A Study of Fine Sand From Nine Mile Island At Dubuque

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INTRODUCTION

The specifications for concrete sand in Iowa have been used for many years with very good results. In several locations of the state, it is becoming more difficult to produce concrete sand consistently at a reasonable cost. Both ASTM and AASHTO have specifications for concrete sands that allow a finer, poorer graded sand than the Iowa specification. The ASTM and AASHTO specifications are based on the use of trial mix testing prior to construction. Iowa does not currently use the trial mix procedure.

Changes in the gradation requirements for concrete sand in Iowa are shown in table 1. The specification published in the 1948 "Standard Specifications for Highway and Bridge Construction" were quite different from the previous specifications. The major changes were:

1. Limit the gradation so that not more than 40 percent shall pass one sieve and be retained on the sieve with the next higher number.

2. Increase the mortar cube strength ratio to 1.5.

3. Eliminate the option of designing special mixes using sand failing to meet cube strength or gradation requirements.

4. Adopt a #200 sieve requirement of 0 to 2.5% passing.

The changes since 1948 have been to reduce the percent passing the #200 sieve and open up the gradation requirements on the other sieves. Otherwise, little change has been made in the last forty years.

Table 1. Gradation Changes to Concrete Sand Specifications from 1924 to 1988

	Percent Passing					
	1924a	1930a	1937a	1948e	1960e	1977e
3/8"	100	100	100	100	100	100
#4	95-100	95-100	95-100	95-100	95-100	95-100
#8	85-100	80-100	80- 95	75- 95	75-100	70-100
#16						
#30	15-40	15-40	20-40	20-55		
#50						
#100	0-5	0-5	0-5			
#200				0-2.5	0.1.5	0-1.5
Mortar Strength Ratio c	1.0b	1.0d	1.0d	1.5f	1.5	1.5

a. Sand failing gradation may be used if mortar strength is adequate.

b. Sand with a mortar strength ratio of between 1.0 and 0.75 due to poor grading may be used provided that the cement is increased to meet minimum compressive strength on concrete made with the project aggregates.

c. The proportions and testing of mortar cubes changed in the 1940's.

d. Sand which fails mortar strength due to poor grading may be used in special mixtures designed by laboratory studies.

e. When fine aggregate is sieved through the following numbered sieves: 4, 8, 16, 30, 50 and 100, not more than 40 percent shall pass one sieve and be retained on the next higher number.

f. Sand which has shown satisfactory mortar strength may be accepted without further mortar strength tests so long as its fineness modulus is not less than that of the sand from that source which showed a satisfactory mortar strength minus 0.30.

OBJECTIVE

The objective of the study was to determine the feasibility of using a finer sand than is now allowed by Iowa D.O.T. specifications in portland cement concrete.

MATERIALS

The following materials were used in the study:

Cement: Type I, standard laboratory blend of eight portland cements available in Iowa (AC7-350).

Fly Ash: Ottumwa, Class C (ACF8-22).

Coarse Aggregate: Martin Marietta (Fort Dodge A94002) (AAC7-28).

Fine Aggregate:
1. Cordova, IL AIL502 (AAS7-0196)
2. Nine Mile Island, Dubuque A31502 (AAS8-0003)
3. Nine Mile Island, Dubuque A31502 (AAS8-0004).

Air Entraining Agent: Ad Aire, Single Strength, Carter Waters Corp.

PROCEDURE

Five mixes were made and tested as shown in Table 2. Mixes 1 through 3 are the standard C-4-C mix proportions. Mix 4 and 5 are mixes with 5 percent more cement and fly ash than mixes 1 through 3. Table 3 is the aggregate gradations for the mixes. The strength results are shown graphically in Figure 1 and 2.

TABLE 2 MIX RESULTS

Mix No.	Sand	Cement #/Yd.3	Fly Ash #/Yd.3	W/C + F.A.	Air Content %	Slump (In.)	Strength (PSI) Compressive 7 Day	Compressive 28 Day	Flexural 7 Day	Flexural 28 Day
1	Dubuque Fine	529	95	0.380	6.5	1.25	5050	6250	740	790
2	Dubuque Coarse	529	95	0.376	6.2	1.0	5570	6480	780	840
3	Cordova	529	95	0.372	6.5	1.25	5420	7060	790	880
4	Dubuque Fine	556	100	0.363	6.0	1.25	5370	6450	840	850
5	Dubuque Coarse	556	100	0.367	6.0	1.25	5500	6360	830	850

TABLE 3 AGGREGATE GRADATONS

(Percent Passing)

Sieve No.	Nine Mile Island Fine	Nine Mile Island Coarse	Cordova	Fort Dodge Coarse Aggr.
1"				100
3/4"				77
1/2"				40
3/8"	100	100	100	12
#4	99	94	99	0.5
#8	93	75	93	0.3
#16	81	60	79	
#30	58	47	44	
#50	12	18	8.5	
#100	0.6	2.3	1.0	
#200	0.3	0.8	0.2	
Fineness Modulus	2.56	3.04	2.75	
Mortar Strength Ratio	1.4	1.3	1.6	
	Combined Grading (Percent Passing)			
1"	100	100	100	
3/4"	88	88	88	
1/2"	70	70	70	
3/8"	56	56	56	
#4	50	47	50	
#8	47	38	47	
#16	41	30	40	
#30	29	24	22	
#50	6.2	9.2	4.4	
#100	0.4	1.3	0.6	
#200	0.3	0.6	0.2	
Fineness Modulus	4.82	5.06	4.92	
Specific Surface (Sq. Ft./Lb.)	14.9	14.2	13.4	

FIGURE 1. COMPRESSIVE STRENTH COMPARISON

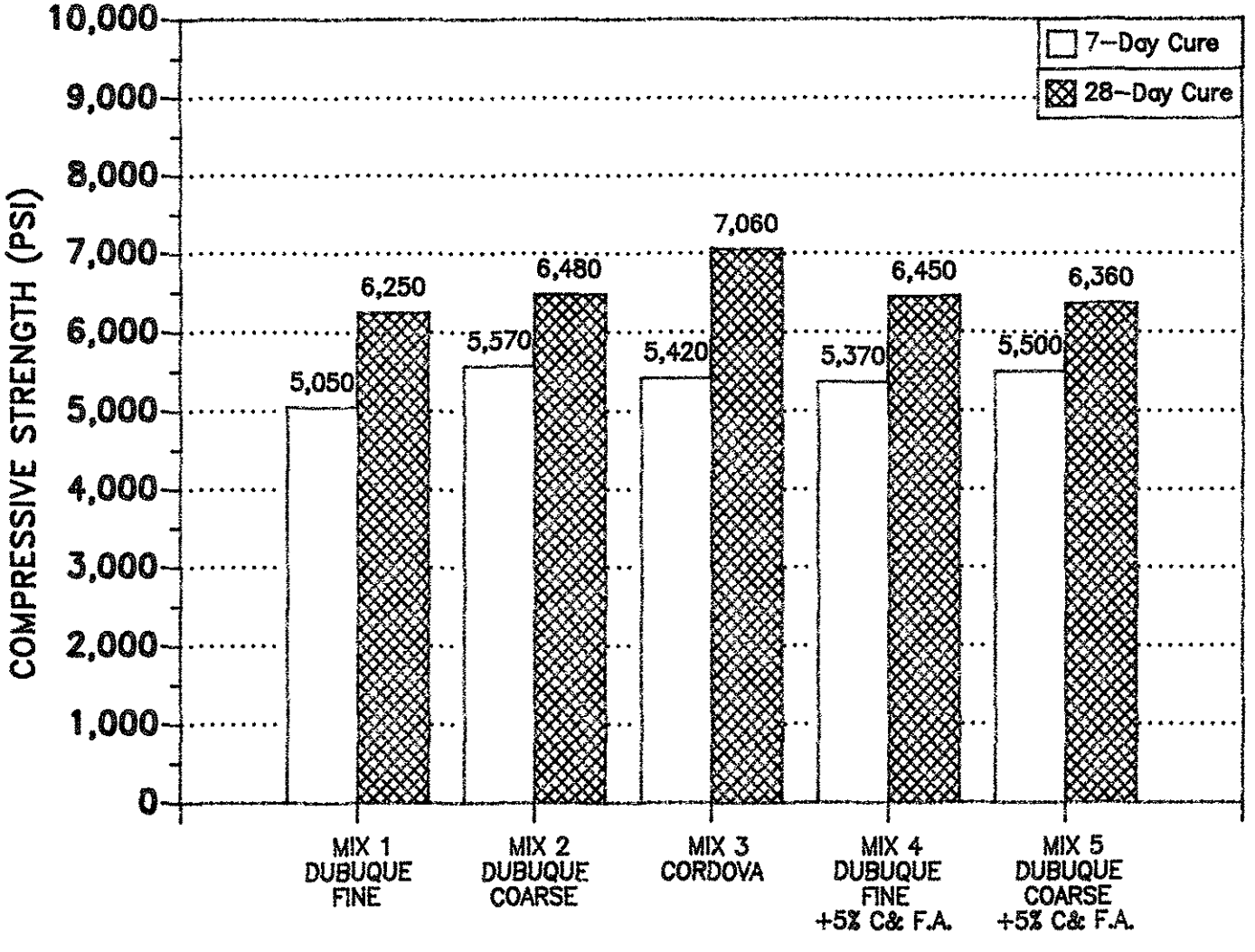
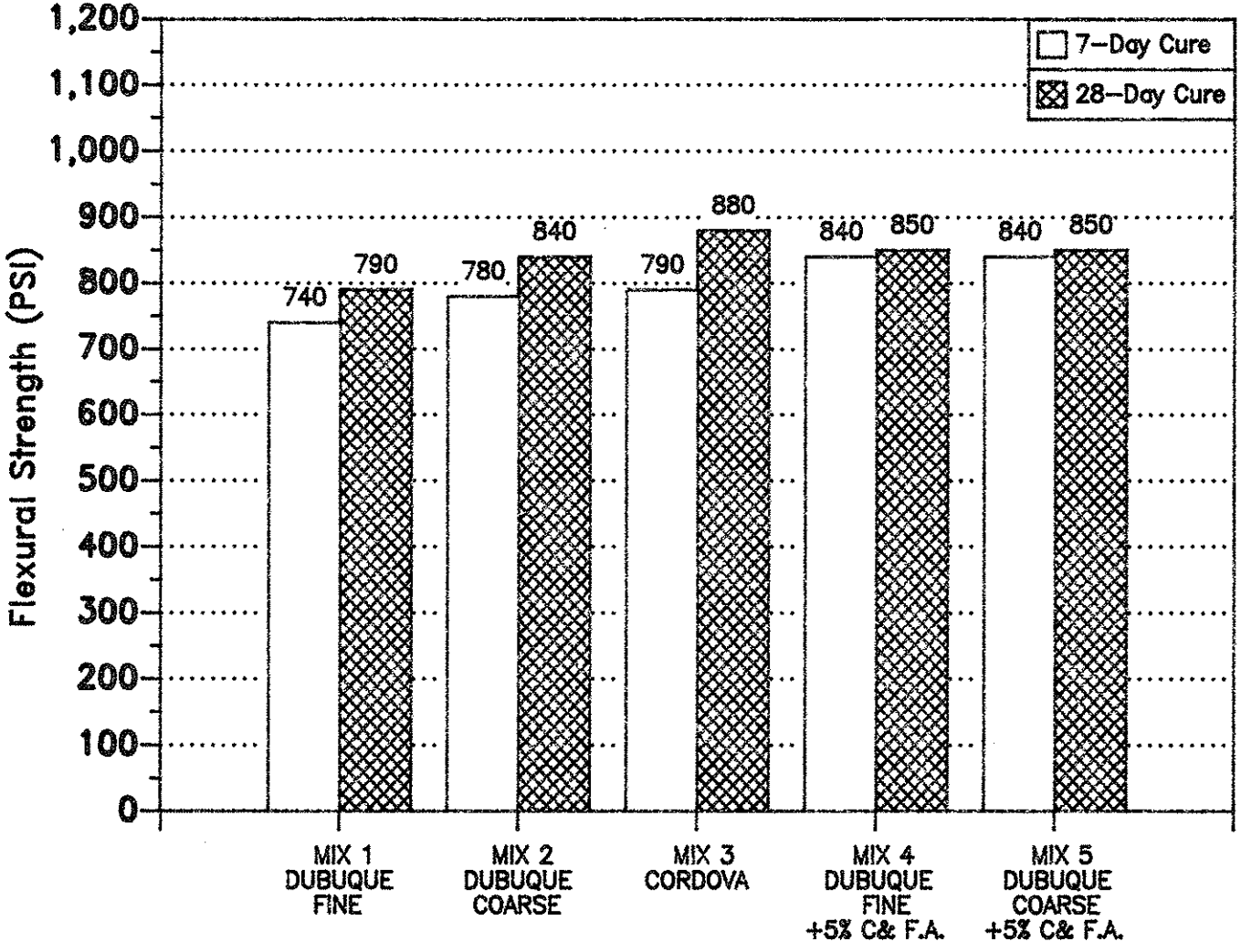


FIGURE 2. FLEXURAL STRENTH COMPARISON



TEST RESULTS

The fine sand from Dubuque tested about 5 percent lower on strength in the C-4-C mix than the coarse sand from Dubuque. The higher cement factor mix with the fine sand compared very favorably with the C-4-C mix and coarse sand. Strengths for the higher cement factor mix and fine sand were within 30 psi on the 28-day compressive and 10 psi on the 28-day flexural of those for the standard C-4-C mix with coarse Dubuque sand.

Results on the higher cement factor mix and coarse Dubuque sand were different than expected. The mixes were repeated and the same result of no strength increase with the higher cement and fly ash content occurred. In order to realize a strength difference, the water to cement ratio (w/c) would normally need to go down. The reduction in w/c for the coarse sand was about half that of the fine sand mix.

Results on the mix with Cordova Mississippi sand were as expected. The fineness modulus of the Cordova sand was between that of the two Dubuque sands. Because the Cordova sand had less material passing the #30 through #200 sieves, the surface area of the aggregate was less which contributed to a slightly lower w/c ratio. The 28-day compressive strength was 580 psi higher than any of the other mixes.

SUMMARY

Aggregate shape, texture and grading do have an affect on concrete strength and workability. The thrust of the study has been to look at the affect of fine aggregate gradation on the concrete strength. A lower compressive and flexural strength was observed at both 7 and 28 days for the C-4-C mix with finer, poorer graded sand. To reduce the water cement ratio and offset the affects of the fine sand, more cement and fly ash were added to the mix. Five percent of additional cement and fly ash was sufficient to increase the strength of the mix to what the C-4-C mix was with a coarser sand.

RECOMMENDATIONS

From the limited study it appears that finer concrete sands may have application in Iowa provided that adjustments to the concrete mixes are made. Based on this study, the following work should be done:

1. Perform tests on at least five other sources of sand representative of sands available from around the state.
2. Examine the effect of silt and organic matter on mortar cube strengths and concrete strengths with finer sand.
3. Formulate specifications and mix designs to provide concrete mixes using finer concrete sand comparable in quality to the current concrete mix designs and specifications.