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Screw Piles In the 19th Century

Helical piles, also known as screw anchors or screw piles, have a rich history dating back to the original screw pile patent granted to Alexander Mitchell in 1833. Born in Dublin, Ireland, on April 13, 1780, Mitchell was known as “the blind inventor” because he had lost his sight by the age of 22. A year later, Mitchell started a brickmaking business and began inventing machines for the brickmaking and construction industries.

Mitchell developed the screw pile for use in mooring, beacon, lighthouse, and dock construction. At the time of its invention, no means were available to construct submarine (underwater) foundations for lighthouses on anything but rock. The screw pile was instrumental in allowing coastal submarine construction in soft bearing materials. The screw piles and devices from the Mitchell patent are shown in Figure 1.

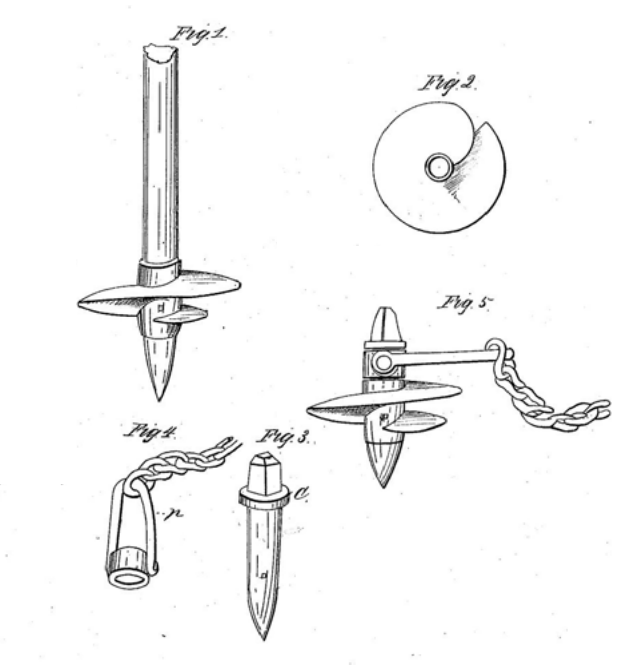

Figure 1: Alexander Mitchell’s screw pile system

Lighthouse Foundations

The Maplin Sands lighthouse at the Thames estuary near Essex, England, was the first lighthouse to utilize Mitchell’s screw piles. Construction began in 1838, and the first lighting was in 1841. Mitchell and his 19-year-old son John oversaw the screw pile installation, which included 4-foot diameter cast-iron screw plates attached to 5-inch diameter wrought-iron shafts. The piles were screwed into the sand to an embedment depth of about 22 feet for an estimated capacity of 64 tons. The piles were installed using a floating platform with a capstan head attached to the pile shaft that allowed rotation from the platform. The capstan was turned manually using handspikes on the capstan (Figures 2 and 3). Nine piles were used for the lighthouse foundation, with one pile in the center and eight piles at the face of an octagonal frame (Figure 4). The screw plate diameter needed for a 64-ton service load was correlated from a load test using a 1-ton static load applied to a boring rod attached to a 6-inch diameter screw plate embedded into the sand.

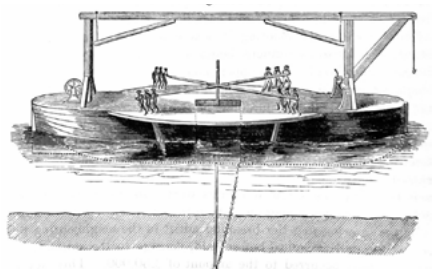

Figure 2: Floating platform and capstan for screw pile installation

Figure 3: Screw pile capstan with handspikes

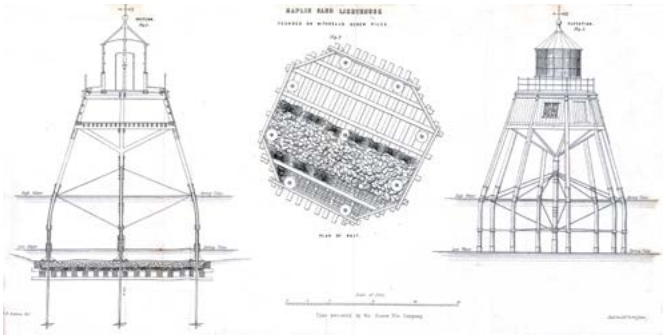

Figure 4: Maplin Sands lighthouse construction drawings

Although the Maplin Sands lighthouse was the first to utilize Mitchell's screw pile system, due to the length of its construction, the Port Fleetwood lighthouse, which was completed in 1840, was the first lighthouse featuring screw piles to be lit. The Port Fleetwood lighthouse was located on the Wyre River near Lancaster, England, and constructed with seven screw piles, one pile in the center and six piles at the face of a 27-foot diameter hexagon platform (see Figure 5).

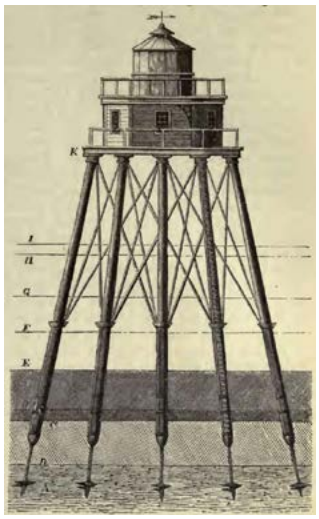

Figure 5: Port Fleetwood lighthouse

Pier Foundations

Mitchell saw other uses for his screw-pile foundations, including piers, dock structures and bridges. The first documented application of the screw pile for a large pier and dock structure was in 1847 at the pier extension for the Village of Courtown in Wexford, Ireland. The ocean surf conditions at this location were extreme and restricted the use of barges or rafts for the installation of the screw piles. A unique system was employed that allowed segmental construction of the pier, with the screw pile installation equipment located on a section of completed pier deck. To install the screw piles, a moveable rope-and-capstan wheel system was used, as shown in Figure 6. The capstan wheel was 17 feet in diameter, with a rope band passed around the wheel to a smaller pulley located about 150 feet away. The capstan was driven by men pulling on the rope. Once one section of pier was constructed, the capstan wheel assembly was extended over the completed section to allow installation of the next section.

The screw piles had 2-foot diameter screw plates with 5-inch diameter shafts and were embedded to depths of about 11 to 15 feet to bear in firm blue clay. The completed pier extension was 260 feet long and 18.5 feet wide, with pile bents at 17-foot spacings. The pier ended at a 54-foot long by 34-foot-wide platform for loading and unloading of small craft, as shown in Figure 7.

Summary

The successful construction of the Maplin Sands and Port Fleetwood lighthouses opened the door for numerous lighthouses constructed on screw piles along the coastlines of England, Scotland, and Ireland. This method became even more popular on the East and Gulf Coasts of the United States, with perhaps as many as 100 lighthouses constructed in the 19th century using Mitchell's helical screw pile system.

It is easy for us, living in the 21st century, to underestimate the impact that Mitchell's screw pile invention had on the lives of sailors and maritime safety in general by allowing submarine construction in areas previously deemed unsuitable. This innovative technology laid the groundwork for what would come several decades later. The modern era of helical pile development, research, and growth began in the 1950s made possible by the advent of the hydraulic drive motor. This era brought about the robust and reliable helical industry we see today. That, however, is a topic for another day.

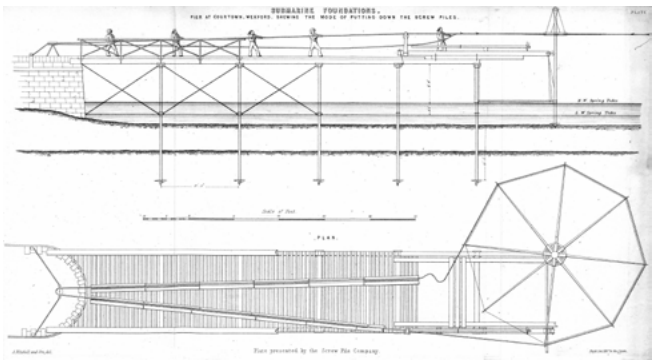

Figure 6: Capstan wheel assembly for Courtown pier

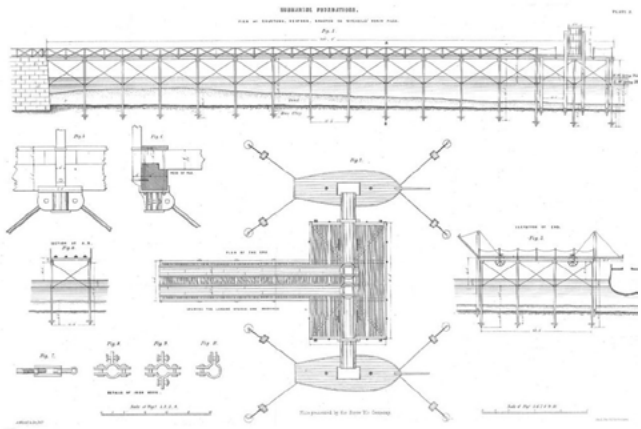

Figure 7: Courtown pier elevation and plan view

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Helical Piles Provide Column Support For Renovation

Project: **Merchants Ice and Cold Storage Complex-Warehouse Renovation**

Location: **Anahuac, TX**

Challenge: The Merchants Ice and Cold Storage Company Complex includes six buildings that were constructed between 1909 and 1957 and encompasses a five-acre site in San Antonio's Eastside. An extensive renovation was approved to change the complex into a technology and life science innovation hub. Building #5 was previously used as a warehouse and would be renovated into a two-story Co-Lab facility. Due to the historic nature of the complex, the original interior columns would remain during removal of the building shell and be visible in the new office spaces after renovation. Nine existing interior columns, which were supported by shallow footings would require additional capacity for the new construction. The new column service loads (design working loads) ranged from 67.5 to 79 kips in compression with tension service loads of 12.9 kips.

Several factors were considered which lead to a design requirement for removal and replacement of the existing column foundations with a deep foundation system including; a geotechnical investigation showed poor bearing soils below the existing footings used to support the existing columns, the existing column pad concrete had deteriorated with age, and the tension loading could not be handled by the shallow column pads. A temporary support system would be needed for the columns to allow access for construction of the deep foundations below the columns. The temporary support system would limit access for large installation equipment.

Column support system in place and pile caps excavated

Solution: Given the access limitations and other project challenges, helical piles were selected as the most economical solution for deep foundation support at the existing column locations. The nine columns were temporarily supported by spanning the existing concrete slab with structural steel elements welded to the columns prior to removal of the column footings. The Model 288 (2.875-inch OD by 0.276-inch wall) helical pile system with new construction brackets was selected for column pad support. Four helical piles were used at each column pad with maximum individual pile service compression and tension loads of 19.8 kips and 3.3 kips, respectively. An 8"-10"-12" helix plate configuration with a minimum termination depth of 19 feet was specified. The minimum termination depth was required to ensure the top helix was below the active soil zone defined in the geotechnical report as 15 feet below existing grade. The helical piles were installed to depths of 19 to 26.5 feet after achieving torque-correlated ultimate capacities of at least 2 times the service load. The 36 helical piles were installed over a period of 5 days.

Adding helical pile extension

Helical piles installed with new construction brackets in place

Concrete pile caps poured, and second floor constructed

Outside of building with shell construction underway