NORTHERN CONSULTANTS

Memorandum

Date: October 5, 2006

Re: Assessment of candidate Michigan Aggregate

Attached for your review is the report detailing the analysis of candidate fine and coarse aggregate specimens provided by William Pfeiffer Associates.

If you have any questions please contact me via email at xxx@umich.edu.

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NORTHERN CONSULTANTS

Assessment of candidate
Michigan Aggregate

Final Report

October 5, 2006

Prepared for

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Summary

The current supplier of aggregate to William Pfieffer Associates is no longer available, and a reliable alternative aggregate supplier must be established. Northern Consultants was asked to provide technical assistance, assessing the quality of aggregate provided by new candidate suppliers. The specific gravity and absorption capacity of both fine and coarse aggregates were determined, as well as the respective gradations of the provided specimens. The volume of aggregate was determined using the volumetric method. The gradations of the fine and coarse aggregate specimens were determined through sieve analysis. The candidate coarse aggregate was found to be unsuitable for application in concrete work in Michigan due to its uneven distribution of grade. 97% of the aggregate remained on the 12.5mm sieve which significantly exceeds limits described by both MDOT and ASTM. The fineness modulus of the coarse aggregate is also substandard at a value of 6.11. However, the candidate fine aggregate meets the grade specifications of both MDOT and ASTM, meeting standards for all sieve sizes. The fineness modulus for the fine aggregate is also acceptable, falling well within the accepted range with a value of 2.51. It is in my professional opinion that the candidate fine aggregate be accepted for use in concrete construction projects in Michigan. The candidate coarse aggregate should be rejected, either to be tested again with more stringent laboratory standards or rejected all together, selecting coarse aggregate from a different source/supplier.

Introduction

On September 25, 2006 Frank Slate, Regional Manager of William Pfeiffer Associates notified Northern Consultants that his company's most reliable aggregate supplier could no longer supply their contractors with aggregate. Northern Consultants was sent aggregate specimens from candidate aggregate suppliers by William Pfieffer Associates and asked to perform analysis of the fine and coarse aggregate. Northern Consultants was also asked to provide recommendations for using these aggregates in the preparation of high quality, durable concrete. The coarse and fine aggregate samples were tested to determine their respective specific gravity and absorption capacity.

A 3 kg sample of wet coarse aggregate was dried to SSD state and weighed. Submerging the sample in water, the volume and specific gravity were determined. The sample was then oven dried over night and weighed the following day, for use in further calculation of its absorption capacity. A 500 mg sample of wet fine aggregate was collected and dried to SSD state using a handheld heating element. The dryness was tested periodically using the cone mold method, until the sample surface was dry to an acceptable degree. A pycnometer was used in conjunction with the volumetric method to determine the specific gravity of the fine aggregate sample. The pycnometer was then emptied into a bowl and the contents oven dried over night to remove all of the moisture from the fine aggregate. On the following day, the oven dried fine aggregate sample was weighed. The oven dried value was used to determine the absorption capacity of the fine aggregate. The grade of the samples was then analyzed using sieve analysis. Sieves were stacked in the order as described in tables 3 and 4 and the aggregate was introduced onto the top

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sieve. The sieve stacks were shaken in mechanical shakers for 5 minutes, after which time the aggregate that remained on each sieve was weighed individually and documented. The values from the sieve analysis were used to determine the gradation of the aggregate samples as well as their respective fineness modulus. The final step of analysis involved the calculation of the unit weight of the coarse aggregate. A cylindrical measure was used to calculate the unit weight (kg/m^3) of the coarse aggregate for both rodded and loose samples.

The laboratory team consisted of four members, each working together on each portion of the laboratory procedures. One member was responsible for collecting the samples and documenting the data. Two members handled the samples and performed the laboratory operations while the final member weighed the samples at each stage of the process and communicated the data to the recorder.

The purpose of this document is to inform you of my methods of laboratory analysis of the candidate supplier aggregate. Also provided are my findings from the analysis regarding the specific gravity, absorption capacity, grade and fineness, as well as my conclusions and recommendations for usage of the coarse and fine aggregate.

Methodology

The ASTM C127 and C128 procedures were followed to determine the density, specific gravity, and absorption capacity of the fine and coarse aggregate.

To determine the gradation of the candidate Michigan aggregate, dried fine and coarse samples were analyzed using the ASTM C136 method.

To determine the unit weight of the candidate Michigan coarse aggregate sample, the ASTM C29 procedure was followed.

Data Results & Analysis

Analysis

Shown in the tables below are the values calculated from data collected in the laboratory analysis of the candidate coarse and fine Michigan aggregate. Provided in tables 1 and 2 are the results of the analysis of the specific gravity and absorption capacity of the coarse and fine aggregate calculated from data obtained when following ASTM C127/C128 procedure specifications. The calculated respective specific gravities (S_G) of the coarse and fine aggregate lie within accepted ranges. The absorption capacity of the aggregate tends to be high for both the coarse and fine aggregate. These high calculated values can be attributed to errors in the lab. The process of drying the aggregate to a state of SSD allowed for a large range of interpretations as to what constituted SSD specifications. In order to determine a more accurate calculation of the absorption capacity, the analysis

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should be repeated, focusing on bringing the aggregate to an acceptable SSD state before proceeding with further analysis and calculations.

Tables 3 and 4 refer to the sieve analysis of the candidate Michigan aggregate. The coarse aggregate fails to meet MDOT and ASTM specifications for gradation due to its high yield value in the 12.5 mm sieve. The value of aggregate remaining on the 12.5 mm sieve is much higher than the acceptable range. Also, due to the uneven distribution of grade in the coarse aggregate, the fineness modulus is slightly below the standard acceptable range. A more appropriate FM_{coarse} would be 7.0. The fine aggregate meets standards described by both MDOT and ASTM. The cumulative percent of aggregate by weight that is passing through each sieve falls within the acceptable ranges at all values. Also, the fineness modulus for the candidate fine aggregate is within accepted standards, where $2.3 < 2.51 < 3.1$.

The results of the unit weight analysis of the coarse aggregate are shown in table 5. The weights of the rodded aggregate along with the respective unit weight are greater than those of the loose aggregate as expected.

Data

Table 1

Density of OD coarse agg. (g/cm^3)	2.667
Density of SSD coarse agg. (g/cm^3)	2.812
OD bulk S_G	2.674
SSD bulk S_G	2.819
Apparent S_G	3.129
Absorption (%)	5.44%

Table 2

Density of OD fine agg. (g/cm^3)	2.162
Density of SSD fine agg. (g/cm^3)	2.517
OD bulk S_G	2.168
SSD bulk S_G	2.523
Apparent S_G	3.362
Absorption (%)	16.4%*

*significant error

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Table 3

Sieve size	Weight Retained	% wt. Retained	Cum. % Retained	Cum.% Passing	MDOT Spec.	ASTM Spec.
25mm (1”)	0	0	0	100	90-100	95-100
19mm (3/4”)	0	0	0	100		
12.5mm (1/2”)	32.65	3.2	3.2	96.8	26-60	25-60
9.5mm (3/8”)	244.15	23.9	27.1	72.9		
4.75mm (#4)	624.15	61.3	88.4	11.6		0-10
2.36mm (#8)	42.36	4.2	92.6	7.4	0-7	0-5
Pan	42.05					
% error	3.3%					
FM (∑CR+400)/100			6.11			

Table 4

Sieve size	Weight Retained	% wt. Retained	Cum. % Retained	Cum.% Passing	MDOT Spec.	ASTM Spec.
4.75mm (#4)	.89	.18	.18	99.8	94-100	95-100
2.36mm (#8)	33.54	6.6	6.78	93.2	80-100	80-100
1.18mm (#16)	111.65	22.0	28.8	71.2	49-85	50-85
0.6mm (#30)	102.3	20.2	50.0	51.0	25-59	25-60
0.3mm (#50)	115.3	22.7	72.7	28.3	8-26	5-30
0.15mm (#100)	99.0	19.5	92.2	8.8	0-10	0-10
.075mm (#200)	34.73	6.8	99.0	2.0	0-3	
Pan	8.4					
% error	.27%					
FM (∑CR)/100			2.51			

Table 5

Weight of Rodded Aggregate (kg)	8.739
Weight of Loose Aggregate (kg)	7.559
Rodded Unit Weight (kg/m^3)	1572
Loose Unit Weight (kg/m^3)	1360

Conclusion & Recommendations

After conducting analysis of the coarse and fine aggregate samples from the candidate aggregate suppliers, conclusions can be made regarding the integrity of the sample aggregate. The coarse aggregate sample is not adequate for use in high quality, durable concrete as desired by your firm. The gradation of the coarse aggregate is not adequately distributed to provide even strength across a slab. The fineness modulus confirms the evidence, which is shown to be lower than accepted values. After analysis of the fine aggregate was conducted, it was shown to meet all of the standards set by both MDOT

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and ASTM, as well as having an acceptable fineness modulus. It is my recommendation that the fine aggregate be accepted for use in high quality durable concrete slab work in the state of Michigan, while the coarse aggregate should either be rejected for further analysis or rejected all together.

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