In House Research
NDOR Research Section

Rev. Date: 01/04/2009

Elastic Modulus Testing for SCC in Concrete Piling

Nebraska Department of Roads

Research Project:
Elastic Modulus Testing for SCC in Concrete piling

Location: In- House

Project Number: N/A

Starting Date: 10/15/08

Completion Date: 10/15/09

Principle Investigators:

Jordan Larsen
Bridge Foundation Engineer

Wally Heyen
PCC Engineer

Lieska Halsey
NDOR Research

P.C.C Laboratory:
Scott Grossenbacher
Highway Quality Assurance Manager

P.C.C Materials:
Tim Krason
Highway Quality Assurance Manager

Purpose of In-House Investigation: Nebraska Department of Roads has been testing piling with a Pile Driving Analyzer (PDA) for over 20 years. One of the material properties needed to properly test a pile is the Modulus of Elasticity (MOE). The modulus can be estimated fairly accurately in the initial stages of pile driving with the PDA but when the compared to the commonly empirical equation used for modulus the PDA estimate is much higher. The purpose of this research is to verify the results of the PDA and give the operator a closer initial value when estimating the modulus of elasticity in the field.

Objective of this Investigation:

- To determine the Elastic Modulus of the Self Consolidating Concrete mix used piling applications
- Determine if the time dependent strength gain and correlate to a time dependent modulus of elasticity gain.

Conducted in the Laboratory:

1. The laboratory testing was consisted of forty 4” by 8” concrete cylinders collected from a standard concrete mix used for piling operations.

2. Five time periods will be tested at 7, 28, 90, 180 days and 1 year. The overall testing will be composed of 6 cylinders. The testing will be conducted according to ASTM C 469 standard Method for static modulus of Elasticity and Passion’s Ratio of Concrete in Compression Specifications.

3. The results obtained would be compared to the formulas proposed on the NCHRP Report 496 Prestressed Losses in Pretensioned High Strength Concrete Bridge Girder and the NDOR-SPR P 310- Study on the “Application of Ultra-High Performance Concrete to Bridge Girders”. There are four basics formulas, which would be used and analyzed in this study, as follows:
    a. The first formula commonly used is based on the compressive strength and unit weight of the concrete (AASHTO Equation 5.4.2.4-1 and ACI-318 Equation 8.5.1)
    b. The second formula is based on a proposed change to the ACI committee 363 to the equation 8.5.1, which included factor found to estimate with accuracy the modulus of elasticity.
    c. The third formula uses empirical values to compensate the effect of aggregate in Modulus of elastic been used in Comite Euro-International du Beton-Federation Internacionale de la Precontrainte (CEB-FIP) Model code (7).
    d. The fourth formula uses a factor to estimate the modulus of elasticity.

   These formulas would be computed and compared with the results obtained from currently SCC concrete mix design used in piling operation.

Conclusion:

This testing has shown that the empirical equation consistently used in standard practices over predicts the laboratory measured MOE for the SCC pile mix. Table 1 represents the testing results for the evaluation of the measured modulus and the predicted modulus. The test results show the prediction method by Tadros being the closest to the measured modulus. However, the AASHTO Equation 5.4.2.4-1 and ACI-318 Equation 8.5.1 comes closed to predict the modulus independent of age of the concrete. In the study done by Tadros determined that the K_1 value referenced in AASHTO should be equal to 0.85. This is found to correlate to this study. Therefore, Materials and Research recommends the use of the K_1 of (0.85) factor in the commonly used formula by AASHTO Equation 5.4.2.4-1 and ACI-318 Equation 8.5.1to appropriate the estimation of MOE in NDOR girders. It is important to mention NDOR's mix design for Type I concrete piles is similar to those mix designs used in NDOR girders.

Table 1.

Modulus of Elasticity (Cylinders) ASTM C469 Plastic Concrete					
Description	Reading	Reading	Reading	Reading	Reading
Age (Days)	7	28	90	180	Year
Average Compressive Strength (psi)	6769	8383	9422	9987	10487
Measured Modulus (ksi)	**4112**	**4658**	**4638**	**4724**	**5055**
Predicted (AASHTO Equation 5.4.2.4-1 and ACI-318 Equation 8.5.1) 33000*(w^1.5)* (f'c^0.5) (ksi)	4653	5178	5489	5651	5791
Predicted (ACI committee 363) [(w/.145)^1.5]* (1000+1265*f'c^0.5) (ksi)	4212	4576	4792	4905	5002
Predicted (CEB-FIP) Model Code (7) 2790*(f'c/1.44)^(1/3) (ksi)	4674	5019	5218	5321	5408
Predicted (Tadros) 33000*0.85*(w^1.5)* (f'c^0.5) (ksi)	3955	4401	4666	4803	4922