CASE STUDY | Bending Tests of Repaired Marine Timber Piles

» Introduction

Marine timber piles are susceptible to damage hwhile in service. Conventional repairs involve a fiberglass jacket that is filled with steel reinforced cementitious grout. Since normal reinforcing steel is often used, adequate cover of the steel bars must be maintained. This results in a large gap between the fiberglass jacket and pile resulting in a significant volume of grout needed to fill the void. Consequently, there is a significant increase in the dead load that the pile is subjected to. In an effort to reduce the additional dead load, alternate reinforcing and grout schemes were investigated.

» Test Specimens

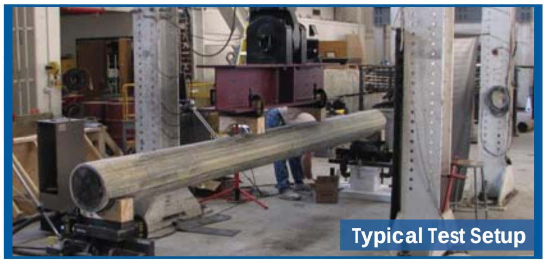
View of Tapered Piles Prior to Repair

Six timber piles were used in the test program as summarized in Table 1. All piles were 16' long, approximately 8" diameter, and of treated southern pine. To simulate marine damage, five of the piles had an hourglass-shaped taper cut into them at mid-span (four of the tapered piles are shown above prior to repair). One pile (Pile #0) was used as the line base specimen and was undamaged.

Three different repair methods were evaluated using a fiberglass jacket with the five tapered piles. Pile #1 and #2 used SS 550 epoxy grout with either one or two layers of C-GRID® 450 (carbon fiber) reinforcing. Pile #3 and #4 used SeaShield 510 cementitious grout with either one or two layers of the C-GRID® 450 reinforcing. The outside diameter of the repaired Pile #1 through #4 was approximately 12". Pile #5 simulated a conventional repair using reinforcing steel for both the longitudinal bars (#4) and hoops (#3). Due to cover requirements for the reinforcing steel, the diameter of Pile #5 was 15" in diameter.

» Test Setup

Independently Tested By: The Dept. of Civil Enginnering at Texas A&M



Typical Test Setup

The six pile specimens were tested in bending using a four-point bending setup (simply supported with two equal loads equally spaced from the mid-span). Rocker bearings were used at the supports to allow rotation of the ends of the specimens during loading. The span length for each pile specimen was 15', measured from center to center of the support bearings.

A single 220,000 lbs. capacity actuator was used to apply the load. While the capacity of this actuator exceeded the expected max bending capacity of the pile specimens, it provided a max stroke of 30" The actuator was operated with a MTS FlexSystem-60 controller. The actuator was operated under load-control with a constant load rate of 250 lbs. per second. A spreader beam was used to evenly apply the load to the specimens, four feet apart. Wooden support saddles, made up three 2 x 8 dimension lumber, were used at the supports and the load points. This gave a bearing length of 4½" The saddles had cut-outs that matched the radii of the pile specimens. Neoprene pads, ¼" thick, were used between the saddles and pile specimens

Company Overview

Denso North America Inc. is a subsidiary of Winn & Coales International, a leading manufacturer of anti-corrosion coatings & tapes and a full line of marine pile protection systems. Winn & Coales was originally established as a business in London, England, in 1883, and the first petrolatum tape manufactured in the UK was Denso tape, manufactured under license by Winn & Coales (Denso) Limited. Denso tape was developed over 90 years ago for the "Long Life Protection" of buried steel pipelines against corrosion. The Denso SeaShield Marine Systems include fiberglass forms, epoxy grouts, underwater epoxies, injectable epoxies, petrolatum tape wrap systems and much more.

Summary of Pile Specimens

TABLE 1

Pile 0	Base Line Pile
Pile 1	2 Layers of C-Grid 450 & SeaShield 550 Epoxy Grout
Pile 2	1 Layer of C-Grid 450 & SeaShield 550 Epoxy Grout
Pile 3	2 Layers of C-Grid 450 & SeaShield 510 UW Cementitious Grout
Pile 4	1 Layer of C-Grid 450 & SeaShield 510 UW Cementitious Grout
Pile 5	#4 Rebar on Verticals & #3 on Hoops & SeaShield 510 UW Cementitious Grout

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» INSTRUMENTATION


Close-up of Actuator


Showing Load Points & String Pots

The displacement of the actuator was measured using the actuator's built-in linear voltage displacement transducer (LVDT). However, this over-estimated the mid-span deflection of the specimens due to the flexibility at the supports and the load points. Therefore, linear string pots, located at the end supports and at mid-span, were used to provide a more accurate measure of the mid-span deflection. The average of the end deflections was subtracted from the mid-span deflection, as measured by the string pots.

» RESULTS

Pile #2 at Failure

The results of the six pile bending tests are summarized in Graph 1 & 2. In general, all repaired piles exceeded the bending strength of the baseline pile (Pile #0) by at least double the maximum load achieved by the baseline pile (9,050 pounds). Above left image provides a view of Pipe #2 at failure.

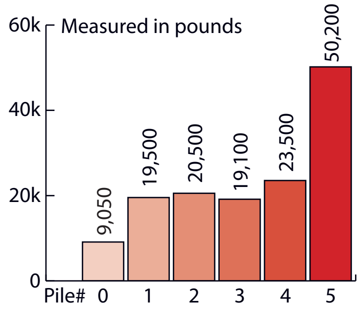
Denso's SeaShield Series 400 System more than doubles the strength of the original timber piles. Contact your Denso representative to request a complete copy of the report.

SeaShield Series 400

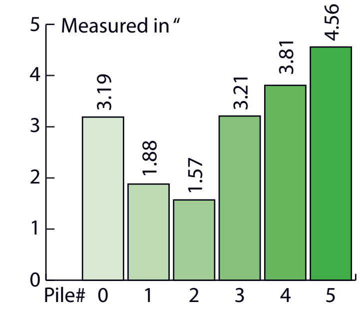
Doubles the maximum load for timber piles

BENDING TEST RESULTS

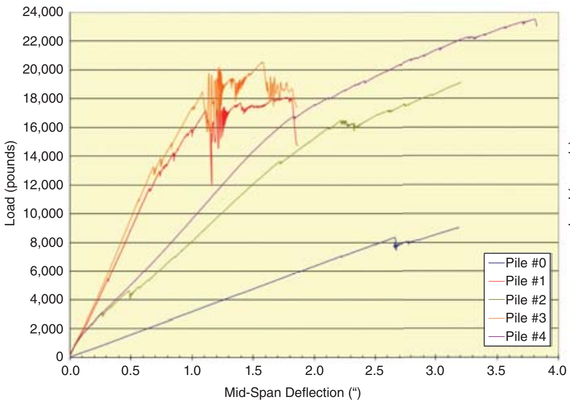
Maximum Load
GRAPH 1

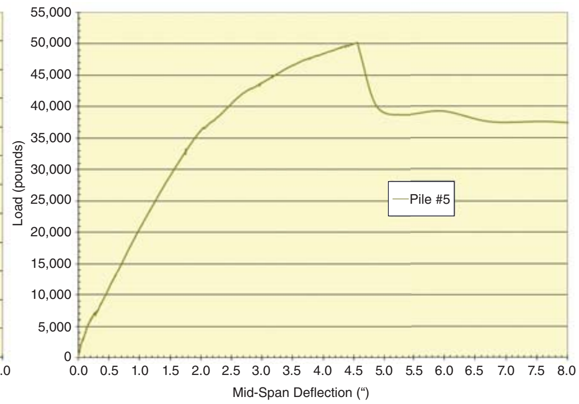


Mid-Span Deflection at Max Load
GRAPH 2



PLOT OF LOAD VERSUS DEFLECTION





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