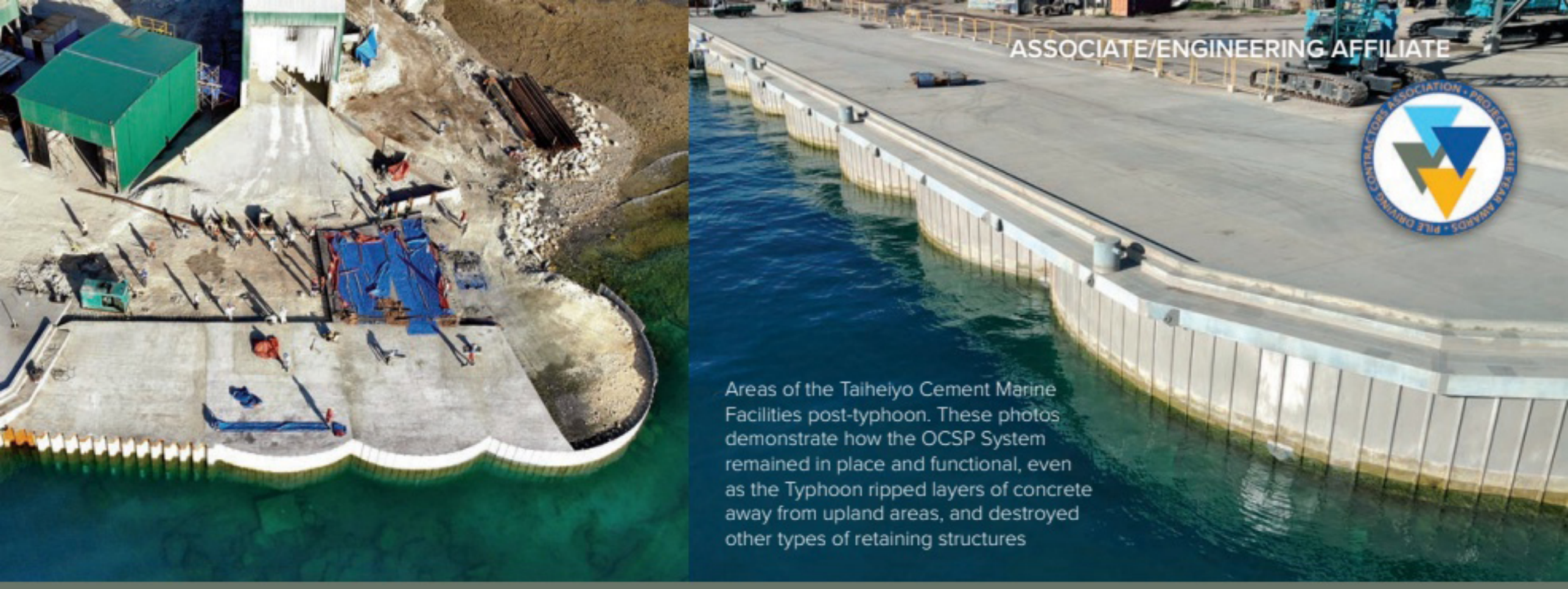
The sheet pile driving represented a large majority of the planning and cost of the project and now provides a safe and stabile surface for operations along the strengthened jetty face.

The OPEN CELL system for Berths 1 to 4, Echo Beach and Alpha Beach rely on five primary types of steel sheet piles. It uses vertically driven, interlocked flat sheet piles to form a wall of adjoining U-shaped cells. It consists of two elements composed of flat sheet piles: arc-shaped faces that form the exposed front, and straight tailwalls that extend back into the earthen embankment. The two are joined by wye (Y) piles at the junctions of the arcs and tailwalls. Steel HP anchor piles are driven at the end of each tailwall.

The flat sheets used in construction were manufactured by Nippon. They were NS-SP-FXL sheet piles on the arc faces and NS-SP-FL flat sheet piles on the tailwalls located within the earthen embankment. The wye piles are fabricated steel piles composed of three welded half NS-SP-FXL sheet piles. The anchor piles are HP14 steel piles welded to a half NS-SP-FL sheet pile. To provide a continuous berthing face with the existing jetty, HAT sheet piles filled with concrete provide closures between the new and existing structures. HAT sheet piles were manufactured by Nippon and are 900 mm wide and shaped like a magician's hat.

Berths 1 to 4 used 1,100 flat web sheet piles, 19 wye piles, 21 anchor piles and 15 HAT sheet piles. Sheet piles varied in length from 10.5 meters (34 feet) to 14 meters (46 feet) except for the HAT sheets which were 19 meters long (62 feet) to achieve necessary toe embedment for stability.

Echo Beach used 280 flat web sheet piles, three wye piles, five anchor piles and 43 HAT sheet piles. The taller Echo Beach site required sheet piles varying in length from 10.5 meters (34



ASSOCIATE/ENGINEERING AFFILIATE

Areas of the Taiheiyo Cement Marine Facilities post-typhoon. These photos demonstrate how the OCSP System remained in place and functional, even as the Typhoon ripped layers of concrete away from upland areas, and destroyed other types of retaining structures

MARINE FACILITIES

Award in the Associate/Engineering Affiliate category

feet) to 20 meters (66 feet) except for the HAT sheets, which were 20 meters long (72 feet).

Alpha Beach RORO ramp quay wall used 120 flat web sheet piles, two wye piles, four anchors piles and 13 HAT sheet piles. The sheet piles required sheet piles varying in length from 20 to 33 feet.

The pile driving installation was performed from on top of the jetty using a single CSK1100 110-ton crawler crane manufactured by KOBELKO and a SGV 200 vibratory hammer (2,200 in-lb eccentric moment) manufactured by BRUCE Piling Equipment. The crane lofted and set the sheet piles and then used the vibratory hammer to advance the sheet piles to design tip using stagger driving methods.

Choosing driven piles

The facility is in a region subject to severe seismic accelerations as well as extreme wind and wave loads from tropical storms and typhoons. The design team took an innovative approach to the jetty facility upgrades to resist these loads along with the day-to-day loading from heavy bulk-handling equipment. The reinforced earth mechanics of the OPEN CELL SHEET PILE bulkhead provide for a stable structure against high seismic accelerations and high ground surface loads.

The aging, existing walls consisted of caisson or concrete blocks, but the owner needed a wall system that could accommodate future dredging of up to an additional two meters. The driven OPEN CELL SHEET PILE system allowed for a taller quay wall with heavier operating loads in a severe loading environment. The OPEN CELL system was chosen over a tieback wall because the cost was less than 50% of the tieback, according to a local contractor who was eventually awarded the project.

On Dec. 16, 2021, the constructed areas of the OPEN CELL system withstood the effects of Category 5 Typhoon Rai.

Challenges and solutions

Berths 1 to 4 and Echo Beach: The most challenging aspect of the project was advancing the design, procuring materials and phasing construction during the COVID-19 pandemic. The design team was scattered between the U.S., Japan and the Philippines, each with their own pandemic protocols and restrictions. The project needed to be designed and revised based on a dynamic and responsive approach to changing conditions, including material, equipment and crew disruptions caused by the pandemic.

Another challenge for Berths 1 to 4 was using a contractor with no experience with cell structures or even flat sheets. The solution was to bring in a construction expert from the U.S. to

oversee the entire project, from fabrication to driving template design to sheet pile installation using stagger driving methods to field welding. The result was that the contractor finished four months earlier than their schedule.

Alpha Beach: We had only two months to design, procure and build before the first ship arrived. The fast-track timeline was driven by damage to the old concrete block wall facility caused by Typhoon Rai, which made landfall directly over San Fernando in December 2021. The solution was to build a hybrid wall consisting of OPEN CELL flat sheets and cantilevered HAT sheet piles with leftover materials, plus bring in a highly skilled contractor who could meet the deadline.

Collaboration

The Taiheiyo Cement Marine Facilities project demonstrates a collaborative approach between engineering consultants from the U.S. and Japan to overcome site challenges found in many port projects located on the "Ring of Fire": high seismic and storms loading. This required the expertise of individuals familiar with both the Philippines Building Codes, local fabrication techniques and advances in the application of marine structural design technologies.

The approach taken by the design team is innovative and the first of its kind in the region.

Tim Green of Nautilus Marine Construction Consulting, an American construction/fabrication expert, was brought in to help the contractor with all aspects of the construction. He first helped in procuring the right tools and equipment needed for the OPEN CELL construction. He then designed and helped fabricate the sheet pile driving templates. He also taught and trained the contractor to fabricate the wyes and anchors. On the field, he oversaw the driving and field welding operations and installed anodes underwater.

The project also uses innovative and unique technologies, particularly as applied in the Philippines. The concrete jetty was reinforced with new OPEN CELL bulkheads, using mechanically stabilized earth to resist earth, seismic and equipment loads.

Cost saving measures

The original design proposed for Berths 1 to 4 was quoted by a local contractor to be approximately $14 million USD, while the OPEN CELLL system was built by the same contractor for approximately $7 million USD. The system uses less material, simplifying the construction by using only flat sheet piles and eliminating tie-rods.

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