



Optimized Aggregates Gradations for Portland Cement Concrete Mix Designs Evaluation

Nebraska Department of Roads

Research Project: Optimized Aggregates Gradations for Portland Cement Concrete Mix Designs Evaluation

Location: Ready Mix Plant (Gothenburg, NE- Kimball, NE and Grand Island, NE)

Project Number: R-2008

Starting Date: May 2008

Completion Date: to be determined

Principle Investigators:

Wally Heyen
PCC Engineer

Lieska Halsey
NDOR Research

Investigation Collaborators:

Robert Rea
Assistant M&R Engineer- Flexible Pavement Engineer

Mick Syslo
Pavement Design Engineer

PCC Laboratory:

Tim Krason
Highway Quality Assurance Manager

Tom Gernert
Highway Mat. & Test Technician III

Jeremy Weigel
Highway Mat. & Test Technician II

Debra Swanson
Highway Mat. & Test Technician II

Aggregate Laboratory:

Jim Beason
Highway Quality Assurance Manager

Purpose of the Research Project:

The Nebraska Department of Roads began to explore various blended aggregate gradations for the Nebraska 47B concrete in January 2008. The purpose of this is to optimize aggregate blends utilizing more locally available materials. These blends are being evaluated for mechanical and durability characteristics for paving mix designs. The outcome of these evaluations should result in the introduction of a new blend aggregate grading band 47B Revised (47BR), which would allow the use of more locally available materials currently being produced in the state, thereby optimizing its economy.

Scope of this Project:

- To determine the effect of blending locally available materials and determine the potential benefits resulting from using optimized gradation in concrete mixes.
- To ensure workability and constructability so that the mixes can be easily used in engineering applications.
- To evaluate concrete mixes for mechanical properties and durability characteristics that is compatible with NDOR requirements for good performance mix design.

Plan of Action in the field and Laboratory:

In order to assess the performance and effects of an optimized gradation, ready mix field trials were proposed to analyze the effects on constructability, strength, segregation, and required water and air entraining agent dosage. NDOR, Paulsen Construction Concrete Company, Inc, Lyman-Richey Corporation and Hooker, Bros Sand & Gravel worked together on these ready mix field trials providing their available ready to use aggregate.



Field and Laboratory Testing: In order to analyze what type of guidelines NDOR would need to set on the proportioning and optimization of aggregates, five concrete mixes were proportioned or analyzed using different aggregates currently produced in the western and central part of the state. The plan of action in the field is described as follows:

Plan of Action in the Field (Ready Mix Plant) and Laboratory by Tasks:

Conducted in the Field-Sampling & Testing

1. Slump Test by method (ASTM C 143)
3. Checked Air by the pressure method (ASTM C 231)

Conducted in the Laboratory:

1. Standard Test Method for Microscopic Determination Parameters of The Air Void System in Hardened Concrete by the Linear Traverse Method B (ASTM C457-90)
2. ASTM C 1567 Alkali Silica Reaction (ASR)
3. ASTM C 1202 Permeability
4. ASTM C 666 Freeze & Thaw Durability
5. Mechanical Properties:
 - i. ASTM C39 Compressive Strength
 - ii. ASTM C293 Flexural Strength



Coarser Sand- Western, Nebraska

Test results for the testing conducted in the field and laboratory testing for the five trials mixes in the ready mix plants at the locations of Gothenburg, NE Kimball, NE and Grand Island, NE are presented in Table 1.

Table 1-Description of Proportioned Mix Designs and Test Results

Performed	*Proportioned Mix Designs	W/CM ratio	14 Days Compressive Strength (psi)	28 days Compressive Strength (PSI)	28 days Flexure Strength (PSI)	84 days Flexure Strength (PSI)	Freeze & Thaw (Percentage)	Total Air Count (Percentage)	ASTM C 1567
	NDOR's Req.	Max 0.48	3500 min.psi	3500 min.psi	Design 700 psi	Design 700 psi	Durability > 70% 300 cycles	7.5-10 %	28 Day % Expansion < 0.13%
6--4-08	30% Coarse Gravel Gothenburg- 70% 47B Fine Paulsen Inc.	0.41	4060	5010	575	650	88%	10.5%	0.06
10-7-08	40% Coarse Gravel Gothenburg- 60% 47B Fine Paulsen Inc	0.40	3500	3910	520	620	80%	13.5%	0.06
9-16-08	40% Coarse Gravel Crushed- 60% 47B Fine Lyman Rickey-Kimball (**)	0.35	3740	4300	450	470	71%	6.0%	0.07
9-16-08	70% 47M Coarse Gravel Crushed- 30% Coarse Gravel Crushed Lyman Rickey- Kimball (**)	0.37	3120	3730	470	520	76%	8.8%	0.07
12-02-08	45% Grand Island Coarse Gravel- 55% Grand Island Fine Hooker, Bros	0.36	4060	4460	580	640	81%	6.1%	0.05
NA	47B-Paving Blend Average Performance	NA	3500	5000	680	NA	71%	NA	NA

(*) All Proportioned Mix design followed NDOR specifications for concrete paving using IPF class of concrete.

(**) These two mixes were performed with a high slump, which was not a good mix for paving operation.

Project Results to Date:

Based on the field trial performance the results have helped NDOR to identify the combined aggregate gradations that would help improve the current mix design the Nebraska Department of Roads have had for the last 60 plus years. These initial efforts have dealt with the concept of maximum density with the idea of a denser gradation. A denser gradation helps to improve air entrainment for a better spacing factor, reduces entrapped air voids and can give less shrinkage due to fewer voids needed to be filled with cement paste. The 47B Revised (47BR) gradation band was developed from the analysis of the current 47B gradation band with the identification of the best combined gradation and its mechanical properties. Figure 1. represents the five blends plotted and compared with the current 47B gradation band. Four of the five gradation plotted were outside the 47B maximum and minimum tolerance. When analyzing the results, the flexure strength shown in Table 1. was the only property these trials mixes did not achieve the average values of 47B blend. With the development of the 47BR gradation band, which is showing in Figure 2, the mechanical properties will exhibit a better and closer performance due to the denser gradation. This new 47BR gradation band gives an opportunity that would allow the use of more locally available materials currently being produced in the state, thereby optimizing its economy. NDOR is currently planning on selecting a couple of projects for this year and the next construction season to evaluate the properties and performance of these blended aggregate gradations on a full scale project and investigate the saving potential for each individual project.

Figure 1. 47B Standard- All Gradations Combined

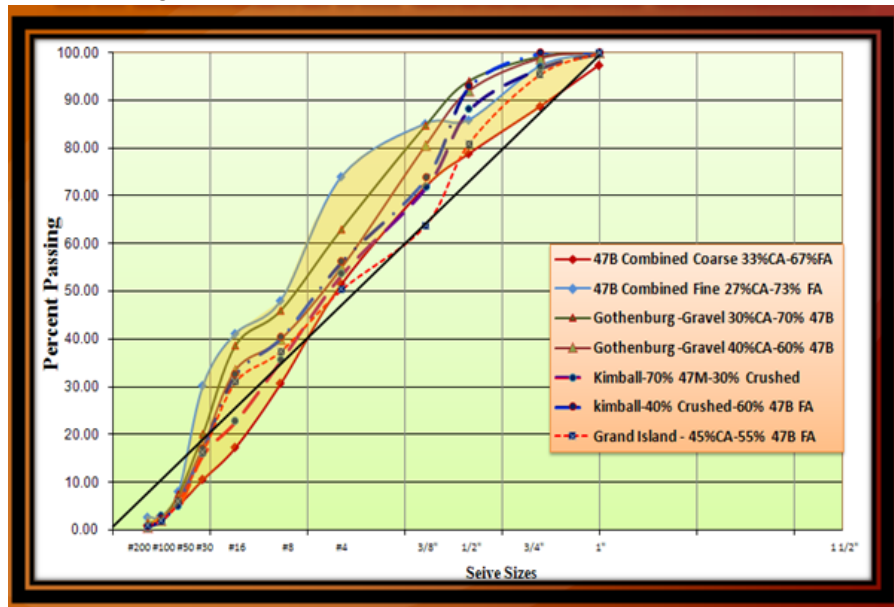


Figure 2. 47B Revised Gradation Band

