TECHNICAL MEMORANDUM

Response to Goldenrod Blue Report on Brooklyn Bridge Park Preventative Maintenance Plan

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Goldenrod Blue (GB), a ship and equipment design company based in Ohio, has developed a memo with technical and program review comments on the CH2M report "Brooklyn Bridge Park Preventative Maintenance Plan" dated November 2015. The purpose of the CH2M report was to present the results of a study of two proposed maintenance approaches to Brooklyn Bridge Park's (BBP) waterfront structures and highlight the benefits of the preventative approach. The purpose of this technical memo is to address the comments from GB and allay any concerns brought up by their claims. This memo assumes the reader has an understanding of and access to the content of both reports.

This memo does not address the financial modeling comments in GB's report as this was undertaken separately by BBP. CH2M reported costs for each maintenance approach in 2015 dollars. This was per BBP's request so that their financial team may apply their own cost modeling to the outputs. GB points out that the two models as presented in the CH2M report do not consider the present value of money, however at the same time they ignore the fact that the presented models do not consider the escalation of construction costs, which has proven to be significant year over year. If this escalation had been considered in the models, the savings of the preventative maintenance option would be even greater than what is shown.

Two major technical arguments are made in the GB report. The first is that there is a third, "Phased Preventative Maintenance" option that is not considered in the CH2M report and that this option is in fact, the best. The second technical argument against the CH2M report is that the deterioration model used for the repair projections is flawed. These two arguments are addressed in the following sections.

Phased Installation

Goldenrod Blue asserts that a phased installation to preventative maintenance is a third choice that is technically superior and the lowest cost option for BBP. This claim is based on the idea that the cited case studies of epoxy encasement installations also used a phased installation approach - specifically referring to the use of these epoxy encasements on the Lake Pontchartrain Causeway. The Lake Pontchartrain Causeway was included in the CH2M report as a case study to demonstrate that epoxy encasements are not a new technology and that this type of system has been successfully in use for nearly 30 years. The parallels between that project and BBP end at the product. Lake Pontchartrain used epoxy encasements as a reactive repair to their concrete piles, and the phased approach for that reactive strategy is not comparable to a phased approach for preventative maintenance. Epoxy encasements were only installed on the concrete piles which exhibited cracks that were identified during regular maintenance inspections of the causeway. In order to prevent damage to the prestressing strands inside the piles, the epoxy encasements were installed to effectively seal these cracks.

As stated in the CH2M report, the driver for choosing the type of repairs for marine structures is typically driven by available funding. It is atypical that a public entity has the opportunity to install preventative epoxy repairs on the majority of its piles. These other entities are trapped in the reactive "catchup" mode where only reactive repairs are feasible, however they are installing epoxy encasements whenever they can. Epoxy encasement installation is time sensitive, while there is a possibility for BBP to phase the installations, for each year the program is delayed, there are cost tradeoffs, as the number of timber piles requiring structural repairs will increase due to continued deterioration of the piles from marine borers and rot.

The Brooklyn Bridge Park preventative maintenance program as it is currently proposed is a large scale installation. As presented in CH2M's report, the park wide preventative maintenance program at BBP would be at an advantage to receive lower unit costs due to the motivation of bidders to secure a large quantity of work, and also the repetitive nature of the installations. This significant savings from "buying in bulk" would likely be lost through a phased program. For the epoxy encasement projects that CH2M has worked on, which typically involves much smaller quantities than what is being proposed for BBP, the installed cost is nearly double what has been quoted for BBP during preliminary conversations with suppliers.

Deterioration Rates

At this time, there are no published, standardized deterioration rates for timber piles. Both the US Navy and the American Society of Civil Engineers (ASCE), often considered the authorities of this industry, are silent on this subject. ASCE's Waterfront Facilities Inspections and Assessment Manual, which was released in 2015, does not recommend any specific deterioration rates, however, does go on to state that remaining service life for timber structures may be estimated by combining sound engineering judgment with a good understanding of historical data and current conditions. This is not surprising given the fact that it is a combination of many site specific factors that lead to timber deterioration. For the CH2M lifecycle studies, the rate of timber deterioration was set at 0.0625 in. for the initial 6 years, 0.125 in. for the subsequent 6 years, and 0.250 in. for the remaining 38 years of the study. The reasoning behind the phased increased deterioration rate is described in detail on page 10 of the CH2M report. Also outlined in the report is that these numbers came from a combination of a site study and condition analysis of the piers, knowledge of the NY marine environment[1], and engineering judgment. The deterioration was advanced for each timber pile at Brooklyn Bridge Park, and structural capacity calculations were performed on each element to highlight which are in need of repair. So far, the model has been in use for 6 years, and it's projections for reactive based repairs (the current repair method at the park) have been very accurate.

The GB report includes an "alternative model" for deterioration that they developed. This seven page study of their own tables and calculations demonstrates creosote retention in the BBP timber piles. The study treats the presence of creosote and condition of the pier as if they are the same thing, and as the only factor in timber deterioration. In their analysis once the creosote has completely leached from the piles, the pier is considered "degraded".[2]* This approach is completely incorrect. As stated, there are several factors contributing to the deterioration of the piles - and more importantly, creosote loss does

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[1] In 2007, CH2M did a specific study on timber pile deterioration at Pier 88 in New York City. The deterioration rates of the piles in that study (based on actual measured pile diameters) averaged to 0.19in/year over the years 2000-2005. The levels of creosote retention and the age of the structure at that site were different, however it puts the deterioration rate adopted at BBP within the same order of magnitude. Pier 88 was built in 1935 and has been undergoing multiple rounds of rehabilitation, including the installation of epoxy grout encasements.

[2] It is unclear what "degraded" means exactly in the GB report. They state it is the "projected 2034 creosote loading value derived from the model for the pilings on Pier 3." It is unclear why they are using this year for the projection of the service life of Pier 3. In the CH2M preventative model, Pier 3 would receive preventative repairs on all piles in good condition, and reactive repairs on the remaining piles that are in poor condition until 2034. This year was chosen based on available finances, not because it is the end service life of the piles. In a reactive only model, Pier 3 would receive repairs from 2016-2058, with the highest number of repairs occurring in 2046.

not equate to timber section loss. Creosote is a preservative compound in the pile, its loss only opens the pile to greater risk of invasion by borers. As shown in Photo 1, which was included in the CH2M report, the creosote treated timber piles are already under attack from marine borers. It is noted that even if a pile were to be fully creosoted at the recommended level, it is still susceptible to a particular type of marine borer known as teredo due to inevitable imperfections or breaches in the creosote treatment. Teredo attacks the pile by burrowing into the timber pile surface at these points of weakness and begin eating the interior of the pile (which is not treated) while leaving the treated surface untouched. The creosote testing performed by Wood Advisory Services in 2010, and detailed in the CH2M report, demonstrated that all Piers have level of creosote below the 8.0 pcf threshold recommended by the American Wood Protection Association (AWPA) for the protection of piles. The only point correctly demonstrated by the GB study, is that the level of creosote in the timber piles will continue to decrease each year, below the already ineffective level of protection. This is in agreement with CH2M's assessment. This does not demonstrate the option to delay maintenance of these structures, whether preventative or structural.

Regardless of the creosote retention methodology presented in the GB report and the projected year of "pier degradation", which GB wrongly interprets to be equivalent to when the creosote reaches an assumed minimum threshold, it is clear from CH2M's inspection of the piers that the timber piles are already susceptible to marine borer attack at the current creosote levels.

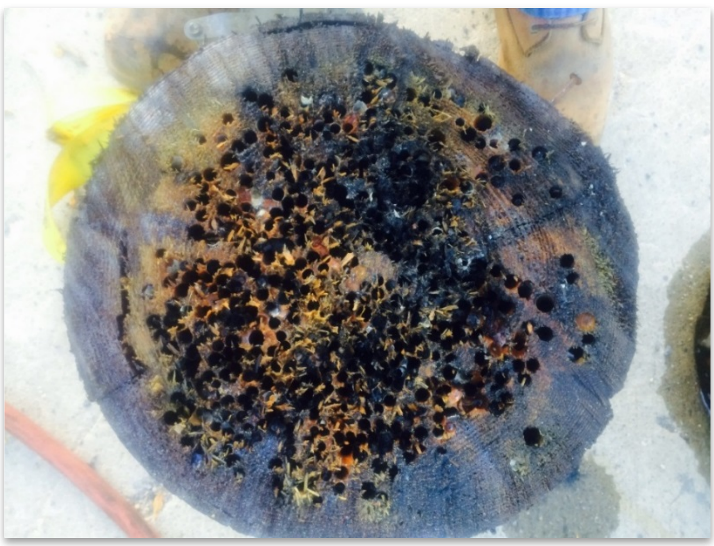

Photo 1
Marine Borer Attack on Pile at Pier 3

It is noted that GB claims there is an uncertainty in the year the BBP Piers were constructed. GB may not have access to the as-built drawings for these structures, however CH2M has a history at this project site for the past 20 years, even before it was purchased by BBP, and is intimately familiar with the piers' construction and history of repairs. The as-built drawings confirm that Pier 1 was stamped for construction in 1958, Pier 2 in 1957, Pier 3 in 1958, Pier 5 in 1962, and Pier 6 in 1959. It is understood that each pier would take approximately 2-3 years to be constructed. On this basis, an average year of construction of 1960 was used in the CH2M report for simplicity.

GB also questions whether the timber piles at BBP need repair at all, citing a source that claims the piles should have a useful life of over 100 years. When investigated, this source specifies that "fully embedded, treated" piles will last 100 years or longer. This is an important difference from the piles at BBP, which are neither full embedded nor adequately treated. Unlike piles used in upland applications where they are buried below ground, the timber piles supporting the piers at BBP are directly exposed to the marine environment, with lengths ranging from 5 ft to 30 ft. Furthermore, every single pile, extension, and underdeck portion of the piers at Brooklyn Bridge Park have been part of routine dive inspections performed by CH2M and are revisited approximately every three years. Prior to being transferred over to BBP, the piers were owned and operated by the Port Authority of New York and New Jersey, during which time CH2M was also responsible for numerous rounds of cyclical inspections. Each inspection has uncovered advanced deterioration, which is summarized into condition reports that are the basis for the reactive repairs outlined in the CH2M report. Many of the timber piles at BBP are already past their useful life and will need repair, whether preventative or reactive, to keep the piers in a state of good repair and remain open to the public.

GB's assertion that there is no technical reason to install epoxy grout encasements to protect the timber piles demonstrates GB's lack of understanding of marine structures and the deterioration mechanisms involved. The goal of the preventative maintenance program is to protect the timber piles from further deterioration, while at the same time being much less expensive than structural concrete repairs. Structural concrete encasements to the piles become necessary when the level of deterioration on the pile reaches a point where it can no longer support the intended load. Continuing to install structural encasements is certainly an option, and may be phased over several years or decades as part of a reactive maintenance strategy, however at the end of the day, the cost of encasing the pile in its entirety (as it continues to deteriorate) will far exceed the cost of encasing the entire pile now using epoxy as part of the proposed preventative maintenance approach.

In addition to the increased cost for the structural pile encasement, the total weight of the concrete encasement over the full length of pile will be significantly greater than the weight of an epoxy encasement. It is noted that the structural encasements that are currently being installed typically cover the top of the timber piles and are relatively short in length. Thus, the added weight from these encasements are not considered an issue at this time. However, should a reactive maintenance be adopted, structural encasements will continue to be installed in short segments until eventually the entire pile is fully encased in concrete. The added weight from these fully encased piles, particularly at the offshore end of the pier where the piles are 30 ft in length, will result in a reduction in the pier's load rating.

There are many technical reasons why the epoxy encasements are a wise investment for BBP and for the community. The only place where there is no technical reasoning is in GB's misinformed commentary.

CH2M has a 60 year history of providing planning, design and construction support services for waterfront, port and intermodal facilities worldwide with 400 in-house experts in maritime engineering, waterfront asset management, and construction support. CH2M applies this knowledge and expertise to each project to best assist our clients with their engineering challenges.