78-2

# EVALUATION OF FLY ASH IN PORTLAND CEMENT CONCRETE PAVEMENT in MONONA COUNTY, IOWA



CONSTRUCTION REPORT
FOR
IOWA HIGHWAY RESEARCH BOARD
PROJECT HR-200

IN COOPERATION WITH

DEPARTMENT OF TRANSPORTATION
IOWA

HIGHWAY DIVISION

ORVILLE D. IVES, P.E.
MONONA COUNTY ENGINEER
DECEMBER 1978

Form 000020
2-75 H-11977

**IOWA DEPARTMENT OF TRANSPORTATION**

APR 13 1979

To Office Director

Date April 10, 1979

Attention Raymond Kassel

Ref. No. HR-200

From Vernon Marks

Office Materials-Research

APR 16 1979
D.O.T. Research Unit

Subject Construction Report HR-200, "Evaluation of Fly Ash in Portland Cement Concrete Pavement in Monona County, Iowa"

Attached is one copy of the research noted above. The research involved the construction of five miles of secondary pavement where 10 and 15% fly ash was substituted for Portland Cement. The objectives were to investigate handling and batching of fly ash and demonstrate that quality concrete can be produced using fly ash. The use of fly ash exhibited potential benefits resulting in recommendations for development of specifications for continued use in P.C. Concrete.

VJM/jmn

cc:
D. E. McLean
R. H. Given
G. Calvert
R. McIntire
T. McElherne
K. McLaughlin
J. V. Bergren
B. C. Brown
D. Stohlmeyer
S. Moussalli
F. O. Bloomfield
C. L. Huisman
L. Richardson
H. Schiel
G. Sisson
C. Pestotnik
K. Davis
District Engineers (6)
I. MacGillivray
Library
AASHTO-AMRL Lab-Dick Hay
FHWA (3)
Adjoining States Materials Engrs.
M. Knutson, ICPA
E. Renier, PCA
County Engineers

# CONSTRUCTION REPORT

# FOR

# IOWA HIGHWAY RESEARCH BOARD

# PROJECT HR-200

# EVALUATION OF FLY ASH

# IN

# PORTLAND CEMENT CONCRETE PAVEMENT

# IN

# MONONA COUNTY, IOWA

BY

ORVILLE D. IVES, P.E.
MONONA COUNTY ENGINEER

DECEMBER 1978

TABLE OF CONTENTS

# FLY ASH IN PORTLAND CEMENT CONCRETE PAVEMENT

## MONONA COUNTY PROJECT HR-200

## FM-67(3)--55-67

## INTRODUCTION

In today's era of spiraling costs, environmental regulations and shortages of various raw materials, it is interesting to note that we may not be utilizing all available materials. One of the underused materials is fly ash. Although it has been used in some asphalt work, I doubt that this use of fly ash is utilizing it to its full potential.

In this project we were utilizing this material as a cement substitute and not as a mineral filler. Iowa has had very limited use of fly ash in portland cement concrete so we can benefit some from the experience of other states. Both Minnesota and North Dakota have used fly ash with good results.

Nationwide, fly ash is available in large quantities from hundreds of power plants, but we, as engineers, using this for paving material must note that the principal product of a generating plant is electrical power. Much fly ash produced is not of suitable quality for use as a cementing agent.

The fly ash used in this project was uniform and of high quality.(Appendix A) This fly ash was produced by Port Neal Plant #3 in Sioux City, Iowa. This plant produces approximately 181,000 tons per year.

Usually only plants which burn coal from a single source, ground finely and uniformly for combustion, and collected by an electrical precipitator can deliver the quality of fly ash required.

As Monona County is close to Sioux City, I have at different times considered the use of fly ash and welcomed the opportunity to pursue a research project utilizing fly ash as a cementing agent.

I believe if we, as engineers, are willing to incorporate some of these by-products where it is advisable to do so, we can help the nation save energy. The savings will be in transportation of raw materials, the cost of the disposing of fly ash as a waste material and in the processing of portland cement.

## OBJECTIVES

The primary objectives of this research project were:

1. Determine and recommend solutions for problems relating to shipping, storing and batching of fly ash.

2. Establish a procedure for batching, mixing and placing uniform concrete with specified air content and consistency.

3. Demonstrate that concrete of comparable quality can be produced.

## PROJECT LOCATION

The project is located on Monona County Road E-54, beginning two miles north of Blencoe, Iowa, at Old 75 and extending

easterly for five miles. It is incorporated in Monona County Project FM-67(3)--55-67.

## PROJECT FUNDING

The project was funded with Monona County Farm-to-Market funds. Funding for additional costs to the project were approved by the Research Board as follows:

| | |
|---|---|
| Administration and Testing (excluding core testing) | $ 3,000.00 |
| Coring and core testing | 6,300.00 |
| Additional Contractor Set-Up Costs | 4,000.00 |
| Contingency for Maintenance | 3,000.00 |
| Total | $16,300.00 |

## TEST SECTION AND MIX PROPORTIONS

The project was constructed by the Irving F. Jensen Co., Inc. of Sioux City and included six sections (Figure 1) with different mix proportions. (Appendix B) They are as follows:

1. Standard B-4 mix (approximately ½ mile) Referred to in this report as Mix #1.

2. Standard B-6 mix (approximately ½ mile) Referred to in this report and Mix #6.

3. Modified B-4 mix with a 10% cement reduction and fly ash replacement at 1.5 times that weight (approximately 1 mile) Referred to in this report as Mix #2.

4. Modified B-6 mix with a 15% cement reduction and fly ash replacement at 1.5 times that weight (approximately 1 mile) Referred to in this report as Mix #3.

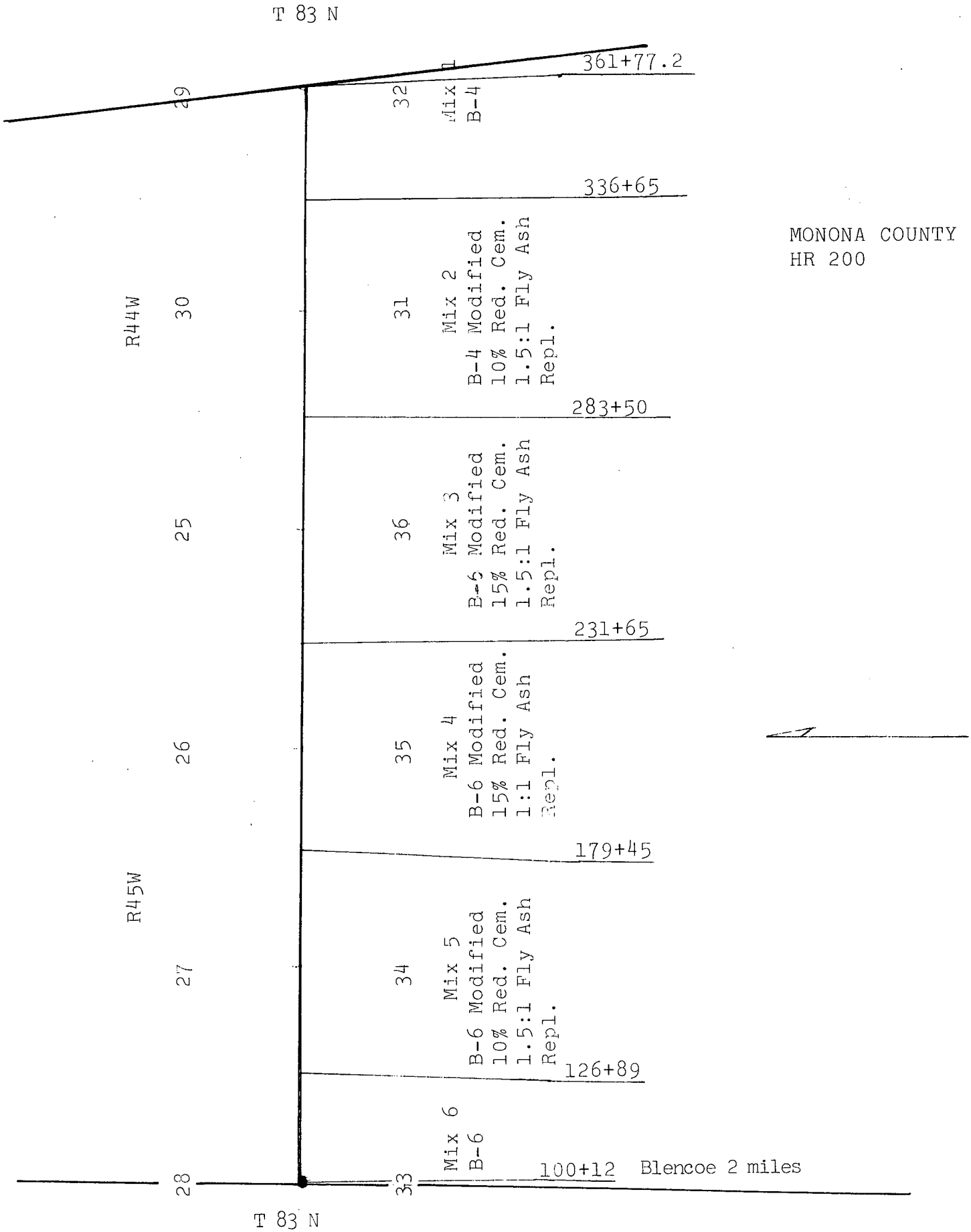



Figure 1. PROJECT LAYOUT FOR MONONA COUNTY HR-200

5. Modified B-6 mix with 15% cement reduction and replacement with equal weight of fly ash (approximately 1 mile) Referred to in this report as Mix #4.

6. Modified B-6 mix with 10% cement reduction and fly ash replacement at 1.5 times that weight (approximately 1 mile) Referred to in this report as Mix #5.

## TESTING AND EVALUATION

Additional testing done on this project by Monona County was as follows:

1. Determine the modulus of rupture at 7, 14, 28 and 56 days (4-6" x 6" x 33" beams per section)

2. Cylinders (6-4½" x 9" per section) for compressive strength determination at 3, 7 and 14 days

3. Coring ( 5 per section) for compressive strength determination at 7 days, 14 days, 28 days, 6 months and 1 year.

The Iowa Department of Transportation obtained and tested 3-4" x 4" x 18" durability beams per section.

## EQUIPMENT

The equipment used on the project was essentially the same as a normal paving project. A Rexnord Model S plant with a single 9 yard drum produced the concrete.

The major change was a 100 ton silo adjacent to the mixing tower for storage of the fly ash (see page 7 ) with an air slide pipe for feeding fly ash into the cement weigh bin. A second

limit switch was added to the cement scales and the batching was automatically controlled. (see page 8)

Some problems were encountered with the boot between the silo and the air slide in early operations. This boot was modified with a steel cylinder connection. I believe if the steel cylinder had been cone shaped, it would have provided a better connection. (see page 8)

Initial air volume was not enough for the fly ash silo and another air compressor was provided to furnish more air.

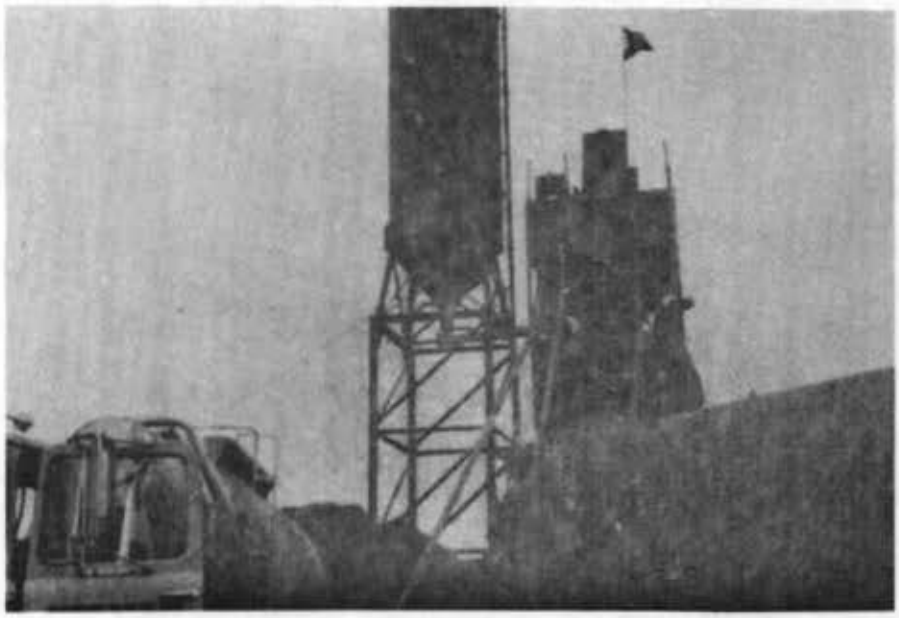
No special problems occurred in controlling plant dust with the Buffalo Forge dust control unit. Some problems were encountered with fly ash dust in the connection between the silo and the air slide. It might be noted that fly ash is very fine and will almost leak out where water will not. (18% is retained on a 325 wet sieve).

The fly ash was hauled to the plant site in regular cement delivery trailers.

Out on the grade a CMI "Iowa Special" Autograde trimmed the subgrade just ahead of the Rex Town and Country paver. (see page 9)

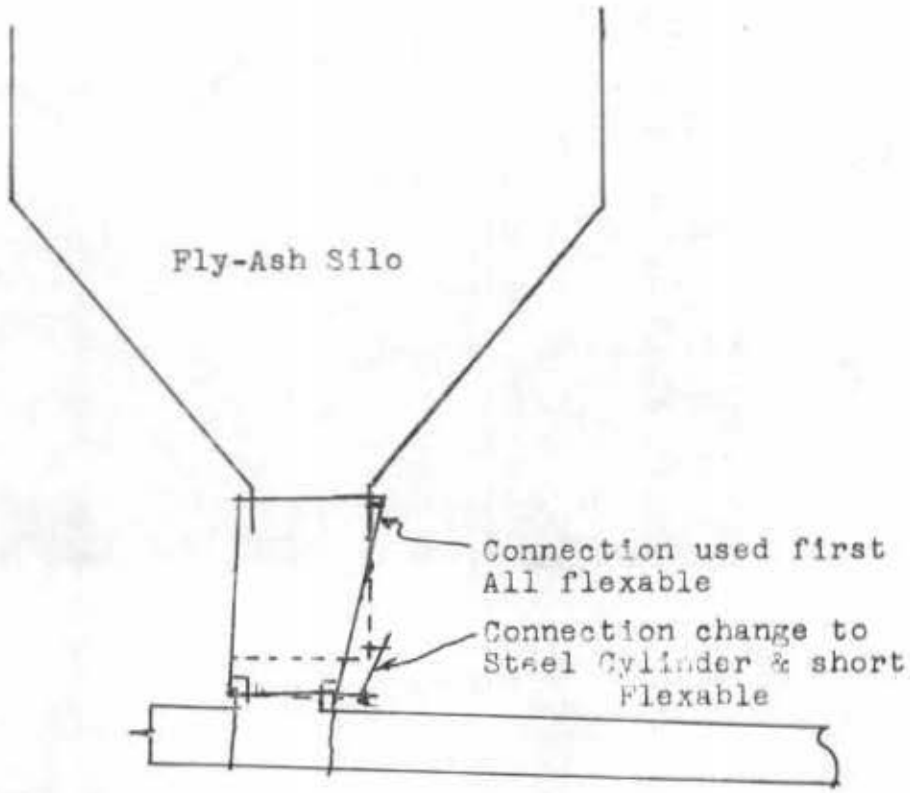
Plastic subgrade sheeting was used on this project along with 12 foot transverse bars alternating on 4 foot centers each side of centerline.

ERECTING FLY ASH SILO

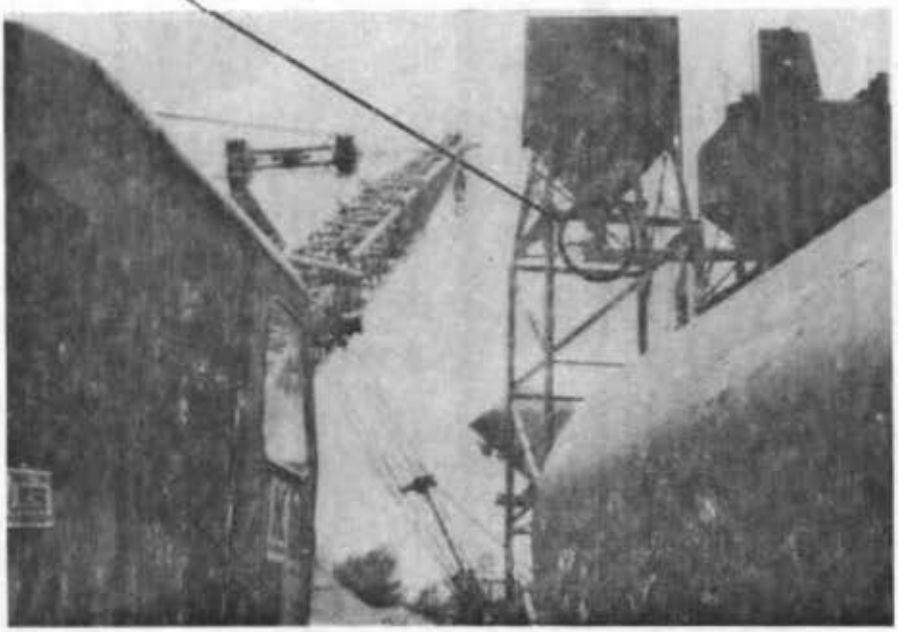


FLY ASH SILO IN PLACE

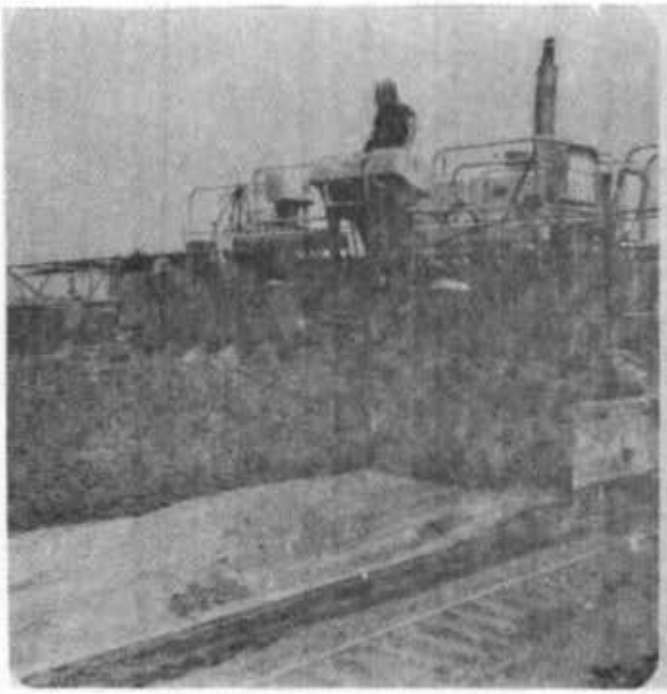
Monona County HR-200 Air-slide Connection




Connection Location



PAVING TRAIN



MIX IN FRONT OF PAVER

FINISHED SLAB

MIX #2

A burlap drag towed by the paver and followed by an astro-grass drag imparted the final texture.

The mixed concrete on this project was hauled to the paver in both batch trucks and 9 yard Agitor trucks. No difference was noted in the mix's workability due to the manner of delivery.

PHYSICAL MIX CHARACTERISTICS

We encountered no problems in controlling the air or slump on the project. Edge raveling was diminished with the use of fly ash. Also the finishers did state that the fly ash mix finished easier. This was probably due to the lubricating qualities of the fly ash. Hand finishing could be done earlier or later with no change in the finish ability of the concrete.

We had no difficulty in the sawing, experienced no raveling at the saw cuts, and had no random cracking on the project. Transverse joints were sawed at 40 foot intervals. All of the cuts were made within 24 hours of placement of the concrete.

Temperature during construction ranged from the low 60's at night to the mid 80's in the day time. I feel this ideal temperature may have some effect on the random cracking and the sawing.

Gilmore time of set laboratory testing on mortar made with a standard cement yielded an initial set of 3.17 hour and a final set of 5.00 hour. Using one part fly ash and four parts standard cement, the results were 5.50 hour for initial set and 7.33 hour for final set or a 58% retardation in initial set and 33% retardation on final set. This retardation characteristic yielded beneficial results in the paving operations.

TEST RESULTS

A summary of test results are in Appendix G. Flexural testing was done on 6" x 6" x 30" beams. Each beam was tested twice. The 7 day average mid-point flexural breaks varied from the low of 434 psi on Mix #5 to high of 601 psi on Mix #1. These 7 day flexural breaks indicated that we were not going to have any problem developing a desirable flexural stength of 550 psi for the normal 14 day opening of the road to traffic. Average mix breaks at 14 days varied from 592 psi on Mix #5 to 686 psi on Mix #6.

All mixes continued to show increases in flexural strength through the 56 day break. The maximum difference in the average flexural strength of the mixes was 167 psi at 7 days; 94 psi at 14 days; 83 psi at 28 days and 68 psi at 56 days. The twenty-eight day break on beam 4-4 was disregarded for average breaks as it broke 2 3/4" off center.

In checking with past records of pavement placed in Monona County, the following can be noted: The B-4 mix has had higher beam breaks, on the average, than the B-6 or B-8 mixes. Some of this I feel is due to the aggregate used. Most B-6 and B-8 mixes in Monona County use a different source of aggregate than was used in this project. The same source as usually used for B-4 mixes was used for this project. The aggregate used on this project was gravel produced by Peters Construction at Rodney.

Cylinders and cores (Appendix D and E) were tested for compressive strength also and the control and fly ash mixes all were good. (Appendix F) As of this writing, the cores on Mix #2 are the highest on a 28 day core. You might note, however, that this mix produced the lowest strength of all the mixes on the 14 day cylinders.

Durability beams were run on each mix. The results are as follows: Mix #1 (86); Mix #2 (86); Mix #3 (88); Mix #4 (92); Mix #5 (92); Mix #6 (92). Air tests and slump tests on the grade indicated no control problems in the fly ash mixes. We also encountered no problems in switching from one mix to another mix.

When we look at the water-cement ratio, we find the design water-cement ratio was lower on fly ash mixes than on the conventional B-4 or B-6 mix. All mixes except Mix #5 were placed at a water-cement ratio below design mix. (See Appendix G)

All test reports received to date indicate that fly ash used with a reduction of cement and a good sound aggregate will produce a good quality of concrete.

OBSERVATIONS

With the projected amount of fly ash that is and will be available in the State of Iowa, I feel that it is advisable that we continue the use of fly ash in portland cement concrete pavements and also develop the use of fly ash in structural concrete. Due to the workability of the fly ash concrete, it should leave less porous wall finishes and should require less effort for a good finish on flat work.

I do feel from all that I have heard and read on fly ash concrete that entrained air is an important item (approximately 6% - 6.5%) to assure a good product.

The contractor on this project indicated to me that if only one fly ash mix had been used throughout the project, a cost savings of 20 to 30 cents per square yard would have been realized. On this particular project, he indicated a savings of approximately 8 to 10 cents per square yard.

This savings, due to transportation costs, would vary from county to county. With the shortages of cement encountered last summer and the projected increase in the cost of cement and hauling, I believe that future savings will be greater.

Considering a compromise on the designs used in this project, I would recommend reducing cement content 12% and a fly ash replacement of 1.25 to 1.0. The amount of concrete available for use will increase. This represents a mix that appears very comparable to our present paving mixes. I do not believe that we need the 1.5 to 1 replacement on any work.

Development for use of fly ash in portland cement will depend on the ability of the power plants to produce a consistent quality fly ash at all times. If this can be done, I believe we can then recognize fly ash as a by-product and not a waste product.

## CONCLUSIONS

The primary objectives of this research project have been achieved. On this project, it was shown that fly ash could be shipped, stored and batched in the same manner as portland cement. Some additional equipment was needed for the storage of fly ash. This included an additional storage silo for the fly ash and a second limit switch on the cement scales.

We were, under field conditions with the use of present specifications for portland cement concrete, able to batch, mix and place a concrete with specified air content and a consistent slump.

The concrete produced has shown to date that it is of comparable quality to standard portland cement concrete.

RECOMMENDATIONS

I would recommend that the use of fly ash be continued and specifications be developed for a fly ash portland cement concrete for paving and structural work.

At the present time, I would recommend this mix be placed only during warm weather.

The control of the quality of the fly ash should be the responsibility of the producer. This would require some type of acceptable test monitoring be established to provide production sampling with test results being provided from each individual producer and plant.

In cool weather, the sawing of the concrete may have to be delayed due to the retarding action of the fly ash in the mix.

For an earlier strength, the use of an admixture should be considered. This would be desirable for formed concrete or cold weather pours.

It might be noted at this point that in the past, we have had problems with excessive heat in large mass concrete pier pours. The slower set of the fly ash concrete could be highly advantageous in this type of usage.

It is my hope that fly ash can be used in future work throughout the State of Iowa. With the results Monona County has on its project, we will be willing to use it in the future.

ACKNOWLEDGEMENTS

The author wishes to extend appreciation to the Monona County Board of Supervisors, to my staff and to all personnel of the Iowa Department of Transportation that made this project possible.

APPENDICES

IOWA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS
TEST REPORT - MISCELLANEOUS MATERIALS
LAB LOCATION AMES

MATERIAL FLY ASH LAB NO. ACM8-13

INTENDED USE PC PAVING

COUNTY MONONA PROJ NO. FM-67(3)--55-67

DESIGN CONTRACT NO. 14660

PRODUCER IOWA PUBLIC SERVICE CONTRACTOR I. F. JENSEN

SOURCE PORT NEAL #3. WOODBURY CO.

UNIT OF MATERIAL SAMPLED FROM TRUCK. TICKET #2766. 48,680 LBS.

SAMPLED BY DICK BEEDLE SENDER'S NO. 3DB8-1525

DATE SAMPLED 5/25/78 REC'D 5/30/78 REPORTED 8/11/78

---

CHEMICAL ANALYSIS

| | |
|---|---|
| MOISTURE | 0.0% |
| LOSS ON 800 DEG. C IGNITION | 0.09% |
| SO3 | 0.65% |
| SILICON DIOXIDE)<br>ALUMINUM OXIDE )<br>IRON OXIDE ) | 79.67% |

PHYSICAL RESULTS ASTM 311

| | |
|---|---|
| 325 MESH | 78.2% PSG. |
| AUTOCLAVE | .09% |
| POZZLANIC ACTIVITY | 86.3% |

COPIES:
MISC. CONC.
J. BUMP
O. IVES
M. I. SHEELER
FM-67(3)--55-67, MONONA

DISPOSITION: COMPLIES WITH SP-212



SIGNED: BERNARD C. BROWN
TESTING ENGINEER

SP-212

IOWA DEPARTMENT OF TRANSPORTATION

Ames, Iowa

SPECIAL PROVISION

for

PORTLAND CEMENT CONCRETE PAVING

USING FLY ASH

March 28, 1978

THE STANDARD SPECIFICATIONS, SERIES 1977, ARE AMENDED BY THE FOLLOWING SPECIAL PROVISIONS. THESE SHALL PREVAIL OVER THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.

ADD the following to 2301.01:
The location, class, and mix proportion number of concrete to be used shall be as indicated on the plans or the proposal.

ADD the following to 2301.03:

When fly ash is required and used in the mix proportions, the fly ash shall meet the requirements of ASTM C 618 Class C except that the loss on ignition shall be a maximum of 5 percent, the available alkalies shall be limited to a maximum of 1.5 percent, and the total silicon dioxide ($Si0_2$) plus aluminum oxide ($Al_2O_3$) plus iron oxide ($Fe_2O_3$) shall be not less than 70% by weight.

Approval of the source of fly ash will be required. Fly ash will not be subject to certified gradation testing by the contractor. Inspection will be arranged by the engineer.

ADD the following proportions to 2301.04:

Basic Absolute Volumes Per Volume of Concrete

| | B410-1.5 | B610-1.5 | B615-1.5 | B615-1 | C410-1.5 | C415-1.5 | C415-1 |
|---|---|---|---|---|---|---|---|
| Coarse Aggr. | .346770 | .275217 | .273324 | .278943 | .329192 | .324530 | .331826 |
| Fine Aggr. | .346770 | .412825 | .409987 | .418415 | .329192 | .324529 | .331825 |
| Air | .06 | .06 | .06 | .06 | .06 | .06 | .06 |
| Water | .144231 | .143637 | .143637 | .139482 | .151947 | .155508 | .152540 |
| Cement | .083928 | .089031 | .084117 | .084117 | .106422 | .100562 | .100562 |
| Fly Ash | .018301 | .019290 | .028935 | .019043 | .023247 | .034871 | .023247 |

Approximate Quantities of Materials per Cubic Yard of Concrete: (Pounds)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Coarse Aggr. | 1548 | 1229 | 1220 | 1245 | 1470 | 1449 | 1482 |
| Fine Aggr. | 1548 | 1843 | 1830 | 1868 | 1470 | 1449 | 1482 |
| Cement | 444 | 471 | 445 | 445 | 563 | 532 | 532 |
| Fly Ash | 74 | 78 | 117 | 77 | 94 | 141 | 94 |
| Water | 243 | 242 | 242 | 235 | 256 | 262 | 257 |
| Design W/C Ratio | .47 | .44 | .43 | .45 | .39 | .39 | .41 |
| Max. W/C Ratio | .53 | .50 | .49 | .51 | .45 | .45 | .47 |

Note: Fly Ash is included in the water/cement ration calculation.

Those quantities are based on the following assumptions:

Specific Gravity of Cement - 3.14

Specific Gravity of Fly Ash - 2.40

Specific Gravity of Coarse and Fine Aggregate - 2.65

Weight of one cu. ft. of water - 62.4 lbs.

DELETE the second and third paragraphs of 2301.04H.
It is not the intention to increase cement content or to adjust proportions to correct the yield for this project. The mixture characteristics are to be controlled within the limits specified in 2301.04H and I and within the specified maximum water-cement ratio; these are to be modified only with specific, prior authorization of the engineer.

ADD the following to 2301.06A:

Fly ash shall be transported, stored, and batched in such a manner as to keep it dry. Proportioning equipment for the fly ash shall meet requirements of 2001.20, either Paragraph A, Manual Batching Equipment, or Paragraph B, Automatic Batching Equipment.

ADD the following:

Certain aspects of the work on this project are of a research nature. Because of this, the engineer may modify requirements in order to assure that meaningful research results are obtained.

Monona County FM-67(3)--55-67 PCC Pavement

(Special Provisions Continued)

The concrete shall be Class "B" and fly ash modified Class "B" with proportions and production in accordance with the supplemental specification. The mix proportions and location shall be:

| Station to Station | | Area sq.yd. | Mix Proportion No. |
|---|---|---|---|
| 100+12.0 | 126+20 | 6355.8 | B6 |
| 126+20 | 179+40 | 13004.4 | B610 - 1.5 |
| 179+40 | 231+50 | 12735.6 | B615 - 1 |
| 231+50 | 283+70 | 12760.0 | B615 - 1.5 |
| 283+70 | 336+40 | 12882.2 | B410 - 1.5 |
| 336+40 | 361+77.2 | 6202.0 | B4 |

A transition of $\pm$ 50 feet will be allowed on the stations above when changing mix proportions.

# FLEXURAL BEAM DATA

Monona County Project FM-67(3)--55-67 HR-203

| Beam No. | Mix No. | Air % | Slump inches | W/C Ratio | Mod. of rupture (Days) 7 | 14 | 28 | 56 | Loc. Break off CL. inches |
|---|---|---|---|---|---|---|---|---|---|
| 1-1 | 1 | 5.6 | 2.50 | .531 | 629 | 616 | | | 1<br>1.5 |
| 1-2 | 1 | 7.2 | 2.00 | .503 | | 660 | | 711 | .25<br>.875 |
| 1-3 | 1 | 5.7 | 1.25 | .497 | | | 681 | 835 | 1<br>.75 |
| 1-4 | 1 | 6.4 | 1.75 | .497 | 574 | | 740 | | .25<br>.375 |
| Average | | 6.2 | 1.88 | .507 | 601 | 638 | 710 | 773 | |
| 2-1 | 2 | 6.5 | 1.25 | .481 | 547 | | 681 | | .5<br>1.125 |
| 2-2 | 2 | 6.4 | 2.75 | .440 | 573 | 653* | | | 0<br>0 |
| 2-3 | 2 | 5.5 | 1.5 | .434 | 535 | | | 714 | .5<br>0 |
| 2-4 | 2 | 6.5 | 1.75 | .409 | | 659 | | 734 | 1.625<br>.5 |
| 2-5 | 2 | 5.3 | 1.5 | .413 | | 584 | 624 | | 1.75<br>0 |
| Average | | 6.0 | 1.75 | .435 | 552 | 632 | 652 | 724 | |
| 3-1 | 3 | 6.0 | 1.00 | .450 | | | 688 | 776 | 1<br>1.125 |
| 3-2 | 3 | 5.3 | 1.50 | .442 | 608 | 689 | | | .5<br>.25 |
| 3-3 | 3 | 5.5 | .75 | .445 | 559 | 646 | | | .5<br>1.5 |
| 3-4 | 3 | 7.2 | 2.00 | .418 | | | 629 | 759 | .5<br>.875 |
| 3-5 | 3 | 6.2 | 1.75 | .418 | 587* | | 614 | | .375<br>.125 |
| Average | | 6.0 | 1.4 | .435 | 585 | 668 | 643 | 768 | |
| 4-1 | 4 | 6.5 | 2.00 | .441 | 608 | 672 | | | .625<br>1 |
| 4-2 | 4 | 5.9 | 1.50 | .441 | | | 671 | 710 | .5<br>0 |
| 4-3 | 4 | 6.3 | 1.5 | .460 | 481 | 544 | | | 1.5<br>.5 |
| 4-4 | 4 | 6.0 | 1.00 | .466 | | | 477# | 700 | 2.75<br>1 |
| Average | | 6.2 | 1.5 | .452 | 544 | 608 | 671 | 705 | |

* 6 or 13 day break

\# Broke too far off center to use

Appendix C
Cont.

FLEXURAL BEAM DATA

Monona County Project FM-67(3)-- 55_67 HR-200

| Beam No. | Mix No. | Air % | Slump inches | W/C Ratio | Mod. of Rupture (Days) 7 | 14 | 28 | 56 | LOC. Break .off CL. inches |
|---|---|---|---|---|---|---|---|---|---|
| 5-1 | 5 | 6.6 | 2.00 | .466 | | | 685 | 723 | 1.75 .375 |
| 5-2 | 5 | 6.4 | 1.5 | .457 | 431 | 594 | | | .5 0 |
| 5-3 | 5 | 6.4 | 1.75 | .459 | 437 | | 678 | | .125 1.375 |
| 5-4 | 5 | 6.4 | 1.75 | .486 | | 590 | | 708 | 0 .25 |
| Average | | 6.4 | 1.75 | .462 | 434 | 592 | 682 | 716 | |
| 6-1 | 6 | 6.4 | 1.75 | .522 | 515 | 676 | | | 0 1 |
| 6-2 | 6 | 5.0 | 1.00 | .495 | | 696 | | 756 | 1 .5 |
| 6-3 | 6 | 7.3 | 2.00 | .505 | | | 736 | 761 | 1.125 .25 |
| 6-4 | 6 | 7.9 | 2.00 | .505 | 589 | | 716 | | 0 1 |
| 6-5 | 6 | 7.5 | 1.75 | .525 | 521@ | 572@ | | | .375 0 |
| Average | | 6.8 | 1.70 | .511 | 552 | 686 | 726 | 758 | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |

@ Fillet beam - Do not use

# COMPRESSIVE STRENGTH DATA - CYLINDERS

Monona County Project FM-67--55-67 HR-200

| Cylinder No. | Date Taken | Date Tested | % Air | Slump In's. | W/C Ratio | Comp. Str. (days) 3 | 7 | 14 |
|---|---|---|---|---|---|---|---|---|
| C1-1 | 5-19-78 | 5-26-78 | 5.6 | 2.5 | .531 | | 2770* | |
| C1-2 | 5-22-78 | 5-25-78 | 7.6 | 2.0 | .503 | 2070 | | |
| C1-3 | 5-22-78 | 5-25-78 | 5.5 | 1.25 | .503 | 2770 | | |
| C1-4 | 5-22-78 | 5-29-78 | 5.7 | 1.25 | .511 | | 3580 | |
| C1-5 | 5-22-78 | 6- 5-78 | 6.3 | 1.75 | .511 | | | 4670 |
| C1-6 | 5-22-78 | 6- 5-78 | 6.4 | 1.75 | .499 | | | 4870 |
| | | Average | 6.18 | 1.75 | .501 | 2420 | 3175 | 4770 |
| C2-1 | 5-22-78 | 5-25-78 | 6.5 | 1.25 | .481 | 2200 | | |
| C2-2 | 5-23-78 | 5-26-78 | 7.0 | 1.75 | .481 | 2700 | | |
| C2-3 | 5-24-78 | 5-31-78 | 5.5 | 1.5 | .434 | | 3400 | |
| C2-4 | 5-24-78 | 5-31-78 | 6.5 | 1.75 | .409 | | 3400 | |
| C2-5 | 5-24-78 | 6- 7-78 | 5.3 | 1.5 | .409 | | | 3790 |
| C2-6 | 5-24-78 | 6- 7-78 | 5.7 | 1.75 | .409 | | | 3430 |
| | | Average | 6.08 | 1.58 | .437 | 2450 | 3400 | 3610 |
| C3-1 | 5-24-78 | 5-31-78 | 6.0 | 1.0 | .405 | | 3900 | |
| C3-2 | 5-25-78 | 5-28-78 | 6.6 | 1.75 | .445 | 2580 | | |
| C3-3 | 5-25-78 | 5-28-78 | 5.3 | 1.5 | .445 | 2890 | | |
| C3-4 | 5-26-78 | 6- 2-78 | 5.5 | 0.75 | .445 | | 3580 | |
| C3-5 | 5-26-78 | 6- 9-78 | 5.7 | 1.0 | .445 | | | 4650 |
| C3-6 | 6- 2-78 | 6-16-78 | 7.2 | 2.0 | .418 | | | 4020 |
| | | Average | 6.05 | 1.33 | .434 | 2735 | 3740 | 4335 |
| C4-1 | 6- 2-78 | 6- 5-78 | 6.5 | 2.0 | .441 | 2360 | | |
| C4-2 | 6- 2-78 | 6- 5-78 | 5.5 | 1.25 | .441 | 2300 | | |
| C4-3 | 6- 2-78 | 6- 9-78 | 5.9 | 1.5 | .441 | | 3710 | |
| C4-4 | 6- 3-78 | 6-10-78 | 6.3 | 1.5 | .460 | | 3400 | |
| C4-5 | 6- 3-78 | 6-17-78 | 6.5 | 2.0 | .460 | | | 3770 |
| C4-6 | 6- 3-78 | 6-17-78 | 6.0 | 1.0 | .466 | | | 3840 |
| | | Average | 6.12 | 1.54 | .452 | 2330 | 3555 | 3805 |

*very porous

# COMPRESSIVE STRENGTH DATA - CYLINDERS

Monona County Project FM-67--55-67 HR-200

| Cylinder No. | Date Taken | Date Tested | % Air | Slump In's. | W/C Ratio | Comp. Str. (days) 3 | 7 | 14 |
|---|---|---|---|---|---|---|---|---|
| C5-1 | 6- 3-78 | 6- 6-78 | 6.6 | 2.0 | .466 | 2640 | | |
| C5-2 | 6- 5-78 | 6- 8-78 | 5.8 | 2.0 | .466 | 2830 | | |
| C5-3 | 6- 5-78 | 6-12-78 | 6.4 | 1.5 | .457 | | 3520 | |
| C5-4 | 6- 5-78 | 6-12-78 | 6.4 | 1.75 | .459 | | 3400 | |
| C5-5 | 6- 5-78 | 6-19-78 | 6.2 | 1.5 | .459 | | | 4400 |
| C5-6 | 6- 6-78 | 6-20-78 | 6.4 | 1.75 | .486 | | | 3960 |
| | | Average | 6.30 | 1.75 | .465 | 2735 | 3460 | 4180 |
| C6-1 | 6- 6-78 | 6- 9-78 | 5.7 | 1.75 | .522 | 2520 | | |
| C6-2 | 6- 6-78 | 6- 9-78 | 5.0 | 0.75 | .495 | 2520 | | |
| C6-3 | 6- 6-78 | 6-13-78 | 5.0 | 1.0 | .495 | | 3770 | |
| C6-4 | 6- 6-78 | 6-13-78 | 7.3 | 2.0 | .505 | | 4090 | |
| C6-5 | 6- 6-78 | 6-20-78 | 7.1 | 2.0 | .505 | | | 4780 |
| C6-6 | 6- 6-78 | 6-20-78 | 7.9 | 2.0 | .505 | | | 4150 |
| | | Average | 6.33 | 1.58 | .505 | 2520 | 3930 | 4465 |

| Cylinder No. | Mix Identification |
|---|---|
| C1-1 - C1-6 | B-4 |
| C2-1 - C2-6 | B410-1.5 |
| C3-1 - C3-6 | B615-1.5 |
| C4-1 - C4-6 | B615-1 |
| C5-1 - C5-6 | B610-1.5 |
| C6-1 - C6-6 | B-6 |

APPENDIX E

CORING DATA - LAB. NO.ACE8-581-677

Monona County Project FM-67(3) -- 55-67 HR-200

I N F O R M A T I O N A L T E S T S

| Mix No. | Station | Lab. No. | Core No. | Dist. ℄ | Age at Test Days | Corr. Str. PSI | Computed Str. PSI | | % Air Hard Conc. | Uncut Length |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 28 day | 1 year | | |
| 1 | 355+00 | 0584 | 3-2181 | 9.0R | 7 | 3760 | 5125 | 6660 | 7.5 | 6.00 |
| | 351+00 | 0585 | 3-2182 | 3.0L | 7 | 3800 | 5180 | 6735 | 7.8 | 6.55 |
| | 347+00 | 0586 | 3-2183 | 6.0R | 7 | 4040 | 5510 | 7160 | 6.9 | 5.80 |
| | 343+00 | 0587 | 3-2184 | 9.0L | 7 | 4740 | 6470 | 8405 | 5.9 | 6.10 |
| | 339+00 | 0588 | 3-2185 | 3.0R | 7 | 3470 | 4730 | 6150 | 8.6 | 6.25 |
| | | | Average | | | 3962 | 5403 | 7022 | 7.34 | |
| 2 | 334+00 | 0581 | 3-2178 | 9.0L | 7 | 3055 | 4170 | 5420 | 6.3 | 6.00 |
| | 329+00 | 0582 | 3-2179 | 3.0R | 7 | 3660 | 4990 | 6490 | 7.5 | 5.75 |
| | 315+00 | 0583 | 3-2180 | 6.0L | 7 | 3230 | 4410 | 5730 | 7.7 | 6.15 |
| | | | Average | | | 3315 | 4523 | 5880 | 7.17 | |
| 3 | 257+52 | 0600 | 3-2197 | 5.0L | 7 | 2695 | 3675 | 4775 | 9.2 | 6.15 |
| | 257+52 | 0601 | 3-2198 | 4.0R | 7 | 2525 | 3445 | 4480 | 10.2 | 6.35 |
| | 242+00 | 0605 | 3-2202 | 9.0L | 7 | 3050 | 4160 | 5405 | 5.9 | 6.00 |
| | 237+00 | 0606 | 3-2203 | 6.0R | 7 | 3005 | 4095 | 5325 | 8.4 | 6.10 |
| | 233+00 | 0607 | 3-2204 | 3.0L | 7 | 3060 | 4175 | 5425 | 8.0 | 6.30 |
| | | | Average | | | 2867 | 3910 | 5082 | 8.34 | |
| 4 | 223+00 | 0608 | 3-2205 | 9.0R | 7 | 3240 | 4420 | 5745 | 8.3 | 5.85 |
| | 212+00 | 0609 | 3-2206 | 6.0L | 7 | 2845 | 3880 | 5045 | 8.6 | 6.00 |
| | 202+00 | 0610 | 3-2207 | 3.0R | 7 | 3490 | 4760 | 6190 | 8.8 | 6.30 |
| | 192+00 | 0611 | 3-2208 | 9.0L | 7 | 2945 | 4015 | 5215 | 6.9 | 6.45 |
| | 182+00 | 0612 | 3-2209 | 6.0R | 7 | 2390 | 3260 | 4235 | 9.4 | 6.05 |
| | | | Average | | | 2982 | 4067 | 5286 | 8.40 | |
| 5 | 175+00 | 0613 | 3-2210 | 3.0L | 7 | 2745 | 3745 | 4865 | 8.5 | 5.85 |
| | 166+00 | 0614 | 3-2211 | 9.0R | 7 | 3080 | 4205 | 5465 | 6.9 | 6.60 |
| | 156+00 | 0615 | 3-2212 | 6.0L | 7 | 2775 | 3785 | 4920 | 9.6 | 6.30 |
| | 146+00 | 0616 | 3-2213 | 3.0R | 7 | 3140 | 4285 | 5570 | 6.0 | 6.10 |
| | 136+00 | 0617 | 3-2214 | 9.0L | 7 | 3165 | 4320 | 5615 | 7.2 | 5.75 |
| | | | Average | | | 2981 | 4068 | 5287 | 7.64 | |
| 6 | 125+00 | 0618 | *3-2215 | 6.0R | 7 | 3130 | 4270 | 5550 | 9.6 | 5.55 |
| | 126+00 | 0619 | E3-2216 | 6.0R | 7 | 3100 | 4230 | 5495 | 9.2 | 6.90 |
| | 124+00 | 0620 | E3-2217 | 6.0R | 7 | 3190 | 4350 | 5655 | 8.1 | 5.95 |
| | 119+00 | 0621 | 3-2218 | 3.0L | 7 | 2850 | 3885 | 5050 | 9.0 | 5.85 |
| | 114+00 | 0622 | 3-2219 | 9.0R | 7 | 3055 | 4170 | 5420 | 8.6 | 6.20 |
| | 105+00 | 0623 | 3-2220 | 6.0L | 7 | 3220 | 4390 | 5705 | 8.0 | 6.05 |
| | 100+00 | 0624 | 3-2221 | 3.0R | 7 | 3520 | 4805 | 6245 | 6.5 | 6.40 |
| | | | Average | | | 3152 | 4300 | 5588 | 8.43 | |

CORING DATA - LAB. NO.ACE8-581-677

Monona County Project FM-67(3) -- 55-67 HR-200

## I N F O R M A T I O N A L T E S T S

| Mix No. | Station | Lab. No. | Core No. | Dist. ℄ | Age at Test Days | Corr. Str. PSI | Computed Str. PSI | | % Air Hard Conc. | Uncut Length |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 28 day | 1 year | | |
| 1 | 361+00 | 0589 | 3-2286 | 9.0L | 17 | 4215 | 4815 | 6255 | 6.1 | 9.40 |
| | 356+00 | 0590 | 3-2187 | 6.0R | 14 | 3675 | 4195 | 5455 | 5.6 | 6.65 |
| | 353+00 | 0591 | 3-2188 | 3.0L | 14 | 4060 | 4635 | 6020 | 7.4 | 5.80 |
| | 347+00 | 0592 | 3-2189 | 4.0R | 14 | 3900 | 4455 | 5790 | 8.0 | 5.90 |
| | 340+00 | 0593 | 3-2190 | 7.0L | 14 | 4585 | 5240 | 6805 | 5.3 | 6.05 |
| | | | Average | | | 4107 | 4668 | 6065 | 6.48 | |
| 2 | 333+00 | 0594 | 3-2191 | 3.9R | 15 | 4085 | 4665 | 6065 | 6.6 | 5.60 |
| | 319+00 | 0595 | 3-2192 | 4.0L | 15 | 4880 | 5570 | 7240 | 5.1 | 6.50 |
| | 305+00 | 0596 | 3-2193 | 6.0R | 14 | 3920 | 4475 | 5815 | 7.9 | 6.50 |
| | 292+00 | 0597 | 3-2194 | 3.0L | 14 | 3720 | 4250 | 5520 | 7.3 | 6.70 |
| | | | Average | | | 4151 | 4740 | 6160 | 6.73 | |
| 3 | 280+00 | 0598 | 3-2195 | 1.5R | 15 | 4265 | 4870 | 6325 | 6.9 | 5.60 |
| | 272+00 | 0599 | 3-2196 | 6.0L | 15 | 3525 | 4025 | 5225 | 7.6 | 6.15 |
| | 262+00 | 0602 | 3-2199 | 3.0R | 14 | 3590 | 4100 | 5330 | 9.1 | 5.95 |
| | 253+00 | 0603 | 3-2200 | 9.0L | 14 | 3980 | 4545 | 5905 | 7.8 | 6.00 |
| | 247+00 | 0604 | 3-2201 | 6.0L | 14 | 3690 | 4215 | 5475 | 9.5 | 6.30 |
| | 238+00 | 0625 | 3-2222 | 9.0L | 14 | 3490 | 3990 | 5180 | 6.4 | 6.65 |
| | | | Average | | | 3757 | 4291 | 5573 | 7.88 | |
| 4 | 228+00 | 0626 | 3-2223 | 6.0R | 14 | 2585 | 2955 | 3840 | 8.8 | 5.90 |
| | 218+00 | 0627 | 3-2224 | 8.0R | 14 | 3880 | 4430 | 5670 | 7.5 | 6.30 |
| | 208+00 | 0628 | 3-2225 | 9.0R | 14 | 3585 | 4090 | 5315 | 6.6 | 6.20 |
| | 198+00 | 0629 | 3-2226 | 6.9L | 13 | 2040 | 2330 | 3025 | 9.1 | 5.80 |
| | 188+00 | 0630 | 3-2227 | 3.0R | 13 | 3215 | 3670 | 4770 | 12.5 | 5.85 |
| | | | Average | | | 3061 | 3495 | 4542 | 8.90 | |
| 5 | 178+00 | 0631 | 3-2228 | 9.0L | 14 | 3140 | 3585 | 4610 | 8.7 | 6.20 |
| | 168+00 | 0632 | 3-2229 | 6.0L | 14 | 3195 | 3650 | 4740 | 10.6 | 5.95 |
| | 158+00 | 0633 | 3-2230 | 3.0L | 14 | 3150 | 3600 | 4675 | 9.5 | 5.90 |
| | 148+00 | 0634 | 3-2231 | 9.0R | 14 | 3340 | 3810 | 4955 | 8.0 | 6.45 |
| | 138+00 | 0635 | 3-2232 | 6.0L | 14 | 2965 | 3390 | 4405 | 9.0 | 5.90 |
| | | | Average | | | 3158 | 3607 | 4687 | 9.16 | |
| 6 | 118+00 | 0636 | 3-2233 | 3.0R | 14 | 3080 | 3520 | 4575 | 9.1 | 5.80 |
| | 114+00 | 0637 | 3-2234 | 9.0L | 14 | 3615 | 4125 | 5365 | 7.1 | 5.90 |
| | 106+00 | 0638 | 3-2235 | 6.0R | 14 | 4255 | 4860 | 6315 | 7.6 | 6.40 |
| | 103+00 | 0639 | 3-2236 | 3.0L | 14 | 3930 | 4490 | 5835 | 7.9 | 5.80 |
| | 100+91 | 0640 | 3-2237 | 9.0R | 14 | 3790 | 4330 | 5625 | 7.1 | 6.80 |
| | | | Average | | | 3734 | 4265 | 5543 | 7.76 | |

CORING DATA - LAB. NO.ACE8-581-677

Monona County Project FM-67(3) -- 55-67 HR-200

## I N F O R M A T I O N A L T E S T S

| Mix No. | Station | Lab. No. | Core No. | Dist. ℄ | Age at Test Days | Corr. Str. PSI | Computed Str. PSI | | % Air Hard Conc. | Uncut Length |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 28 day | 1 year | | |
| 1 | 358+00 | 0641 | 3-2238 | 6.0R | 28 | 3440 | 3440 | 4470 | 7.5 | 6.00 |
| | 348+00 | 0643 | 3-2239 | 3.0L | 28 | 5005 | 5005 | 6510 | 5.8 | 6.15 |
| | 337+00 | 0644 | 3-2240 | 9.0R | 28 | 3990 | 3990 | 5185 | 11.5 | 6.45 |
| | 340+00 | 0645 | 3-2241 | 6.0L | 28 | 4365 | 4365 | 5675 | 11.9 | 6.10 |
| | | | Average | | | 4200 | 4200 | 5460 | 9.18 | |
| 2 | 310+00 | 0642 | 3-2242 | 3.0R | 27 | 5045 | 5045 | 6555 | 5.5 | 6.60 |
| | 327+00 | 0646 | 3-2243 | 6.0L | 28 | 4125 | 4125 | 5365 | 8.4 | 6.15 |
| | 317+00 | 0647 | *3-2244 | 3.0R | 28 | 5510 | 5510 | 7165 | 9.0 | 5.50 |
| | 318+00 | 0648 | E3-2245 | 3.0R | 29 | 5300 | 5300 | 6890 | 6.1 | 6.30 |
| | 316+00 | 0649 | E3-2246 | 3.0R | 29 | 5125 | 5125 | 6660 | 6.8 | 6.20 |
| | 307+00 | 0650 | 3-2247 | 9.0L | 28 | 4630 | 4630 | 6020 | 6.9 | 6.40 |
| | 296+00 | 0651 | 3-2248 | 6.0R | 28 | 4565 | 4565 | 5930 | 6.4 | 6.35 |
| | 286+00 | 0652 | 3-2249 | 3.0L | 28 | 4825 | 4825 | 6270 | 6.7 | 5.90 |
| | | | Average | | | 4891 | 4891 | 6357 | 6.98 | |
| 3 | 276+00 | 0653 | 3-2250 | 9.0R | 29 | 3350 | 3350 | 4355 | 8.7 | 6.60 |
| | 266+00 | 0654 | 3-2251 | 6.0L | 28 | 4690 | 4690 | 6095 | 6.8 | 6.20 |
| | 255+00 | 0655 | 3-2252 | 3.0R | 28 | 4190 | 4190 | 5445 | 7.9 | 6.05 |
| | 245+00 | 0656 | 3-2253 | 9.0L | 28 | 3610 | 3610 | 4695 | 6.6 | 5.80 |
| | 235+00 | 0657 | 3-2254 | 6.0R | 28 | 2770 | 2770 | 3600 | 7.7 | 6.30 |
| | | | Average | | | 3720 | 3720 | 4840 | | |
| 4 | 225+00 | 0658 | 3-2255 | 3.0L | 28 | 3520 | 3520 | 4575 | 9.7 | 5.90 |
| | 214+00 | 0659 | 3-2256 | 9.0R | 28 | 4450 | 4450 | 5785 | 8.7 | 6.10 |
| | 204+00 | 0660 | 3-2257 | 6.0L | 28 | 3700 | 3700 | 4810 | 8.8 | 6.25 |
| | 194+00 | 0661 | 3-2258 | 3.0R | 28 | 3390 | 3390 | 4405 | 9.2 | 5.85 |
| | 184+00 | 0662 | 3-2259 | 9.0L | 28 | 3380 | 3380 | 4395 | 8.9 | 6.35 |
| | | | Average | | | 3690 | 3690 | 4795 | | |
| 5 | 173+00 | 0663 | *3-2260 | 6.0R | | | | | | 5.65 |
| | 174+00 | 0664 | E3-2261 | 6.0R | 28 | 4970 | 4970 | 6404 | 6.2 | 6.10 |
| | 172+00 | 0665 | E3-2262 | 6.0R | | | | | | 5.70 |
| | 171+00 | 0666 | E3-2263 | 6.0R | 28 | 3800 | 3800 | 4940 | 8.4 | 5.95 |
| | 163+00 | 0667 | 3-2264 | 3.0L | 28 | 4060 | 4060 | 5280 | 7.8 | 5.90 |
| | 153+00 | 0668 | 3-2265 | 9.0R | 28 | 4210 | 4210 | 5478 | 6.8 | 6.15 |
| | 143+00 | 0669 | 3-2266 | 6.0L | 28 | 3280 | 3280 | 4264 | 9.0 | 6.60 |
| | 132+00 | 0670 | 3-2267 | 3.0R | 28 | 3250 | 3250 | 4225 | 7.8 | 6.10 |
| | | | Average | | | 3930 | 3930 | 5105 | | |

CORING DATA - LAB. NO.ACE8-581-677

Monona County Project FM-67(3) -- 55-67 HR-200

## I N F O R M A T I O N A L  T E S T S

| Mix No. | Station | Lab. No. | Core No. | Dist. ℄ | Age at Test Days | Corr. Str. PSI | Computed Str. PSI | | % Air Hard Conc. | Uncut Length |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 28 day | 1 year | | |
| 6 | 122+00 | 0671 | 3-2268 | 9.0L | 28 | 4240 | 4240 | 5510 | 5.8 | 6.75 |
| | 115+00 | 0672 | 3-2269 | 6.0R | | | | | | 6.10 |
| | 112+00 | 0673 | 3-2270 | 3.0L | 28 | 3650 | 3650 | 4745 | 8.2 | 6.30 |
| | 107+00 | 0674 | 3-2271 | 9.0R | 28 | 4780 | 4780 | 6215 | 5.7 | 6.60 |
| | 102+00 | 0675 | *3-2272 | 6.0L | | | | | | 5.50 |
| | 103+00 | 0676 | E3-2273 | 6.0L | 28 | 4530 | 4530 | 5890 | 6.9 | 6.00 |
| | 101+00 | 0677 | E3-2274 | 6.0L | 28 | 4630 | 4630 | 6020 | 4.6 | 6.60 |
| | | | Average | | | 4365 | 4365 | 5675 | | |

CYLINDER AND CORES

HR-200, "Fly Ash in P.C. Pavement - Monona County"

Appendix F

Compression Strength in PSI

| Mix 1 | Ave. | Calculated Ave. 28 day | 1 yr. |
|---|---|---|---|
| 3 day cylinders | 2420 | | |
| 7 day cylinders | 3175 | | |
| 14 day cylinders | 4770 | | |
| 7 day cores | 3962 | 5403 | 7022 |
| 14 day cores | 4107 | 4668 | 6065 |
| 28 day cores | 4200 | 4200 | 5460 |
| 6 month cores | | | |
| 1 year cores | | | |
| Mix 2 | | | |
| 3 day cylinders | 2450 | | |
| 7 day cylinders | 3400 | | |
| 14 day cylinders | 3610 | | |
| 7 day cores | 3315 | 4523 | 5880 |
| 14 day cores | 4151 | 4740 | 6160 |
| 28 day cores | 4891 | 4891 | 6357 |
| 6 month cores | | | |
| 1 year cores | | | |
| Mix 3 | | | |
| 3 day cylinders | 2735 | | |
| 7 day cylinders | 3740 | | |
| 14 day cylinders | 4335 | | |
| 7 day cores | 2867 | 3910 | 5082 |
| 14 day cores | 3757 | 4291 | 5573 |
| 28 day cores | 3720 | 3720 | 4840 |
| 6 month cores | | | |
| 1 year cores | | | |

CYLINDER AND CORES

HR-200, "Fly Ash in P.C. Pavement - Monona County"

Appendix F
Cont.

Compression Strength in PSI

| Mix 4 | Ave. | Calculated Ave. 28 day | 1 yr. |
|---|---|---|---|
| 3 day cylinders | 2330 | | |
| 7 day cylinders | 3555 | | |
| 14 day cylinders | 3805 | | |
| 7 day cores | 2982 | 4067 | 5286 |
| 14 day cores | 3061 | 3495 | 4542 |
| 28 day cores | 3690 | 3690 | 4795 |
| 6 month cores | | | |
| 1 year cores | | | |
| Mix 5 | | | |
| 3 day cylinders | 2735 | | |
| 7 day cylinders | 3460 | | |
| 14 day cylinders | 4180 | | |
| 7 day cores | 2981 | 4068 | 5287 |
| 14 day cores | 3158 | 3067 | 4687 |
| 28 day cores | 3930 | 3930 | 5105 |
| 6 month cores | | | |
| 1 year cores | | | |
| Mix 6 | | | |
| 3 day cylinders | 2520 | | |
| 7 day cylinders | 3930 | | |
| 14 day cylinders | 4465 | | |
| 7 day cores | 3152 | 4300 | 5588 |
| 14 day cores | 3734 | 4265 | 5543 |
| 28 day cores | 4365 | 4365 | 5675 |
| 6 month cores | | | |
| 1 year cores | | | |

SUMMARY CONCRETE TEST DATA
Monona County Fly Ash Research
FM-67(3)--55-67
HR-200

| Mix* | Mod. of Rupt. -- Days 7 | 14 | 28 | 56 | Cylinders -- Days 3 | 7 | 14 | Cores -- Days 7 | 14 | 28 | Durability |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 601 | 638 | 710 | 773 | 2420 | 3175 | 4770 | 3962 | 4107 | 4200 | 86 |
| 2 | 552 | 632 | 652 | 724 | 2450 | 3400 | 3610 | 3315 | 4151 | 4891 | 86 |
| 3 | 585 | 668 | 643 | 768 | 2735 | 3740 | 4335 | 2867 | 3757 | | 88 |
| 4 | 544 | 608 | 671 | 705 | 2330 | 3555 | 3805 | 2982 | 3061 | | 92 |
| 5 | 434 | 592 | 682 | 716 | 2735 | 3460 | 4180 | 2981 | 3158 | | 92 |
| 6 | 552 | 686 | 726 | 758 | 2520 | 3930 | 4465 | 3152 | 3734 | | 92 |

*1 B-4  2 B-4 10-1.5  3 B-6 15-1.5  4 B-6 15-1  5 B-6 10-1.5  6 B-6

Average Water-Cement Ratios - Air - Slump

| Design Mix No. | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Design W/C | .536 | .469 | .430 | .441 | .450 | .537 |
| Ave. W/C @ beams | .507 | .435 | .440 | .452 | .462 | .511 |
| Ave. Field W/C | .513 | .428 | .440 | .448 | .457 | .506 |
| Ave. % Air - Field | 6.2 | 6.0 | 6.0 | 6.2 | 6.4 | 6.8 |
| Ave. Slump - Inches | 1.88 | 1.75 | 1.30 | 1.50 | 1.75 | 1.70 |