RESEARCH NOTES

March 2008

Determine Methods to Control Heat of Hydration with Placement of Mass Concrete for Cast-In-Place Concrete piles

RESULTS: ***When placing concrete in large areas, excess heat generated while curing can reduce the performance of the final structure. Detrimental chemical reactions and cracking occur above 140-160 degrees Fahrenheit in concrete while curing. The research found by limiting the cement and flyash content in large piles temperature can be controlled. These limits will be incorporated into Caltrans new Standard Specifications.***

Background

Current standard special provisions on mass concrete placement for structural elements with dimensions in excess of 6 feet exclude cast-in-place concrete piling. This exclusion was decided when Caltrans Structure Design Substructure Committee and the Association of Drilled Shaft Contractors (ADSC) agreed the benefits in controlling heat of hydration for shaft concrete are offset by cooling tubes that obstruct concrete flow or may result in detrimental adjustments to an already good concrete mix design.

Temperature in mass concrete produces two potential long term issues: cracking and adverse chemical reaction of the cement paste. Cracking is not a significant issue because piles are under compression and the reinforcing steel is not exposed to corrosive environments. However, high temperatures may have adverse chemical consequences that affect pile performance long after construction is completed.

The research studied temperatures in mass concrete and acceptable ways to keep these temperatures low enough to ensure proper chemical reactions and reduce the severity of potential cracking.

Why We Pursued This Research

The need to address mass concrete temperature issues for the Noyo River Bridge and various Toll bridges led to the development of new specifications. After discussions with contractors and Caltrans Substructure Committee, some requirements in these specifications may be excessive for large diameter piles. Therefore a research project was initiated to accurately look into mass concrete temperature issues in piles.

What We Did

A contract was initiated with San Jose State University to research mass concrete and compare the results with current Caltrans methods in controlling temperature. The research tested five varying diameter concrete piles each with 14 concrete mixes and with different amount of flyash in a Q-Drum test. Then with the help of ABAQUS, a finite element analysis software and ACI (American Concrete Institute) 207 Schmidt model, mapping the internal temperature profile was achieved as shown in figure 1.

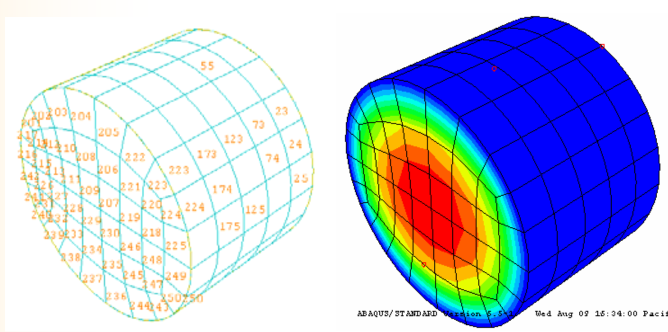

Figure 1: Heat profile from Q-Drum Test

Research Results

The research shows that the ABAQUS model correlates to experimental results and yields better temperature profile predictions than Schmidt model. Although the Schmidt model was faster to run, Schmidt overestimates the peak temperature. By using the results from the ABAQUS model, a specification can be recommended that will result in acceptable concrete for large CIDH piles in the range of 6 to 14 feet in diameter.

Recommendations

All large diameter piles should have cement and flyash content according to the table below. This should be incorporated into the next Caltrans Standard Specification.

			Initial temp 75˚ F			
Pile Size	Cement Content		degrees F	degrees F	degrees F	degrees F
14 ft diameter	cm kg/m3	lb/cy	15% flyash	25% flyash	35% flyash	50% flyash
	300	506	126	118	115	112
	350	591	138	127	121	115
	400	675	146	137	133	118
	projected 425	717	151	142	138	123
	projected 450	760	156	147	143	128
	projected 475	802	161	152	148	133
12 ft diameter	300	506	122	116	112	109
	350	591	133	124	119	112
	400	675	141	134	129	116
	projected 425	717	146	139	134	121
	projected 450	760	151	144	139	126
	projected 475	802	156	149	144	131
10 ft diameter	300	506	118	112	109	105
	350	591	128	120	115	109
	400	675	136	129	124	112
	projected 450	760	146	139	134	122
	projected 475	802	151	144	139	127
8 ft diameter	300	506	113	108	105	102
	350	591	118	115	110	104
	400	675	129	122	118	108
	projected 450	760	139	132	128	118
	projected 475	802	144	137	133	123
6 ft diameter	300	506	107	103	101	98
	350	591	111	108	104	99
	400	675	120	114	111	103
	projected 450	760	130	124	121	113
	projected 475	802	135	129	126	118

References:

Akthem Al-Manaseer, Najah Elias; "The Effects of Heat of Hydration of Mass Concrete for Cast-in-Place Concrete Piles", Final Report, June 30, 2007.

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