DEEP FOUNDATIONS INSTITUTE DFI

Deep Foundations

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Beware of the Unknown

SUBSURFACE CHARACTERIZATION
SPECIAL ISSUE

Wick Drains Into the Unknown

There are many factors that can result in a site characterization being limited. For example, a client may undervalue the importance of a good geotechnical report, or an owner may feel that it would take too much time to perform an appropriate investigation among other reasons. For this project, neither was the case. The challenge was that the construction sequence of work required wick drains to accelerate the settlement of soil that had yet to be placed, resulting in the need to create a wick drain bid package based on unknown settlement parameters.

This wick drain project took place in Long Beach, California, at the Long Beach Middle Harbor Redevelopment. For much of the past decade, the Port of Long Beach undertook a $1.5 billion redevelopment of two outdated terminals to create the Long Beach Container Terminal (LBCT). To achieve this goal, the existing terminals were demolished and the slip that serviced one of the older terminals was designed to be infilled to create the new area that would allow for the LBCT to manage 3.3 million TEUs (a commonly used freight term meaning twenty-foot equivalent unit) of cargo each year. Ultimately, the construction of the LBCT would be performed under multiple contracts to allow the new terminal to begin operation in a phased approach. Menard performed the wick drain installation under two out of three contracts, and this case history focuses on the challenges anticipated and faced under the second of these awarded contracts.

The Bid

The overall contract consisted of 15 general scopes of work that can be grouped together into five overall items: demolition of an existing wharf and associated quay wall, construction of a new containment dike and concrete wharf, dredge and infill of the area behind the new containment dike, wick drain and surcharge program to minimize the long-term settlement of the newly placed material, and installation of sewer and electrical utilities to service the container yard. The project was publicly bid and followed a design-bid-build project delivery system.

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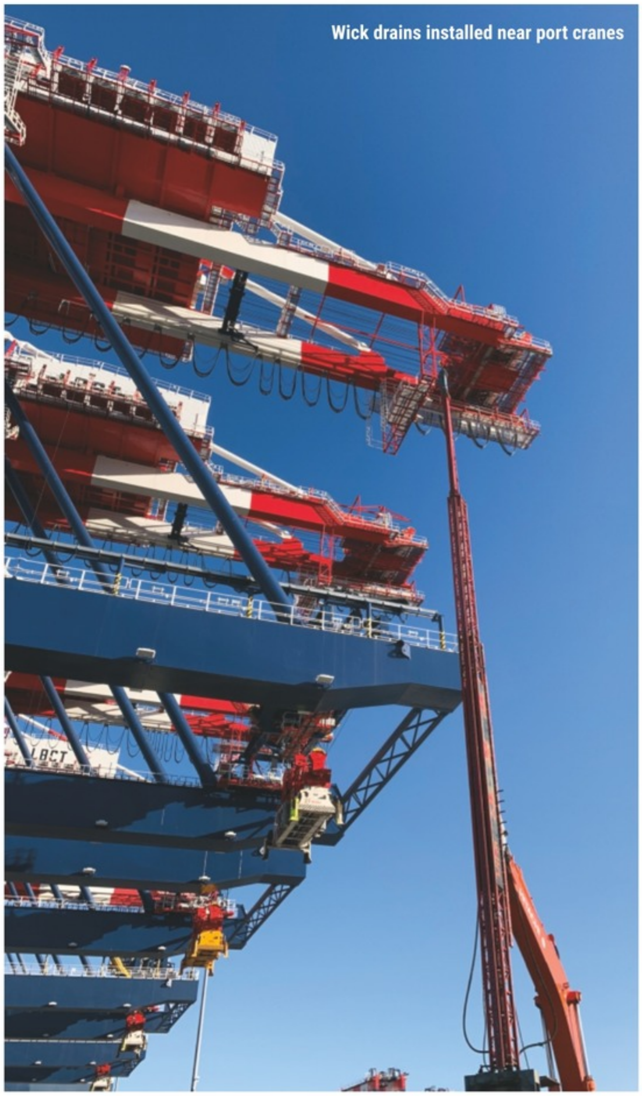


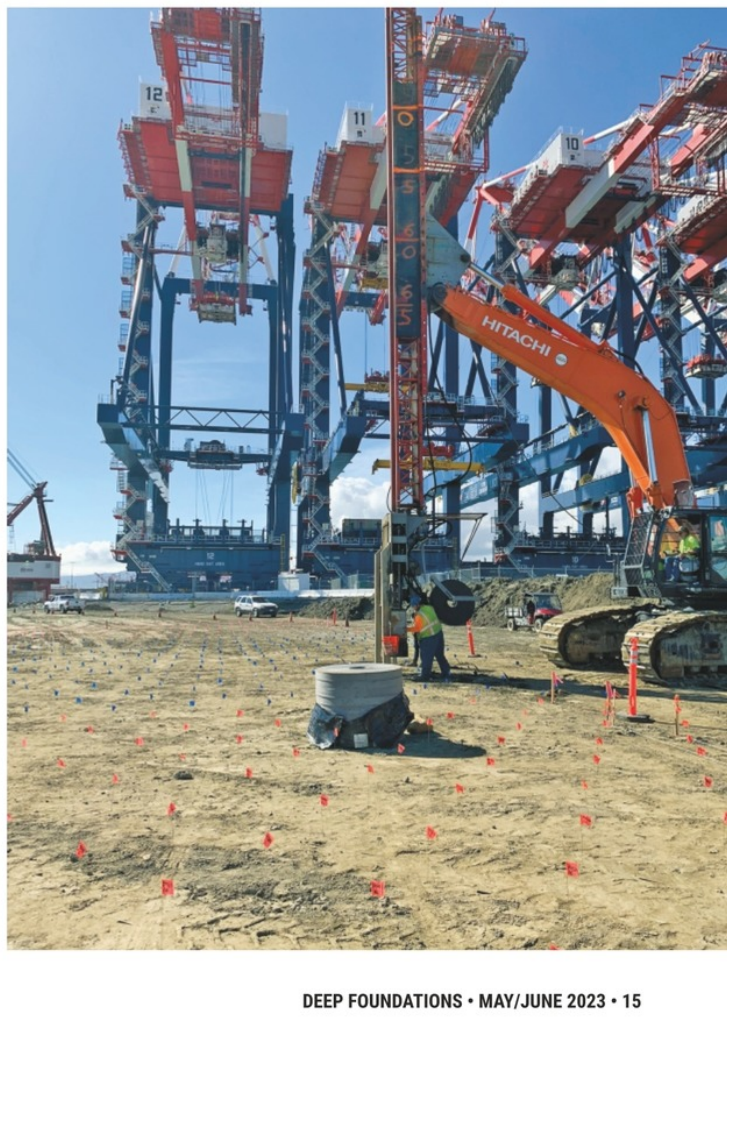
Wick drains installed near port cranes

The content contained in the geotechnical report led to assessing the biggest "known unknown" and biggest risk: what would be the soil properties of the fill material through which the wick drains are installed.

During bid preparation, a risk assessment was performed to vet potential exposure on the project. The knowns were relatively simple: the bid would be based on rigorously meeting the requirements presented in the wick drain specification and installing the wick drains at the designed spacing of 3.5 ft (1 m) triangular and to the designed target tip elevation of -65 ft (20 m). The equipment would meet the requirements of the project with a minimum push force of 40,000 lb (18,000 kg). Performing an independent takeoff based on the areas shown on the drawings confirmed that the bid quantity of 2 million lft (600,000 m), was consistent with the available geotechnical information on soils that would lie below the new material placed.

The content contained in the geotechnical report led to assessing the biggest "known unknown" and biggest risk: what would be the soil properties of the fill material through which the wick drains are installed. The four borings in the soils report consisted of approximately 50 ft (15 m) of water that transitioned into a mudline about 10 ft (3 m) thick before becoming dense sand. Based on an understanding of the wick drain specifications and design, the drains would be installed 76 ft (23 m) deep from a working elevation of +11 ft (3.4 m) and a termination elevation of -65 ft (20 m). Most of the material that is expected to be treated wouldn't be placed until after the bid and right before the start of work. In fact, no additional geotechnical information would be available until after the wick drain production work had commenced.

Early wick drain installation



Finishing wick installation in pre-augered holes

Cone Penetration Testing Results

Location	CPT Depth in ft (m)	Comments
CPT-2	33 (10)	Refusal
CPT-3	25 (7.6)	Refusal
CPT-6	29 (8.8)	Refusal
CPT-7	30 (9)	Refusal
CPT-8	50 (15)	Refusal
CPT-9	29 (8.8)	Refusal
CPT-10	50 (15)	Refusal
CPT-14	28 (8.5)	Refusal
CPT-15	26 (8)	Refusal
CPT-16	26 (8)	Refusal
CPT-17	32 (9.7)	Refusal
CPT-18	43 (13)	Refusal
CPT-19	45 (13.7)	Refusal
CPT-20	42 (13)	Refusal
CPT-27	27 (8)	Refusal
CPT-28	33 (10)	Refusal
CPT-29	52 (16)	Refusal
CPT-30	47 (14)	Refusal
CPT-31	43 (13)	Refusal
CPT-32	42 (13)	Refusal
CPT-MCJV44	57 (17)	Refusal
CPT-MCJV45	41 (12.5)	Refusal
CPT-MCJV47	60 (18)	Refusal
CPT-MCJV50	34 (10)	Refusal
CPT -Z	36 (11)	Refusal

The specifications presented additional risks beyond the typical geotechnical risks to installation quantity and schedule. Pre-augering, a supplemental activity that loosens the soil at the wick drain location using a continuous flight auger, was considered incidental to the wick drain installation. Based on previous experiences at the site, as well as from other port projects, it can be common for the fill material placed above the water line using mechanical means (i.e., dump trucks and bulldozers) to require pre-augering to meet typical production rates. Another anticipated risk was the requirement to make up to two reattempts at wick drain installation if the drains hit an obstruction or a dense layer prior to the designed termination elevation. Ultimately, an installation plan was developed to attempt all wick drains without pre-augering, and, if needed, would return to an area with shallow obstructions/dense layers with a pre-auger and only make one installation attempt on pre-augered locations.

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The contract was awarded in the fall of 2018 and Menard mobilized to the site in January 2019.

Wick Drain Installation

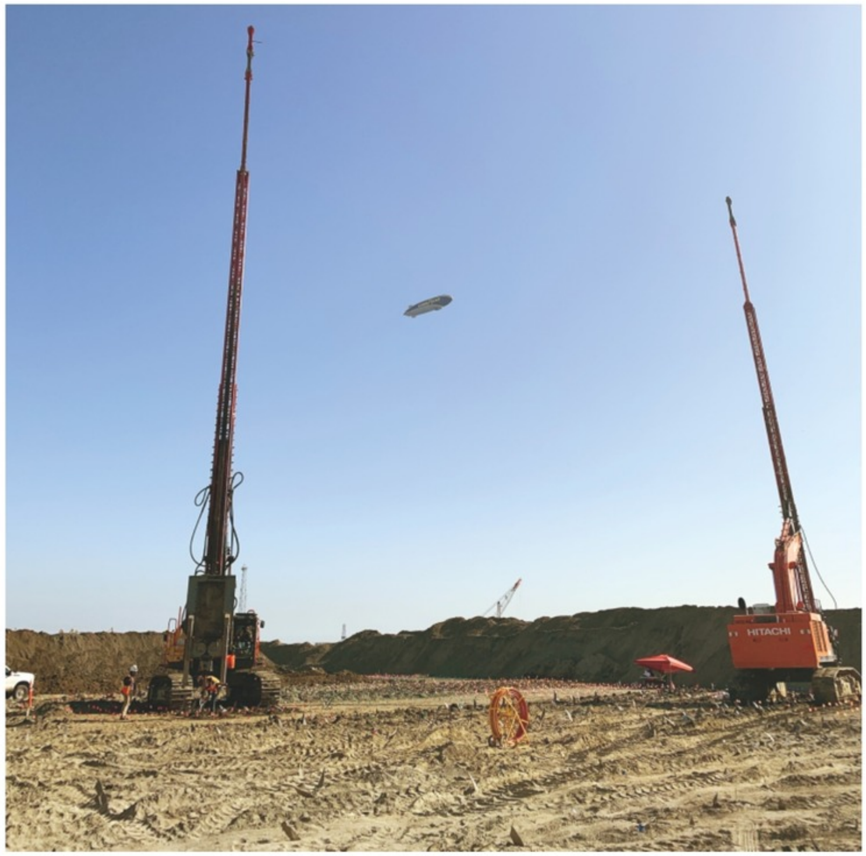
The impact of the limited site characterization, in particular the unknown behavior of the material being placed, became apparent as soon as the team had mobilized to the site. Based on past experiences and the approach of meeting the letter of the specification, it was hoped that any challenges could be overcome or resolved with the project team. The project started with the equipment being verified to have met the project specifications, and production began.

The impact of the limited site characterization, in particular the unknown behavior of the material being placed, became apparent as soon as they had mobilized to the site.

The challenges faced with recently placed soil became apparent quickly. A majority of the wick drains were met with shallow refusals and reattempts at nearly every location. Whereas the potential for shallow refusals and carried costs for pre-augering was expected, the actual refusals were occurring much deeper than could be economically addressed with pre-augering. At the start, refusal was defined as any drain that didn't get within 5 ft (1.5 m) of design tip elevation. To meet the letter of the specification, there were instances where two additional offset 65 ft (20 m) wick drains were installed within 18 in (450 mm) of the initial 65 ft (20 m) "refused" wick drain, with each trying to get to 76 ft (23 m).

The first additional site characterization that explored the newly placed dredged fill did not occur until two weeks into the wick drain installation. The results of the cone penetration testing (CPT) are presented in the table.

The results of the CPTs did not change the target for the wick drain design. Instead, it became a reference for the design team to ultimately accept whether the drains in that area were final, or if additional remedial wick drains would need to be installed. Specifically, it changed the acceptance criteria of the drains that would be decided after installation. This ultimately led to delays in the project and quantity overruns with nearly three times as much material being installed per drain. The effect was further compounded when the port decided that the last area would have the wick drains installed from the top of the surcharge pile. This required deeper pre-augering than what was initially proposed and deeper than the team's capabilities at the time. The port ultimately directed the general contractor to directly subcontract the predrill contractor and wick drain installation continued at the pace of the downhole hammer pre-auger production, approximately 60 drains a day, less than a quarter of the production anticipated at bid time.



Wick drain installation and the Goodyear Blimp

A majority of the wick drains were met with shallow refusals and reattempts at nearly every location.


Installation with reattempted wicks in the foreground

Final Impacts

Ultimately, the cost of the wick drain contract ended up being double what was bid with the total cost impact to the project being approximately four times the initial contract. The wick drain installation and remediation cost 10 months of delay to the overall project schedule. The lack of borings and CPTs through the newly placed dredged material was inevitable based on how the project was bid. However, the lack of site characterization prior to wick drain installation and lack of a mechanism to contractually accommodate this new information in the project schedule and approach are what caused the most problems. Instead of being in a position to be proactive about managing these risks, the entire project team was reacting to what was encountered in the field. Even though our experience was telling us that site conditions were not in the spirit of what was expected during the design process, the work progressed as-is because "time is of the essence." This was a case where, despite bidders being in line with the project specifications and requirements, the results ended up costing the owner significantly more in time and money than anticipated. With foresight to allow for an appropriately phased geotechnical investigation and a contract structure that allowed for changes to means and methods to accommodate new information, the project could have been completed more efficiently and economically.

Brian McGlynn is a regional estimating engineer with Farrell Design-Build, and previously worked with parent company Menard including on the wick drain project. He has spent the past decade working on ground improvement projects focusing on the Gulf and West Coast markets.

Dredged material being placed