

CASE STUDY

DEFYING NATURE: HOW COMPOSITE MARINE PILES PERFORMED IN THE DULUTH SUPERIOR HARBOR'S HARSH ENVIRONMENT.

INTRODUCTION

With its aggressive conditions, the Great Lakes have always posed a unique challenge for marine design and construction. Conventional materials, like steel and timber piling, have often succumbed to the relentless movements of ice sheets during Minnesota's cold winters, traditional decay, and the corrosive actions of microorganisms in the fresh water of the harbors. The search for a durable, non-corrosive, and rot-resistant solution was paramount.

Situated on the shores of the Duluth Superior Harbor, AMI Consulting Engineers faced firsthand the challenges posed by the harbor's aggressive conditions. Principal and Vice President of AMI Consulting Engineers, Chad Scott, notes, "The need for a solution beyond traditional materials became evident as we witnessed the abrasion and decay on conventional wood piling and severe corrosion on steel piling each year." Determined to find an answer, AMI partnered with Bedford Technology (now Tangent Technologies) to explore a groundbreaking solution: fiberglass-reinforced HDPE plastic piles.

THE HDPE PLASTIC PILE TEST

November 2015, AMI installed a 45-foot length 16SP16F14 SeaPile, designed and manufactured by Tangent Technologies, just offshore of AMI's harbor side office. Within the first month of installation, the pile was put to the test as it resisted the movement of large ice sheets pushed by high winds and late season ocean and lake vessels. After each ice sheet season, the pile demonstrated impressive resilience by returning to its original position.

DURABILITY OVER EIGHT YEARS

Since installation, the HDPE plastic pile has endured eight years of diverse challenges in the Duluth Superior Harbor. Each cycle has seen fluctuating water levels and winters with varying thicknesses of ice sheets. Throughout these extreme conditions, the HDPE pile's durability has been showcased. Tangent's commitment to providing durable and sustainable marine solutions was thoroughly tested during this 8-year trial.



Figure 1: Test Pile Installation November 2015

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DATA AND SURVEY EVIDENCE

AMI Engineers collected data and survey evidence to support the HDPE plastic pile's durability claims over 8 years. Key observations include a consistent vertical angle measurement, no increase or decrease in the top elevation (no ice jacking) and center of pile permanent deformation of less than 0.23 inches over the test period. A small taper at the top of the pile was a result of the pile driving process which caused the pile to mushroom slightly under the pile driving pressure, and did not detract from the pile's near-vertical alignment, showcasing its resilience. Additionally, no measured variation in circumference was noted from ice or vessel abrasion. The overall findings collectively underscore the HDPE plastic pile's robustness and its ability to maintain structural integrity under the demanding conditions experienced in the harbor.

COMPARISON WITH STEEL AND WOOD PILING

Since 1998, AMI has observed and monitored freshwater steel corrosion in the Duluth-Superior Harbor, highlighting the susceptibility of conventional steel pilings to microbial-induced corrosion in a freshwater environment. A significant benefit of HDPE plastic piles is that they do not corrode or rot, making them an ideal solution to combat the destructive effects of the harbor's microorganisms.

While steel piles might appear more economical initially, their susceptibility to accelerated corrosion can lead to increased maintenance and eventual replacement in challenging environments like the Duluth-Superior Harbor. To combat steel corrosion, additional treatments such as coatings or pile wraps are required for protection. In contrast, HDPE plastic piles, with their notable durability and reduced maintenance requirements, present a compelling long-term value proposition for marine structures, including residential, commercial, and lighter-duty industrial port environments.

Wood pilings in harbor environments commonly decay due to microbiological action, rot, and erosion from ice forces. HDPE piles are carefully engineered with pultruded rebar and reinforcing structural fibers throughout the cross-section, ensuring exceptional strength and durability against ice abrasion.



Figure 2: Test Pile Resisting Ice Movement in Dec. 2015



Figure 3: Final Measurement July 2023

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Additionally, the material incorporates UV stabilizers that protect the color and integrity of the base resin, reducing the need for recurring maintenance—unlike wood and wood-based composite products. Furthermore, due to the density and smooth nature of HDPE, there is less adhesion from ice compared to timber and steel, resulting in less uplift on the piling from ice forces..

FUTURE APPLICATIONS AND RECOMMENDATIONS

AMI Consulting Engineers and Tangent Technologies are thrilled with the 8-year performance test results for the HDPE plastic pile in the Duluth Superior Harbor's hostile environment. The case study provides a compelling rationale for considering HDPE plastic pilings in future marine construction projects. The durability, resistance to corrosion and rot, and ability to withstand ice movements make HDPE reinforced plastic piles an attractive choice for environments facing similar challenges.

CONCLUSION

AMI Consulting Engineers and Tangent Technologies faced a tough challenge with the full-scale test in the Duluth Superior harbor. The result? The HDPE plastic piles didn't just survive; they outperformed conventional timber materials and provided a real alternative to steel piling in the right design conditions. Even after eight years, the HDPE plastic piles' durability, resilience, and overall effectiveness make them a promising alternative to conventional materials in marine construction projects facing challenging conditions, such as severe ice and accelerated corrosion present in the Duluth Superior harbor. As we look to the future of marine engineering, it's clear that innovations like this can pave the way for products that are safer, environmentally friendly and provide better reliance and sustainability.



Figure 4: Test Pile in July 2023

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