POZZOLAN CEMENT STUDY

Final Report

by

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METRIC CONVERSION CHART

To convert U.S. units to metric units, the following conversion factors should be used:

Multiply U.S. Units	By	To Obtain Metric Units
inches (in.)	2.5400	centimeters (cm.)
feet (ft.)	0.3048	meters (m.)
yards (yds.)	0.9144	meters (m.)
square inches (in^2)	6.4516	square centimeters (cm^2)
square feet (ft^2)	0.0929	square meters (m^2)
square yards (yd^2)	0.8361	square meters (m^2)
cubic inches (in^3)	16.3872	cubic centimeters (cm^3)
cubic feet (ft^3)	0.0283	cubic meters (m^3)
cubic feet (ft^3)	28.3162	liters (l.)
cubic yards (yd^3)	0.7646	cubic meters (m^3)
pounds (lbs.	0.4536	kilograms (kgs.)
pounds (lbs.)	453.592	grams (g.)
gallons (gal.)	3.7853	liters (l.)
ounces (oz.)	0.03	liters (l.)
pounds per square inches (p.s.i.)	0.0703	kilograms per square centimeter ($kgs./cm.^2$)
pounds per cubic feet ($lbs./ft.^3$)	16.091	kilograms per cubic meter ($kgs./m.^3$)
miles per hour (mph)	1.609	kilometers per hour (km./hr.)

ABSTRACT

An experimental section using Type 1P cement concrete was poured on an active construction project in south Louisiana,near Franklin. A comparison in quality was made between this section and the normal Type 1(B) cement concrete poured on the remainder of the project.

In-place tests such as slump, air temperature, concrete temperature, air content and unit weight were run on both the Type 1-P cement concrete and the Type 1(B) cement concrete. Additionally, cylinders and beams were cast for later laboratory tests for strength comparison, durability and 28 day abrasion. Field tests such as skid resistance, Mays Meter rideability and Dynaflect deflection were run on the pavement at different ages.

Mixing, transportation and placing of the Type 1P cement concrete created no problems. The Type 1P cement concrete was a more workable mix for the same slump ranges as compared to the Type 1(B) cement concrete. Finishing of the Type 1P cement concrete was much easier than finishing of the Type 1(B) mix, additionally the transverse tined finishing was not affected by the change in type of cement.

Results of the in-place tests indicate that both mixes are comparable, with only the air contents differing by approximately 1%. Strength tests also indicate that the mixes are comparable, with strengths at later age bringing the Type 1P cement concrete up to the regular mix. Durability tests indicate that the Type 1P cement concrete is less durable than the reference concrete, however, freeze-thaw test results on the Type 1P specimens can be questioned because of equipment malfunctions affecting the procedures. Field test results for skid resistance and rideability show that the Type 1P section is slightly better in these two categories.

It is recommended that Type 1P cement be allowed as an alternate for use in all concrete, except for wearing surfaces under traffic in pavements or bridge decks. It is recommended that Type 1P cement be allowed for use in both cast-in-place and precast structural elements with the above mentioned exception of bridge decks. Another recommended exception is that Type 1P cement should not be utilized in soil cement construction at this time. The wearability of surfaces under traffic should be evaluated for a longer period of time before any recommendations are considered for these surfaces.

The alternate use of Type 1P cement should be accomplished without changing physical specification requirements for the various types of concrete mixes involved.

Research evaluation will continue concerning wearability under traffic of concrete pavement containing Type 1P cement as well as is possible use for soil cement construction.

IMPLEMENTATION STATEMENT

As recommended in this report, a specification revision to Part IX, "Portland Cement Concrete", of the 1977 Louisiana Standard Specifications for Roads and Bridges, Department of Transportation and Development, Office of Highways, allowing the use of Type 1P cement was approved by the Chief Engineer and included in construction proposals, beginning with the October 31, 1979 letting. A copy of the supplemental specifications is in the Appendix.

INTRODUCTION

Portland-Pozzolan (Type 1P) cement is a cement in which a portion of the total volume contains pozzolanic materials. Type 1P cement is a blended, processed and quality controlled material, not a field mixed material. A pozzolan is defined as siliceous or siliceous and aluminous material, which in itself possesses little or no cementitious value. In finely divided form and in the presence of moisture, it will chemically react with calcium hydroxide at ordinary temperatures to form compounds possessing cementitious properties. Since the majority of the available Portland-Pozzolan blended hydraulic cements (Type 1P) substitute a pozzolan for approximately twenty percent (20%) of the Type 1 cement, this would seem to allow a broader base of cements to be used, resulting in more availability of materials and more competition.

The Florida Department of Transportation has a Type 1P cement option, allowing it as an alternate to Type 1 in all classes of concrete and soil-cement work, subject to the conditions as shown in the Appendix. It is realized from the state-of-the-art that these are solely Florida's requirements, and other states may differ in their requirements and/or approach, and that some states may not have any requirements or prohibit the use of this type material.

PURPOSE AND SCOPE

The specific aim or purpose of this experimental construction was to determine if concrete made with Louisiana aggregates and Portland-Pozzolan cement (Type 1P) could be used in pavement or structural construction without sacrificing the present quality of concrete mixes. The field construction project selected and used for the experimental section was Project No. 424-05-12, Garden City-Franklin. This field study was aimed primarily at comparing Type 1P cement concrete with the normal Type 1 cement concrete (in this case, Type 1(B) cement concrete) and reporting the quality of this paving.

The research study scope consisted of comparisons of strength, freeze-thaw durability, abrasion resistance, workability, skid resistance, deflections and rideability of the pavement. This was accomplished by field workability measurements and sampling the concrete mixes through casting of concrete cylinders and beams, along with later laboratory testing of these field specimens. These tests were made at various ages: 7 days, 28 days, 56 days, 6 months and 12 months. Field evaluation will be continued for a 5-year period, with measurements taken at 1-year intervals.

METHODOLOGY

The research study effort was principally divided into three phases as follows: (1) the field installation phase with field observations; (2) the phase involving determination of field test properties of concrete and the laboratory testing of the field cast concrete specimens for strength, freeze-thaw durability, dry shrinkage and 28-day abrasion resistance; and (3) field performance testing phase such as texture depth, rideability and skid resistance measurements.

Field Installation Phase

Study effort was centered around evaluation and comparison of two mix designs, one with a Type 1P cement and the other, a reference mix with Type 1(B) cement. Field observations were made of the concrete mixing, transportation of the concrete and concrete placement. The slip-form placement and performance, along with the workability of the mixes, (Type 1P mix and reference Type 1(B) mix) were noted, in addition to other key possible problem areas such as spreading, compacting and finishing. Water requirements of the concrete mixes were noted and recorded.

Concrete Properties and Laboratory Testing Phase

Test property determinations included: slump, air temperature, plastic concrete temperature, air content and unit weight on both mixes in the field. Concrete test specimens were cast in the field and allowed to cure for an adequate period until ready to be transported into the laboratory for testing. Specimens cast included the following for each concrete mix design: 30 - 6" x 12" concrete cylinders for compressive strengths and splitting tensile strengths, 21 - 3" x 4" x 16" concrete beams for freeze-thaw testing, flexural strength testing (modified) and abrasion resistance testing, and 3 - 3" x 3" x 11 1/4" concrete beams for dry shrinkage testing.

Three (3) 6" x 12" concrete cylinders were each tested on both mix designs at 7 days, 28 days, 56 days, 6 months and 12 months age for both compressive strengths and splitting tensile strengths under ASTM Designations: C-39 and C-496.

Three (3) 3" x 4" x 16" concrete beams were each tested in both mix designs at 7 days, 28 days, 56 days, 6 months and 12 months age for flexural strengths under ASTM Designation: C-293 (modified).

Three (3) 3" x 4" x 16" concrete beams on both mix designs were subjected to freeze-thaw tests under ASTM Designation: C-666, Procedure B.

Three (3) 3" x 4" x 16" concrete beams on both mix designs were tested for abrasion resistance at 28 days age under ASTM Designation: C-418.

Three (3) 3" x 3" x 11 1/4" concrete beams molded as required on both mix designs were tested for dry shrinkage under ASTM Designation: C-490.

Field Performance Phase

Initial texture depths were determined by the sand-patch method (La. DOTD Designation: Tr-617) on both the Type 1P cement concrete section and the Type 1(B) reference cement concrete section. After the pavement section is opened to traffic, measurements will be taken at 1-year intervals for a period of 5-years.

Initial Mays Meter rideability determinations were also run on both the respective test sections, and Present Serviceability Indices (P.S.I.'s) were obtained. As with the texture depths, later determinations will be made.

Initial skid resistance tests were run on each test section at speeds of 30, 40 and 50 mph. All skid resistance measurements were made using a skid testing trailer conforming to ASTM E-274. A skid number is the coefficient of friction x 100. The speed gradient is the slope of the line plotted with skid numbers versus designated speeds. Additional skid resistance tests will be run at 1-year intervals for a period up to 5-years.

Dynaflect deflections were obtained on the asphalt concrete subbase on each test section before the paving was placed. Then initial deflections were taken on each concrete pavement for the test sections. Additional deflections will be obtained at 1-year intervals for a period up to 5-years.

These additional measurements over a 5-year period will be taken to evaluate these sections for loss of field performance properties over an extended period of time.

INSTALLATION

Project Information

State Project No. 424-05-12
Garden City-Franklin
St. Mary Parish, Louisiana

Type 1P Section: Station 498 + 08 to Station 518 + 20 Eastbound Lane

Sampling Locations:	Type 1P	Reference-Type 1(B)
	Station 499 + 10	Station 547 + 50
	Station 503 + 50	Station 557 + 00
	Station 512 + 00	Station 563 + 50

Type 1P Mix Design* for 1 Cu. Yd. of Concrete:

Cement (Type 1P, Dundee)	545 lbs.
Fine Aggregate	1183 lbs.
Coarse Aggregate	1958 lbs.
Water	20 gal.
Set Retarding, Water Reducing Admixture	46.4 oz.
Air Entraining Admixture*	2.9 oz.
w/c ratio	0.31

*Designed for 4% Air in Mix

Field Observations

The Type 1P cement did not create any mixing problems. Batches did not require longer mixing times or any changes in drum revolutions. The batches were mixed in a stationary drum mixer and, generally, transported to the paver in end dump concrete transporters. No segregation in hauling was noted, and the batches were easily dumped and did not leave build-up in the truck beds.

The Type 1P cement concrete was a more workable mix for the same slump ranges as compared to the Type 1(B) cement concrete. The pozzolan mix worked better at the paver than the normal mix in that the paver load "tucked" under the strike-off and pan vibrators without the "shearing" of the normal concrete at the front end of the paver. This workability, as seen at the paver, may give improved compaction under vibration.

The contractor's personnel indicated that finishing of the Type 1-P cement concrete was much easier than finishing of the Type 1(B) mix with which they were currently working.

The type 1P mix stood up at the edges behind the slip forms as well as the normal mix even though workability obviously was improved. No difficulties were encountered with the pozzolan cement in longitudinal joint tie steel placement, transverse joint and load transfer placement, plastic transverse joint former placement and all finishing used in conjunction with these operations.

The transverse tined finishing was not adversely affected by the Type 1P cement. The general workability of the mix may allow a longer time period to tine-finish the surface as compared to the normal concrete containing Type 1(B) cement.

The field observations for this installation would substantiate the state-of-the-art of pozzolanic cement concrete to the effect that it does increase the mix workability without altering other physical properties such as slump. The Type 1P cement enhanced the mix's properties in the field from mixing, hauling, spreading, compacting and finishing through the application of the tined finish.

DISCUSSION OF RESULTS

Field Test Properties

		Type 1P	Reference-Type 1(B)
Slump Ranges	-	1 1/2" - 2"	1 1/4" - 1 3/4"
Air Temp. Ranges	-	88°F - 94°F	88°F - 96°F
Conc. Temp. Ranges	-	87°F - 90°F	91°F - 94°F
Air Content Ranges	-	4% - 5.7%	5.8% - 6.5%
Unit Weight Ranges	-	142.8 - 145.0 lbs./ft^3	142.0 - 144.4 lbs./ft^3

Results of the in-place tests indicate that both mixes are comparable. The only variation appeared to be in the air content of the mixes, with the Type 1P mix having approximately 1% less air than the reference concrete, however, the mix for the Type 1P cement concrete was designed for 4% air. Type 1P concrete needs less air than Type 1(B) concrete because of more workability inherent in this type of concrete.

Test Results

All strength results shown below and on the following page are average values of three specimens for each type mix and at each age, with these specimens being sampled one at each of the three locations noted on page 6.

Average Compressive Strengths (p.s.i.) -	Age	Type 1P	Reference-Type 1(B)
cylinders	7 days	2936	3121
"	28 days	3637	3772
"	56 days	3808	3952
"	6 mos.	4491	4534
"	12 mos.	4850	4732
cores		(5978 @ 161 days)	(5733 @ 156 days)
"		(6201 @ 182 days)	(6021 @ 177 days)

	Age	Type 1P	Reference-Type 1(B)
Average Splitting Tensile Strengths (p.s.i.) -	7 days	255	292
	28 days	336	369
	56 days	383	313*
	6 mos.	437	456
	12 mos.	417*	411*
Average Flexural Strengths (p.s.i.) -	7 days	463	607*
	28 days	595	598
	56 days	703	715
	6 mos.	742	748
	12 mos.	852	869

*Note: These test results appear to be out-of-line and are possibly questionable. However, since the overall evaluation is not affected significantly these value deviations will not be discussed any further.

Seven (7) day strength results indicate that Type 1P cement concrete strengths are slightly lower than the Type 1(B) cement concrete strengths. The twenty-eight (28) and fifty-six (56) day strengths show that Type 1P cement concrete has gained slightly more strength than the reference concrete and at six (6) months both of the types of concrete are comparable in strength. Core strengths indicate that the Type 1P cement concrete, strengths at approximately 160-180 days are slightly higher than the reference concrete.

Durability:

Freeze-Thaw Tests -

	Type 1P D.F.	Type 1P Cycles	Reference-Type 1(B) D.F.	Reference-Type 1(B) Cycles
Field Test Results -	11.67	58	23.00	115
Subseq. Lab. Results (ck.) -	27.20	136	19.00	95
Previous Lab. Results (1973) -	27.10	-	28.30	-

	Type 1P	Reference-Type 1(B)
28 day Abrasion -	0.05 cm^3/cm^2	0.03 cm^3/cm^2
Length Change of Hardened Concrete:	Avg. 2.39% decrease (32 wks.)	Avg. 1.80% decrease (32 wks.)

As shown in the results above on the freeze-thaw tests, the type 1P cement concrete durability factor and the number of cycles to failure for the field test results were approximately half as much as the reference concrete, in other words, less durable; however, there was a breakdown of the freeze-thaw machine at a critical time (the beginning of the test period after the initial readings) on the Type 1P cement concrete beam specimens. An initial modulus reading had already been taken, and when the breakdown occurred, the beams were placed in a frozen state for approximately 3 days, as suggested by ASTM. When the freeze-thaw machine was repaired, normal cycling in the freeze-thaw machine was begun. There is some question as to what effect this had on these specimens. 28 day abrasion data indicate results are comparable, although some are slightly higher for the Type 1P specimens.

As a result of questions on the durability results, laboratory concrete specimens were prepared using Type 1P and Type 1(B) cement and freeze-thaw tests were run. Results are shown above under Durability, labelled Subseq. Lab. Results (ck.). More reasonable comparative results were obtained, with the Type 1P specimens going 136 cycles and a durability factor of 27.20, as compared to the Type 1(B) specimens with 95 cycles and 19.00 durability factor. These Type 1P specimens prepared in the laboratory were obviously more durable in freeze-thaw terms as compared to the field prepared samples.

Also listed on the previous page are freeze-thaw test results from some laboratory testing done in 1973 (not on a research study, but from some exploratory testing). In this series of testing, the Type 1P cement concrete specimens (with air) showed a durability factor of 27.10, which compares favorably with the 28.30 found in regular Type 1 cement concrete (with air) and also is nearly identical with the latest laboratory results of 27.20 for the Type 1P cement concrete specimens (with air). These results are considerably higher than the 11.70 durability factor found on the Type 1P cement concrete field specimens. This seems to reinforce the premise that the field test specimens for the Type 1P cement concrete were somehow affected by the breakdown of the freeze-thaw equipment.

After a review of available literature sources, it was found that the other researchers generally agree that Type 1P cement concrete with air-entrainment would provide satisfactory freeze-thaw durability comparable with regular Type 1 cement concrete with air-entrainment. Also, strengths would start off slightly lower than the regular Type 1 concrete, but generally would gain strength better and would overtake the Type 1 concrete at a later date, sometime after the 28 day strength tests. Actual comparisons of the durability factors by other researchers are not feasible due to the varying conditions and materials present in the study designs.

For the same workability, Type 1P cement concrete needs less air than Type 1 cement concrete because of more workability inherent in this type of concrete. Actual air contents found in the field on this study were from 4% to 5.7% for Type 1P and from 5.8% to 6.5% for Type 1(B) cement concrete. It is felt that this air content was needed in these mixes for better durability as a prerequesite. Type 1P cement concrete should have satisfactory freeze-thaw durability, when used with air and if adequate curing is provided.

Field Evaluations

Initial Skid Resistance (SN):
(average of 3)

Speed, mph	Type 1P	Reference-Type 1(B)
50	Ave. SN = 63	Ave. SN = 61
	Range SN = 59.8 - 66.4	Range SN = 51.2 - 67.7
40	Ave. SN = 59	Ave. SN = 59
	Range SN = 50.9 - 65.1	Range SN = 56.0 - 59.8
30	Ave. SN = 68	Ave. SN = 64
	Range SN= 63.8 - 71.1	Range SN = 61.1 - 67.7
Initial Texture Depth: (average of 10)	Avg. - 0.045"	Avg. - 0.044"
Initial Mays Meter Rideability: (Present Serviceability Indices)	Avg. 3.7 P.S.I.	Avg. 3.5 P.S.I.

Results above show that the initial skid resistance SN's at 50, 40 and 30 mph for the Type 1P cement concrete section are either equal to or slightly higher than the Type 1(B) cement concrete section. Initial Mays Meter rideability test results (Present Serviceability Indices, P.S.I.) above show that the Type 1P cement concrete (reference) section.

Dynaflect Deflection Tests:

Reference Section, Type 1(B)-PCC

Date	Age	Type Constr.	Avg. Defl. (In x 10^{-3})	Total SN'	Total Thick. Coeff.	PCC Coeff.
8/11/78	---	3.5" Black Base (BB)	1.28	1.60	0.46	---
8/16/78	---	9.2" PCC Poured	----	----	----	---
10/17/78	2 mo.	PCC/BB	0.55	5.40	0.43	0.41
12/6/78	4 mo.	PCC/BB	0.55	5.40	0.43	0.41
7/5/79	11 mo.	PCC/BB	0.52	5.40	0.43	0.41

Type 1P-PCC Section

Date	Age	Type Constr.	Avg. Defl. (In x 10^{-3})	Total SN'	Total Thick. Coeff.	PCC Coeff.
8/11/78	---	4.0" Black Base (BB)	1.45	2.00	0.50	---
8/11/78	---	9.0" PCC Poured	----	----	----	---
10/17/78	2 mo.	PCC/BB	0.66	5.10	0.39	0.34
12/6/78	4 mo.	PCC/BB	0.60	5.40	0.42	0.38
7/5/79	11 mo.	PCC/BB	0.66	5.00	0.38	0.33

SN = Structural Number

The average deflections (In x 10^{-3}) shown above have been translated into structural numbers (Total SN'), which normally are the units of strength used in the AASHTO flexible pavement design; however, in this case, concrete sections are compared for structural numbers. Strength coefficients are calculated by dividing the increase in SN' due to a given pavement layer by the particular layer thickness in indexes.

Deflection tests were conducted at eleven locations (0.2 mile sections) on the black base for both the Type 1(B) reference concrete and the Type 1P test section. After the concrete was poured and set up, deflection tests were conducted on the two sections at 2, 4 and 11 month ages. Deflection tests were run on the center of the slabs.

Results show that both the Type 1P and the regular Type 1(B) PCC sections have deflections, structural numbers and coefficients for the concrete portion approximately the same. However the concrete structural number and coefficients of the test sections were lower than expected. Generally, we have found from previous experience, although normally you don't associate SN's with concrete sections, if one does use a structural number calculation, a good PCC section should have a better than 0.45 coefficient when evaluated. At least, one should be expected to have a better value than hot mix.

CONCLUSIONS

1. Overall, the Type 1P cement concrete was comparable in quality to the Type 1(B) cement concrete, as constructed on the experimental section of this construction project.

2. Concrete strength results indicate that the Type 1P cement concrete concrete is comparable in quality to the Type 1(B) cement concrete poured on this construction project. Early strengths are slightly lower for the Type 1P cement concrete, however strengths at later ages are on a par with the Type 1(B) cement concrete.

3. Initial skid resistance tests, along with initial Mays Meter rideability tests, indicate that Type 1P cement concrete is comparable, or slightly better, in both these categories, to the Type 1(B) cement concrete.

4. The Type 1P cement did not create any mixing problems nor require any longer mixing time.

5. The Type 1P cement concrete was a more workable mix for the same slump ranges as compared to the Type 1(B) cement concrete.

6. Finishing of the Type 1P cement concrete was much easier than finishing of the Type 1(B) cement concrete, as related by the contractors personnel.

7. Placement and finishing (tine) was not adversely affected by the Type 1P cement.

8. Freeze-thaw field test results and 28 day field abrasion test results appear to indicate that the Type 1P cement concrete is less durable than the Type 1(B) cement concrete, at least at the earlier

age which the tests were conducted. However, since there was a breakdown of the freeze-thaw machine at a critical time on the Type 1P beam specimens, there is some question as to what effect this had on the specimens.

9. Type 1P cement concrete showed more of a decrease in length of the hardened concrete as determined through the test, ASTM Designation: C-490, measurement of length change of hardened cement paste, mortar and concrete.

10. Deflection results indicated that the two test sections are comparable in structural number and coefficients for the concrete portions of each, although both appear to be slightly lower than expected.

RECOMMENDATIONS

The wearability of surfaces under traffic on pavements and bridge decks should be evaluated for a longer period of time before any recommendations are considered for these surfaces.

The alternate use of Type 1P cement should be accomplished without changing physical specification requirements for the various types of concrete mixes involved. Suggested supplemental specifications are as follows:

SUGGESTED SUPPLEMENTAL SPECIFICATIONS

PORTLAND CEMENT CONCRETE: Section 901 of the Standard Specifications for Roads and Bridges is amended as follows:

Subsection 901.02 is amended to include Portland-Pozzolan Cement (Type 1P) conforming to Subsection 1001.03.

Subsection 901.07(a) is amended to include Type 1P cement for use in concrete in (1) minor structures and (2) cast-in-place, prestressed or precast structural elements, except wearing surfaces on bridge decks. Type 1P cement shall not be used in concrete for the wearing surfaces under traffic in pavements or bridge decks.

Type 1P cement should be subject to the following conditions:

(a) Type 1P Portland-Pozzolan Cement shall meet the requirements of ASTM C-595, except that the pozzolan constituent (flyash or bottom ash) shall not exceed 20 percent by weight.

(b) The pozzolan shall conform to ASTM C-618, Type F, except that the loss on ignition shall not exceed 6 percent.

(c) The contractor shall assume full responsibility for obtaining concrete having the minimum strength requirements set forth in the appropriate specifications.

Research evaluation will continue concerning wearability under traffic of concrete pavement containing Type 1P cement as well as its possible use for soil cement construction.

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APPENDIX

FLORIDA DOT POZZOLAN SPECIFICATIONS

Florida Department of Transportation Directive No. 0521-029, May 16, 1973
Subject: Type 1P Cement and use of Fly Ash in Concrete
Specifications as follows:

<u>Type 1P Cement Option</u>

Type 1P cement will be allowed as an alternate to Type 1 in all classes of concrete and soil cement work subject to the following conditions:

a) Type 1P Portland-Pozzolan Cement shall meet the requirements of ASTM C-595 except that the pozzolan constituent (fly ash) shall not exceed 20 percent by weight.

b) The pozzolan shall conform to ASTM C-618, Type F, except that the loss on ignition shall not exceed 6 percent.

c) Type 1P cement will not be permitted in prestressed concrete members.

d) The contractor shall assume full responsibility for obtaining concrete having the minimum strength requirements set forth in the specifications.

e) The minimum time for removal of forms shall be extended by two days beyond that shown for Normal-Strength Concrete in Section 400 of the standard specifications for floor slabs of bridges, top slabs of culverts, bottoms of pile bent caps, forms under sidewalk, and safety curb overhangs extending more than two feet.

Fly Ash Option

Fly Ash may be used to replace up to 20 percent by weight of the cement content in all classes of concrete where Type I, Type II or Type III cement is used, in accordance with the following conditions:

a) The fly ash shall conform to ASTM C-618, Type F, except that the loss on ignition shall not exceed 6 percent.

b) Fly ash will not be permitted with Type I-S or I-P cement.

c) Fly ash will not be permitted in prestressed concrete members.

d) The contractor shall assume full responsibility for obtaining concrete having the minimum strength requirements set forth in the specifications.

e) The minimum time for removal of forms shall be extended by two days beyond that shown for Normal-Strength Concrete in Section 400 of the standard specifications for floor slabs of bridges, top slabs of culverts, bottoms of pile bent caps, forms under sidewalk, and safety curb overhangs extending more than two feet.

In order to implement the use of Type 1P Cement, and the use of Fly Ash in conjunction with other type cements, the following guidelines are furnished for the information and benefit of Department field personnel:

1) Each such change must be documented by Supplemental Agreement although the District Construction Engineers may authorize approval to proceed while the document is being processed.

2) A Design Mix must be issued by the Division of Materials and Research before the change can be initiated.

3) The use of Type 1P cement, or fly ash added in conjunction with other type cement, should result in a slightly lower water/cement ratio which will be reflected in the design mix.

4) Type 1P cement or fly ash added to other cements will generally require a significantly increased amount of air entraining agent to obtain the desired air content in the concrete mix. Consequently, more frequent air tests should be made for initial adjustment and to insure proper control of entrained air.

5) Type 1P cement may be accepted for use by certification, and test samples submitted at the same frequency required for other approved types of cement.

6) Fly ash may be accepted for use upon certification that it meets the appropriate specification. A one quart verification sample shall be submitted to the Central Laboratory for each 1,500 cubic yards of concrete containing fly ash batched.

7) Before approving a request to add fly ash as a separate ingredient at the concrete plant, a thorough inspection should be made of the plant to ascertain that it has the proper facilities for storage, handling and batching of the fly ash. Separate facilities must be provided for the fly ash such that it will be stored in the same fashion as cement and batched and weighed to the same degree of accuracy as required for cement. The same scales

may be used for weighing both cement and fly ash provided they are handled as a separate operation. The Central Laboratory will be available to assist in the inspection of concrete plants for this purpose.

8) It has been generally substantiated that carefully controlled use of a high quality fly ash can improve the quality of concrete. The use of fly ash in concrete slows down the initial set and the concrete does not gain strength as rapidly in the first few days. Consequently, some adjustment may be necessary in the finishing operations and forms must be kept in place somewhat longer for load bearing members on account of this.

LOUISIANA OFFICE OF HIGHWAYS
SUPPLEMENTAL SPECIFICATIONS

PORTLAND CEMENT CONCRETE

Part IX, Portland Cement Concrete of the Standard Specifications is amended as follows

SECTION 901, PORTLAND CEMENT CONCRETE

901.02 MATERIALS. This subsection is amended to include Portland-Pozzolan Cement conforming to Subsection 1001.03.

901.05, QUALITY CONTROL OF CONCRETE: The second and third paragraphs under Heading (b), Control Tests, of this Subsection are deleted and the following substituted therefor.

For structural concrete, slump testing and (when required) air content testing shall be performed by lot as defined in Subsection 805.18.

For pavement concrete, a minimum of two slump tests and two air content tests shall be randomly taken during each half day of paving operations. When deemed necessary by the engineer for proper control, additional samples shall be taken as directed and tested for slump and (when required) air content.

901.07 COMPOSITION OF CONCRETE. Heading (a) is amended to include Type IP cement for use in (1) minor structures, and (2) cast-in-place, prestressed or precast structural elements, except wearing surfaces on bridge decks. Type IP cement shall not be used in concrete for the wearing surfaces under traffic in pavements.

901.12, MIXING AND TRANSPORTING CONCRETE: The third and fourth paragraphs under Heading (c), Truck Mixing are amended as follows:

The third sentence of the third paragraph is revised to read as follows. When a truck mixer is used for complete mixing, each batch shall be mixed for not less than 70 nor more than 130 revolutions of the drum or blades at the rate of rotation designed as mixing speed by the manufacturer of the equipment on the metal plate on the mixer.

The fourth paragraph is deleted and the following substituted therefor. When the prescribed water is added at the batching plant and the slump is on the low side at the delivery site, it will be permissible to add a minimum of 75 percent of the mixing water at the time the cement and aggregates are added at the batching plant and the remaining mixing water at the job site prior to discharging concrete into forms. The remaining water that is added at the job site may be added in one or two increments with additional mixing within the range of 20 to 30 revolutions at designated mixer speed required for each increment, however in no case will the total of 130 revolutions be exceeded. The truck mixer shall be equipped with means for accurately measuring the amount of water used in each batch. The water added at the job site shall not cause the maximum allowable water-cement ratio of the batch to be exceeded.

901.14, ACCEPTANCE AND PAYMENT SCHEDULE: Heading (c) of this Subsection is deleted and the following substituted therefor.

When structural concrete is incidental to an item or not a direct pay item, lot sizes, sampling and acceptance testing for the actual required quantities shall be in accordance with Subsection 805.18. The value for each cubic yard required shall be assessed at 120 dollars for the purpose of applying the price adjustment percentages in Schedule A. The amount of the price adjustment for the quantity of concrete will be deducted from payment as required.

NOTE: The contractor is advised that acceptance and payment schedules shall apply to the bid item itself for cast-in-place piling and in this case the assessment value of Heading (c) will not apply.

SECTION 902, PORTLAND CEMENT CONCRETE FOR MINOR STRUCTURES

902.03, ACCEPTANCE AND PAYMENT SCHEDULE: Heading (b) of this Subsection is deleted and the following substituted therefor.

When minor structure concrete is incidental to an item or not a direct pay item, sampling and acceptance testing for the actual required quantities shall be in accordance with this Section 902. The value for each cubic yard of concrete required shall be assessed at 120 dollars for the purpose of applying the price adjustment percentages of Schedule B. The amount of the price adjustment for the quantity of concrete involved will be deducted from payment as required.