STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS DIVISION

INVESTIGATION OF STRUCTURAL LIGHTWEIGHT AGGREGATE CONCRETE CONTAINING "SOLITE" 3/4" COARSE AGGREGATE

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ABSTRACT

Tests were performed to determine the physical properties of "Solite" 3/4" structural lightweight aggregate and it's effect on concrete mixtures when used in combination with normal weight fine aggregate. Tests indicate the aggregate is of acceptable quality capable of producing compressive strengths in concrete up to and exceeding 6000 psi.

INTRODUCTION

This investigation was conducted for the purpose of obtaining information relative to the use of "Solite" structural lightweight aggregate in portland cement concrete. Tests were performed to determine the physical properties of "Solite" coarse aggregate (3/4" stone) and it's effect on concrete mixtures when used in combination with normal weight fine aggregate.

The American Concrete Institute has established the following definition of structural lightweight aggregate concrete:

> "Structural lightweight aggregate concretes are defined as concretes having a 28 day compressive strength in excess of 2500 psi. and a 28 day, air-dry unit weight not exceeding 115 pcf.

Coarse lightweight aggregates are defined as those which have a dry, loose weight not exceeding 55 pcf.

The materials included in this investigation are representative of those expected to be used in this area when structural lightweight aggregate concrete is specified. The information obtained may be helpful in determining it's possible future use as a bridge construction material.

MATERIALS

Following are listed the materials used in this investigation and their sources:

Coarse Aggregate: (See Table 1 for test data)
Solite 3/4" - #4
Hudson Valley Lightweight Aggregate Corp.
West New York, New Jersey

Fine Aggregate: (See Table 1 for test data)
Cooley Asphalt Paving Corp.
Plainfield, Vermont

Cement:
Type 1
Northeast Cement Company Inc.
Montreal East, Quebec

Air Entraining Admixture:
NVX
Hercules Powder Company
Wilmington, Delaware

Water Reducing Admixture:
WRDA
W.R. Grace & Co.
Cambridge, Massachusetts

TABLE 1

Sieve Size	3/4" Solite % Passing	Fine Aggregate % Passing
1"	100	
3/4"	97	
3/8"	31	
#4	2	100
#8	1	87
#16		68
#30		44
#50		15
#100		2 F.M. 2.78
Specific Gravity		
Bulk (Dry)	1.45	2.72
Bulk (SSD)	1.62	
Apparent	1.75	
Absorption		
24 hour	12 %	1.3%
20 minutes	5 %	
L.A. Abrasion		
T 96	24.6	
Weight per cubic foot		
Dry Loose	50.42	
Dry Rodded	53.38	

PROCEDURES

Mix proportions were established using data furnished by the lightweight aggregate producer as suggested in ACI 211 (Recommended Practice for Selecting Proportions for Structural Lightweight Concrete). Quantities of coarse and fine aggregate were varied to obtain the desired unit weight and yield. A cement content of 6 1/2 sacks/cubic yard was chosen for this investigation and two of the five batches contained a water reducing admixture.

A Lancaster open pan mixer was used to blend the concrete which was tested for slump, air content, unit weight, yield and compressive strength. The lightweight coarse aggregate was placed in the mixer with part of the mixing water and allowed to soak for 20 minutes prior to adding the remainder of the ingredients.

Air content was determined using both the Chace Air Indicator and Roll-A-Meter (Volumetric Method). Three methods were employed for determining unit weight; (a) AASHTO T 121 - Weight Per Cubic Foot, Yield, and Air Content (Gravimetric) of Concrete, (b) cylinders were weighed in a saturated surface dry condition prior to compression testing, and (c) ASTM C 567 - Method of Test for Unit Weight of Structural Lightweight Concrete, which was followed in obtaining the air-dry weight. Compressive strength specimens were tested at ages of 7, 14 and 28 days. The specimens used to determine air-dry unit weight (batches 3, 4 and 5) were placed in the curing room after their air-dry unit weight was determined. These cylinders were cured to an age of 230 days and then removed for compressive strength testing.

RESULTS

Following are listed the mix designs used and results of all tests performed:

Mix Number	1	2	3	4	5
Mix Design:					
Cement - lbs.	611	611	611	611	611
3/4" Stone (Dry) - lbs.	1000	880	880	880	880
Sand (Dry) - lbs.	1348	1321	1328	1328	1328
Total Water - lbs.	337	314	338	293	324
Air Entraining Admixture - oz/cy	1.4	1.6	1.3	0.8	0.8
Water Reducing Admixture - oz/cy				45.5	45.5
Total Batch Weight - lbs.	3296	3126	3157	3112	3143
Concrete Tests:					
Slump - Inches	2 3/4	2 1/4	3 3/4	1 1/4	2 1/2
Air Content - % (Chace)	5 1/2	5 1/2	6 1/4	6	7 1/2
Air Content - % (Roll-A-Meter)	8	8.2	9.2	9	9
Unit Weight pcf (Plastic)	116.48	116.66	113.97	118.34	112.65
(Cylinder)	119.58	120.58	118.48	122.16	116.95
(Air Dry)			114.68	119.17	114.51
Mix Yield - cu. ft.	28.3	26.8	27.7	26.3	27.9
Compressive Strength-PSI					
7 Days	3236	3590	2706	4403	3545
	3236	3590			
Average	3236	3590	2706	4403	3545
14 Days	3668	3926	3130	5234	3837
	3563	3802	3360	4633	3722
Average	3616	3864	3245	4934	3780
28 Days	3943	4527	3961	5341	4297
	3926	4615	3448	5022	4226
Average	3935	4571	3704	5187	4251
230 Days			4545	6755	5323
			4810	6066	5341
Average			4678	6411	5332

SUMMARY AND CONCLUSIONS

A. Tests performed on the structural lightweight aggregate indicate that grading, wear and dry, loose weight are within acceptable limits.

B. The lightweight concrete exhibited good workability within the range of slumps examined (1 1/4" - 3 3/4").

C. Air contents equaled or exceeded the maximum limits (4% - 8%) recommended by the American Concrete Institute when tested by the volumetric method. The poor comparison between air contents obtained with the Chace air indicator and the Roll-A-Meter (volumetric method) indicate the Chace air indicator may be unacceptable for measuring and controlling air content in lightweight concrete.

D. Three of the five batches of concrete examined were tested for air-dry unit weight. The results of these tests, when compared with other methods of determining unit weight, reveal that only two of the batches would be below the recommended 115 pcf air-dry unit weight. Also, if air contents were controlled within recommended limits the unit weights would show a corresponding increase.

E. The compressive strength of the mixes appeared to vary depending upon other properties of the concrete, ie. air content, slump, and unit weight. No attempt was made to establish a strength ceiling using structural lightweight aggregate in concrete, however, compressive strengths up to and exceeding 6000 psi appear to be attainable.

F. Laboratory tests of actual combinations of materials proposed for a specific job should be made to provide information for design and specification purposes. Rigid control is necessary to assure consistent production of lightweight concrete possessing the desired qualities.