TECHNICAL SUMMARY

EFFECT OF INCIPIENT DECAY ON COMPRESSIVE STRENGTH AND STIFFNESS OF TIMBER PILES

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INTRODUCTION

Louisiana currently has over 4,000 timber bridges in its inventory of over 13,800 bridges. Many of these bridges are in excess of 40 years old and are showing signs of deterioration. One of the most common forms of deterioration is core decay of timber piling resulting in a hollow pile with a solid outer shell. This outer shell may be solid or broken up by vertical splits along the longitudinal axis of the pile. Pile deterioration may extend from a few feet up to the entire length of the pile. Bridge maintenance personnel must make judgements on a regular basis as to the remaining capacity of these hollowed/decayed piles.

The goal of this study was to develop guidelines for bench marking strength and stiffness properties of deteriorated in-service timber piles as a function of the age of the pile and the in-service environment. A concurrent research project undertaken to evaluate the load capacity of hollowed timber piles showed a significant reduction in the strength and stiffness of the undamaged portions of the piles. While it is well known that preservative treatment adversely affects the mechanical properties of timber piles, the level of reduction in these properties in the undamaged portion of the piles was significantly higher than expected.

There are two key factors that control strength properties of the seemingly undamaged section of a given pile in service. They are: (a) the amount of cellulose material in the wood; and (b) the quality of the resin bond between the wood fibers. Piles which appear to be undamaged can exhibit a significant loss in strength due to incipient damage occurring in these piles. This incipient damage is generally due to fungus infestation which is not obvious to the naked eye. If the infestation is widespread, the pile could suffer a loss of the cellulose material which can explain the decrease in the strength properties. Also, the leaching of the creosote into the interior of the piles can contribute to some loss in strength. This study was directed towards evaluating the effects of these damage factors on the strength of piles in service and developing guidelines for estimating the pile strength as a function of age and environment.

OBJECTIVES

The objectives of this research project were to:

1. Determine the compressive strength and stiffness properties of coupons taken from undamaged portions of piles.
2. Determine the level of loss of creosote and cellulose in the wood material by chemical analysis.
3. Determine the loss of lignin by chemical analysis and microscopic examination.
4. Develop guidelines for bench marking basic strength and stiffness properties as a function of age and in-service environment.

RESEARCH APPROACH

The Bridge Maintenance Division of DOTD supplied approximately 30 deteriorated timber piles up to 10 ft. (3 m) in length with a representative range of hollowness and splitting (checking). Small coupons were taken from each of the piles to determine the basic material properties. Chemical analyses were performed with samples taken across the width of the piles to determine the levels of creosote, lignin and holocellulose, and wood decay in the samples. The results obtained from the mechanical tests and chemical analysis were compared to determine if guidelines for bench marking basic strength and stiffness properties as a function of age and environment could be developed.

CONCLUSIONS AND RECOMMENDATIONS

The results of this study clearly show that the pile strength and stiffness are correlated to the compressive strength and stiffness, respectively, of coupons taken from the solid portion of the pile. If the average coupon failure compressive stress is known, the pile net failure compressive stress can be estimated as

$$f_n = 1.12\, f_n^c - 1976$$

where f_n = pile net failure compressive stress and f_n^c = coupon failure compressive stress.

Similarly, the modulus of elasticity of the pile can be estimated as

$$E_{pile} = 2.73E_{coupon} - 608{,}900$$

Several other parameters were investigated as to their effect on pile strength. First, the pile compressive strength was found to be independent of specific gravity. Second, the lignin level remained unchanged across the cross section of the pile (and was comparable to normal values of Southern pine), indicating that this parameter is not influenced by either the decay or the service life of the pile. Third, only slightly lower holocellulose content was found in the outer portions compared to the inner portions of the piles. Since the levels were near normal values, this criteria cannot be used to predict the mechanical properties of a deteriorated pile.

In summary, the only parameter studied that correlated well to pile strength was the compression strength of coupons taken from the pile. This conclusion suggests that a predictor of in-place pile strength must be based on a procedure that measures the basic strength of the material.

IMPLEMENTATION STATUS

The chemical composition of a damaged timber pile does not correlate to the strength or stiffness of the pile. However, strength of coupons taken from the pile correlate to overall pile strength. This study provides the scientific basis upon which to develop a methodology for determining the capacity of hollowed timber piles.