HR-526

RECYCLING OF PORTLAND CEMENT CONCRETE ROADS IN IOWA

BY

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DISCLAIMER

The interpretations of the Standard Specifications and Policies mentioned in the following paper and the opinions or conclusions are those of the author only; and are not necessarily the official interpretations of the Iowa Department of Transportation.

Recycling of Portland Cement Concrete Roads in Iowa

Introduction

We are depleting the once seemingly endless supply of aggregate available for concrete paving in Iowa. At the present time, some parts of our state do not have locally available aggregates of acceptable quality for portland cement concrete paving. This necessitates lengthy truck and rail hauls which frequently more than doubles the price of aggregate. In some parts of the state, the only coarse aggregates available locally are "d-cracking" in nature.

Iowa's recycling projects were devised to alleviate the shortage of aggregates wherever they were found to have an economic advantage. We completed our first recycling project in 1976 on a 1.4 project in Lyon County. The data collected in this project was used to schedule two additional projects in 1977. The larger of these two projects is located in Page and Taylor County on Highway #2 and is approximately 15 miles in length. This material is to be crushed and re-used in the concrete paving, it is to be reconstructed on approximately the same alignment. The second project is part of the construction of Interstate I-680 north of Council Bluffs where an existing 24 foot portland cement concrete roadway is to be recycled and used as the aggregate in the slip form econocrete subbase and the portland cement concrete shoulders.

A Brief Review of 1976 Work

The 1.4 mile project constructed in Lyon County proved to our satisfaction that strong and durable concrete could be obtained with concrete manufactured using old crushed portland cement concrete as the major aggregate in the mix. We also verified that it was feasible to use existing crushing equipment for processing the aggregate and that the contractor's central batching and mixing equipment performed very adequately with these type mixes.

We found that it was necessary to incorporate at least 15 percent natural sand along with the crushed and recycled materials in order to obtain workability at a water-cement ratio of approximately 0.5. Our investigation showed that is was necessary to use a water reducing agent to disperse the fine material present on and in the recycled material as no washing was required.

It was readily apparent that on future projects we should divide the crushed material into two separate sizes in order to minimize segregation. With these findings in mind, we proceeded to let two projects previously mentioned for 1977 work.

1977 Construction to Date

The contractor on the Highway 2 construction project, Sterling-McLaren Construction Company and his sub-contractor Kuhlman Construction Company, took maximum advantage on the problems that developed

in the removal and crushing operations in Lyon County. Some innovative ideas that were used on this project include the use of a diesel pile driving hammer to break up the old concrete slab prior to removal. The diesel hammer was mounted on the draw bar of a large tractor which proceeded down the roadway so that the hammer struck the concrete directly over the longitudinal reinforcing steel. A pile driving head with an almost flat configuration was used to shatter the old concrete slab. This worked very efficiently and did a very complete job of breaking the old concrete. The next operation that warrants comment was the utilization of a small drag line unit with a hydraulic boom to which was attached a large steel hook. This machine traveled parallel to the roadway on one shoulder reaching across to the other side and hooking the broken edge on the old slab. The contractor then pulled back the boom pulling the hook through the broken rubble and at the same time pulling most of the steel with it. A great percentage of the steel was pulled free of the concrete in this operation. The few remaining chunks of concrete that were attached to the steel were sheared free by a man with a pair of hydraulic shears. The steel remaining in the detached concrete chunks was to be removed later at the crushing plant. The loading and hauling of the material to the crushing plant was a rather routine operation. The material was picked off the subgrade with a crawler type endloader. The endloader bucket was modified slightly by welding long teeth

with a maximum dimension of about 2 feet to the charging end of the bucket so that the broken concrete could be picked up with a minimum of soil being gathered in the operation.

Once the broken concrete was hauled to the crushing site, the contractor employed a vibratory feeder to convey the material to a 36 inch jaw crusher. The vibratory feeder performed the very essential function of breaking loose any adhering soil and scalping this soil fraction off of the concrete prior to its dropping into the jaw. By careful handling of this material, the percentage of mud balls in the plus three-eights inch material was kept below one percent and the percent of minus 200 material in the minus three-eights material was consistently maintained below 3 percent. An added control feature that was incorporated into the screening plant is a deck of one-eighth inch screen which permits the withdrawal of minus eight material when the 200 fraction approaches the 3 percent limit. The crushed material looks very much like a sand stone with a calcarious binder. This is because the original aggregate used in the concrete was a product referred to as Class 5 aggregate that is washed down the Platte River from the Rocky mountains. It is basically granite and feldspathic material. It has a slight alkaline reactive nature. The material is rather fine containing only about 10 percent material retained on the number 4 and about 5 percent passing the 100 sieve. The steel that remains

is broken free of the concrete in the primary jaw crusher. The steel then progresses up a long conveyor belt to the secondary crusher. A grill work placed at the end of the conveyor system catches most of the larger pieces of steel. The small units that slip through the grill are picked up by an electro magnet. The material is then further processed by screening and crushing through a smaller jaw-roll secondary plant where it is screened to 1-1/2 inches maximum and separated on the 3/8 inch screen. This produces two stockpiles, one 1/2 inch to 3/8 inch size and the other contains the fine material, 3/8 to dust fraction. The crushing operation separates these materials approximately 60-65% coarse fraction retained on the 3/8 and 35-40% minus 3/8 material.

Mix Design Considerations for Page and Taylor Counties

The objective of the mix design is to provide a concrete which will meet Iowa D.O.T. requirements for portland cement concrete pavement and utilize most of the recycled concrete coming from the old roadbed. The basis of the mix is a conventional C4 paving mix with certain necessary modifications in order to use the available materials.

The old concrete pavement crushes in such a way that about 65% of the material is retained on the No. 4 screen with the maximum size being 1-1/2". Slightly more than 1% passes the No. 200. Using a mixture with this much coarse material creates

a mix which is very harsh and not suitable for placement with a slip form paving machine. Therefore, it is necessary to add a quantity of natural sand to offset the imbalance in crushing. It is also the nature of the crushed particles to be harsh and this further necessitates the need for sand. Generally speaking, sand is readily available in most sections of Iowa. A gradation chart of the crushed material is attached to this report.

The C4 mix contains 626 lb. of portland cement per cubic yard of concrete. In the laboratory, a mix with that cement factor was investigated with various combinations of the crushed material, together with natural sand. A mixture containing 45% coarse aggregate and 55% fine aggregate seemed to be the most desireable combination. In order to use 100% of the crushed material, it is necessary to add sand in an amount equal to 31% of the total aggregate. A conventional water reducing admixture will also be incorporated in the mix as well as entrained air.

The water requirement with this material is on the high side as compared to the C4 mix when using conventional aggregates. A water cement ratio of 0.49 by weight of cement is used in the mix design. This will result in a slump of about 2 inches, with 6.5% air. The total amount of free water in the concrete should not exceed a water cement ratio of 0.56.

Mix design batch weights per cubic yard are shown below:

Batch Weights:

Cement	626 lb. per cu. yd.
Crushed concrete-coarse aggregate	1145 lb. per cu. yd.
Crushed concrete-fine aggregate	613 lb. per cu. yd.
Sand-fine aggregate	876 lb. per cu. yd.
	3567 lb. per cu. yd.

Basic absolute volumes:

Cement	.118330
Water	.182217
Air	.060000
Crushed concrete coarse aggregate	.287754
Crushed concrete fine aggregate	.154944
Sand fine aggregate	.196755
	1.000000

Above quantities are based on the following assumptions and mix quantity adjustments should be made for figures different than these:

Specific gravity of cement	3.14
Specific gravity of crushed aggregate	2.35
Specific gravity of sand	2.65
Weight of water per cu. ft.	62.4

Results of concrete compression and flexure tests on specimens made with these materials and 626 lb. of cement are shown below:

Compression

4350 p.s.i. at 7 days

5510 p.s.i. at 28 days

Flexure

702 p.s.i. at 14 days

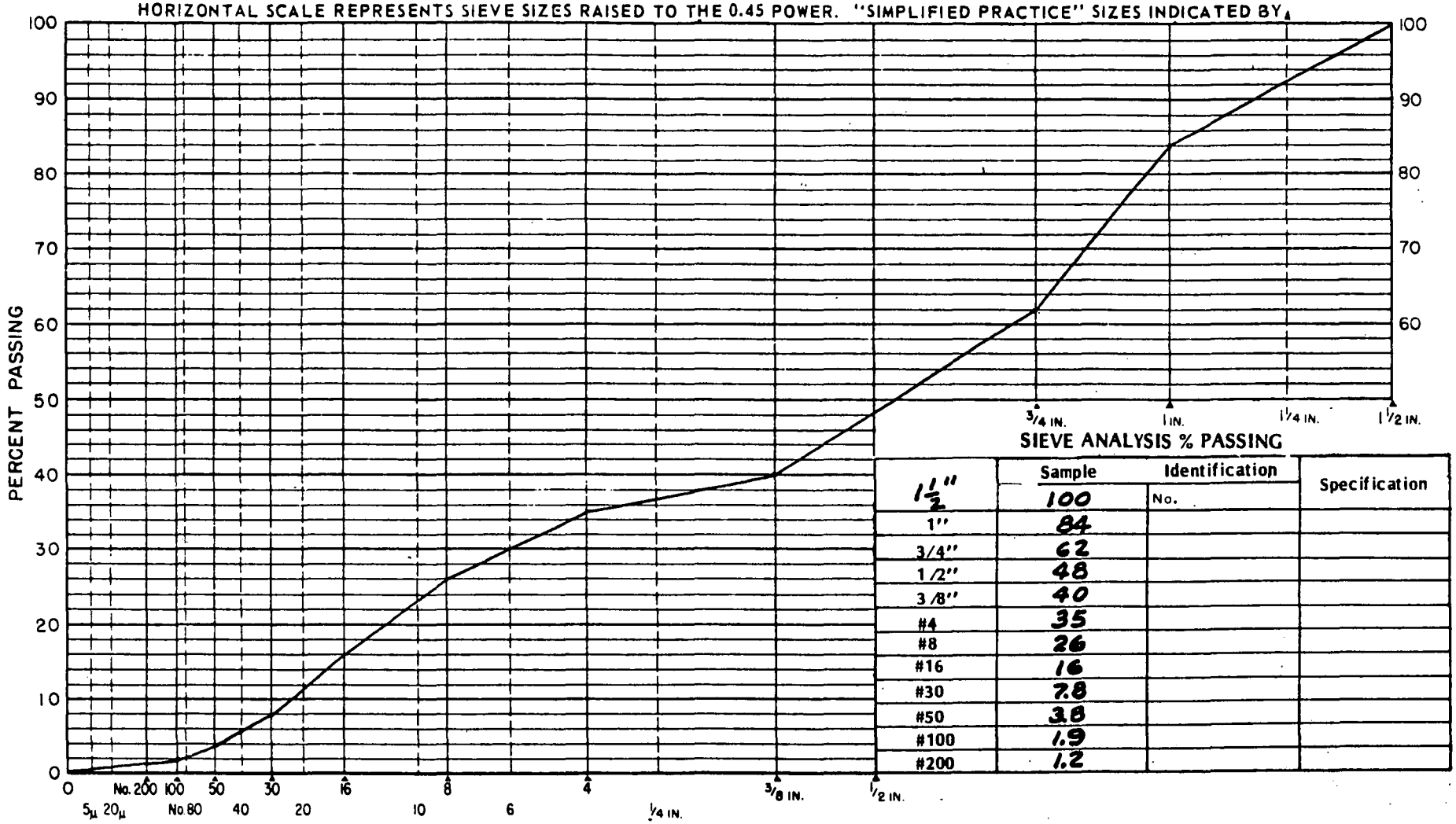
Specimens for durability testing have been made and test results will be available about September 1, 1977.

Form 925
8-75

IOWA DEPARTMENT OF TRANSPORTATION

GRADATION CHART

HORIZONTAL SCALE REPRESENTS SIEVE SIZES RAISED TO THE 0.45 POWER. "SIMPLIFIED PRACTICE" SIZES INDICATED BY▲



SIEVE ANALYSIS % PASSING

	Sample	Identification No.	Specification
1 1/2"	100		
1"	84		
3/4"	62		
1/2"	48		
3/8"	40		
#4	35		
#8	26		
#16	16		
#30	7.8		
#50	3.8		
#100	1.9		
#200	1.2		

65% PLUS 4, 35% MINUS 4

Co. PAGE-TAYLOR PROJECT NO. F-2-2-(4)--20-73

TYPE, SOURCE, PRODUCER OF AGG.
CRUSHED CONCRETE-RECYCLED PAVEMENT

TYPE CONST; LOCATION ON PROJECT
CONCRETE PAVEMENT USING RECYCLED CONCRETE

SAMPLED FROM	SAMPLED BY	DATE	QUANT. REPRESENTED	SIEVED BY	DATE	SIEVE METHOD	REMARKS
					6/1/77		By: STRUM, SPENCER - AMES (LAB)

R. BRITSON