Date: August 2013

Aggregate Class Evaluation for BX Concrete

Nebraska Department of Roads

Research Project: Aggregate Class Evaluation for BX Concrete

Location: Potter-Brownson Project District 5

Starting Date: August 2013

Completion Date: September 2013

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BACKGROUND OF THE IN-HOUSE INVESTIGATION:

Nebraska Department of Roads (Material and Research) started an experimental field trial on the aggregate class for BX concrete shoulder mix pavement using Class B and Class C aggregates. This investigation covers a brief analysis of NDOR specified limits for Class B and Class C on gradations. The analysis was based depending on which side (fine or course) the gradations were running in relation to the specified limits; the combinations of Sand and Gravel (Class B and C) were evaluated as sandy gradation.

The field pavement test section was on the project Potter to Brownson on I-80 in District 5. The project shoulder mix design was BX Concrete using a Class C aggregate. Approximately 100 feet, on the westbound shoulder, Class B Aggregate was used for the purpose of this evaluation for the comparison of Class C aggregate for BX Concrete.

DESCRIPTION OF THE INVESTIGATION (TASKS):

I. Summarize aggregate gradations performed.
II. Evaluate mechanical and permeability properties of the mix design using Class B and Class C aggregate.
III. Identify site construction practices for placement using these classes of aggregates.
IV. Identify lessons learned during placement.
V. Identify the most feasible class of aggregate for this type of application.

SUMMARY OF INVESTIGATION BY TASKS

TASK I&II- Evaluation

The cylinders were made in the field and were brought to the central laboratory in Lincoln. The fabrication and curing of all cylinders was conducted according to specifications ASTM C39. All the mechanical properties were in accordance to ASTM C 78- Flexure strength, ASTM C 469- Modulus of Elasticity and permeability in accordance to AASTHO TXXX-08. The BX concrete mix was within the specified limits for Class B and Class C aggregates. The description of the proportioned mix designs and test results are shown in Table 1.

Table 1. Description of Proportioned Mix Designs, Mechanical and Permeability Test Results

Performed	Proportioned Mix Designs	W/CM Ratio	Slump (in)	7-Day Compressive Strength (psi)	28-day Compressive Strength (psi)	28-day Flexure Strength (psi)	Permeability (SR) Kohm-cm	Modulus of Elasticity Measured @ 28 days (Ksi)
NDOR's Req.		Max 0.48	-	Min. 3000 psi @ 28 days Results 3 specimens averaged		-	-	-
August 2013	30% Class F Aggregate 70% Class B Fine Aggregate	0.45	1/2	4070	4660	560 Results 9 specimens averaged	High	4.6
August 2013	30% Class F Aggregate 70% Class C Fine Aggregate	0.45	1 1/4	3920	5660	560 Results 11 specimens averaged	Moderate	4.1

The field testing performance have shown good correlation concrete mechanical properties of compressive and flexure strengths. However, it was observed that the permeability was from moderate to high, unlike Nebraska's common mix design ranging with low permeability. A low permeability will help keep the salt and deicers from penetrating the concrete surface.

For each aggregate tested, Test Method NDR T 27 Sieve Analysis was performed at the Aggregate Laboratory in Lincoln. The gradation of a particular mix design was determined by a sieve analysis and check according to their specification aggregate range. In a sieve analysis, a sample of dry aggregate of known weight is separated through a series of sieves with progressively smaller openings. Once separated, the weight of particles retained on each sieve was measured and compared to the total sample weight as shown in Figure 1.

Figure 1. Weighing of Particles Retained on Each Sieve

The gradations are checked within the class of aggregate specification range for the maximum and minimum limits of the cumulative percent passing of each sieve sizes. Table 2 and 3 shows the gradations from project sample performed on the BX concrete mix using Class B & Class C Aggregate. When looking at the gradation, it is clear that the Class B aggregate gradation is finer than the Class C aggregate gradation.

Table 2. Class B Aggregate 100% 47B Fine

		Percentage	Percent Passing									
			1 ½"	1"	¾"	½"	3/8	No.4	No.10	No.20	No.30	No.200
AGGREGATE SPECIFICATION RANGE	Class B	Max	--	100	--	--	--	97	70	--	40	3
		Project Sample			--	--	--	91	65	--	26	0.7
		Min	--		--	--	--	77	50	--	16	0

Table 3. Class C Aggregate 100% 47B Fine

		Percentage	Percent Passing									
			1 ½"	1"	¾"	½"	3/8	No.4	No.10	No.20	No.30	No.200
AGGREGATE SPECIFICATION RANGE	Class C	Max	--	100	--	--	--	88	50	--	20	3
		Project Sample			--	--	--	71	46	--	18	0.4
		Min	--		--	--	--	44	24	--	4	0

TASK III & IV- Evaluation

This part of the evaluation was intended to observe the field application on the mix design performance during placing.
Field Observations: During placement while using Class B aggregate, it was observed there was an abundance of entrapped air that was rising to the surface of the concrete, Figure 2 and 3. But when using the Class C aggregate, there was a dramatic reduction in entrapped air rising to the surface, Figure 4. It was discovered the finer gradation in the Class B aggregate produces more entrapped air the Class C aggregate.

Figure 2. Placement of BX Concrete with Class B Aggregate

Figure 3. BX Concrete Placement Characteristic with Class B Aggregate

Figure 4. BX Concrete Placement Characteristic with Class C Aggregate

During the placement of these two mixes it was observed that the air content measured by the pressure meter in accordance to ASTM C 231 was not capturing the "True" air content of the concrete placed with the slipform paver. Table 4 shows hardened air count test results from extracted cores from the same locations of pressure meter measurements.

Table 4. Hardened Air Count Results

Performed	Proportioned Mix Designs	Pressure Meter Field Air Measured		Hardened Air Count	
		Front of Spreader	behind the Paver	Entrained	Entrapped
NDOR's Req.		7.5-10 %	NA	-	
August2013	30% Class F Aggregate 70% Class B Fine Aggregate	8.5%	8.5%	10.9%	2.6%
August2013	30% Class F Aggregate 70% Class C Fine Aggregate	9.5%	6.5%	8.9%	4.8%

Figure 5. Core Visual Observation with Class B Fine Aggregate

The hardened air count test results clearly show that there is no correlation found in the fresh concrete air content. The results of the Pressure Meter air content is lower than the air content measured in the hardened air in the tested cores.

In 2004, the final air investigation had shown a total air loss of 2% through the paver. In 2007, NDOR introduced a change for a higher air specification for all classes of concrete. In fact, there was a followed up investigation to verify the performance of the new specification. The intent of the investigation was to check and to verify how the plastic total air (Pressure Meter) in the field compares with the hardened total air. The followed up investigation checked the total hardened air to confirm the distribution of how well dispersed entrained air voids are for the best freeze/thaw durability protection. The followed up investigation of hardened air showed an increase in entrapped air voids; however, this is not surprise for a typical Nebraska's mix design. The amount of entrapped air in concrete was also a function of aggregate size gradation (especially a fine aggregate gradation). Research has shown that entrapped air usually comprises of 1 to 2 percent of the concrete volume, but in some cases can be comprised as much as 3 or 4 percent. Nevertheless, the results obtained during the verification of the new specification showed that NDOR was getting the adequate entrained air for concrete pavements, which improves the resistance to freeze/thaw when exposed to water and deicing chemicals. Today's new generation of synthetic based air admixtures (alphaolefin) will produce a small well defined and well-spaced air bubbles. It is clear that today's air admixtures produced a finer air bubble that is less affected by slipform vibrators, as shown in Table 4. This phenomenon will be investigated by an In-house research title "Evaluation of Final Air Count during Paving Operations".

TASK V - Identify the most feasible gradation:

- The compressive strength was found to be lower while using Class B aggregate in the BX Concrete due to the increase in fines.
- When using Class B Aggregate, the amount of entrapped air in the mix is significantly higher during the paving operation. As well as, the permeability results were very high versus the moderate permeability of the Class C aggregate, which is a concern for future durability since deicers are being used.

Based on the results to date, NDOR- Material and Research Division will recommend maintaining the Class C aggregate gradation for BX Concrete. This mix design with Class C aggregate has a good mechanical and permeability properties performance in the field. This evaluation has identified the need to evaluate the total final air during paving operations due to the new generation of synthetic air admixtures.

Materials and Research would like to thank Nebraska Department of Roads, District 5 and Bross Construction. Co./C.B Equipment for their assistance during this field evaluation.