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HR-192 ?

HIGHWAY DIVISION

OFFICE OF CONSTRUCTION

CONSTRUCTION OF A BRIDGE FLOOR USING HIGH RANGE WATER REDUCER

CONSTRUCTION REPORT

December, 1978

DEPARTMENT OF TRANSPORTATION
IOWA

CONSTRUCTION OF BRIDGE FLOOR

USING

HIGH RANGE WATER REDUCER

January 1979

CONSTRUCTION REPORT

by

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515/296-1246

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ABSTRACT

The use of a high range water reducer in bridge floors was initiated by an Iowa Highway Research Board project (HR-192) in 1977 for two basic reasons. One was to determine the feasibility of using a high range water reducer (HRWR) in bridge floor concrete using conventional concrete proportioning, transporting and finishing equipment. The second was to determine the performance and protective qualities against chloride intrusion of a dense concrete bridge floor by de-icing agents used on Iowa's highways during winter months.

This project was basically intended to overcome some problems that developed in the original research project. The problems alluded to are the time limits from batching to finishing; use of a different type of finishing machine; need for supplemental vibration on the surface of the concrete during the screeding operation and difficulty of texturing.

The use of a double oscillating screed finishing machine worked well and supplemental vibration on one of the screeds was not needed.

The limit of 45 minutes from batching the concrete to placement on the deck was verified. This is a maximum when the HRWR is introduced at the batch plant.

The problem of texturing was not solved completely but is similar to our problems on the dense "Iowa System" overlay used on bridge deck repair projects.

This project reinforced some earlier doubts about using truck transit mixers for mixing and transporting concrete containing HRWR when introduced at the batch plant.

ACKNOWLEDGEMENTS

This project was initiated to follow the concept developed in Iowa Highway Research Board project HR-192 regarding use of a high range water reducer in bridge floor concrete.

The efforts of Keith Harlan (A.M.Cohron & Son, Inc.) to produce a quality product on this bridge floor were outstanding. His cooperation and use of his best personnel were appreciated.

Technical advice from John Carlson of the ICI Chemical Specialties Company regarding use of the high range water reducer MIGHTY 150 was appreciated. Ralph Britson, Office of Road Design, Iowa D.O.T. also provided technical advice during batching operations.

William Burgan, Resident Construction Engineer, Iowa D.O.T. from Red Oak and his staff worked very hard on the project as well as representatives from the District #4 Materials Office in Atlantic.

DISCLAIMER

The contents of this report reflect the views of the author and do not necessarily reflect the official views or policy of the Iowa Department of Transportation. This report does not constitute a standard, specification or regulation.

BACKGROUND & PRELIMINARY WORK

This project consisted of replacing a 61' x 20' I-beam bridge plus 2 - 22' x 20' I-beam approaches with a 180'-6" x 30' Pretensioned Prestressed Concrete Beam bridge over Buck Creek northwest of Atlantic on Primary Route #83.

This project number is FN-173-1(3) and was let on June 20, 1978. The successful bidder was A.M. Cohron & Son, Inc. for a contract price of $292,168.85. A copy of the contract is included in the appendix.

The Special Provisions for this project are also included in the Appendix as well as information concerning batch weights, concrete cylinder and beam strengths, and other placement details.

A pre-pour meeting was held at the ready mix plant on Monday, November 13, 1978 and the floor was placed on the following Tuesday and Wednesday. The high range water reducer selected was Mighty 150 with a design dosage of 14½ oz. per sack (94 pounds) of cement or 109.5 oz. per C.Y. This translated into 0.855 Gal. per C.Y. and 5.985 or 6 Gallon per 7 C.Y. load. The solid content of MIGHTY 150 is 42% so the water content in this HRWR is about 4 lbs. per C.Y.

A Capital finishing machine with a double oscillating screed was used as specified in the special provisions and the contractor swung the concrete to the deck by cranes using two 1½ C.Y. buckets. Three 8 C.Y. and one 7 C.Y. Smith Transit Mixers (with a mixing speed of 6-18 rpm and an agitation speed of 2-6 rpm) were used for the floor placement.

The scale capacity in the batch plant necessitated batching 3½ C.Y. at a time for the 7 C.Y. load and batching 3 C.Y. twice for a 6 C.Y. load.

The batching procedure for two 3 C.Y. batches to make a 6 C.Y. load in the transit truck mixer was as follows:

1. Batch most of the water and air entraining agent for a 3 C.Y. batch.
2. Batch the coarse aggregate, cement and fine aggregate for the first 3 C.Y. batch.
3. Repeat the above two steps for the remaining 3 C.Y. batch.
4. Add the remainder of the mixing water and all of the HRWR for the 6 C.Y. batch.
5. Mix for 60 revolutions at the plant before sending to the job site.

CONSTRUCTION

The bridge floor placement was scheduled to start on Tuesday morning, November 14th as soon as the air temperature reached 35° and rising. It was a bright sunny day and the contractor applied heat to the north span of the bridge to be sure that the forms and reinforcing steel were above freezing.

It was realized just before batching started that the air entraining agent to be used was a non-vinsol resin base which is slightly incompatable with MIGHTY 150 and might cause erratic air entrainment. Therefore a delay of about one hour was necessary until some vinsol resin base air entraining agent (Protex AES) was obtained. The batching started about 10:30 A.M. using a target W/C ratio of 0.32.

The first load was 3½ C.Y. and the air check indicated 6.2% air with a rather low slump of ½". An additional 2 gallons of water was added and the load sent to the bridge. This first load was very dry with a low slump due to an hour from batch to discharge and it had to be shoveled out of the dump bucket. The next 7 C.Y. load was also dry and 4 gallons of water were added before unloading with very little change in slump noted. The third 7 C.Y. load was also dry so 2 gallons of MIGHTY 150 plus 4 gallons of water were added at the bridge to retemper the concrete and increase workability. This was very successful and that load was placed on the deck in a condition expected from the use of HRWR.

At this point a re-evaluation of the dosage rate of HRWR was made by Ralph Britson (Iowa D.O.T.) and John Carlson (ICI America's Inc.) with a resultant increase in the dosage from 6 gallon to 7½ gallon per 7 C.Y. load. Additional mixing water was added to bring the W/C ratio up to 0.35.

The increase of HRWR dosage and mixing water seemed to solve the apparent low slump experienced in the first 3 loads and the pour proceeded without any great problems the rest of the day except for inconsistent slump from the front of the load (wet) to the back of the load (dry).

The air temperature ranged from a high of 47° to 33° F. and the concrete temperature ranged from 65°F. to 57°F. as it was being placed.

Due to the late start the floor placement was stopped at a header north of the south pier or with about the north 2/3 of the deck placed. The deck was cured and protected with a layer of pre-wetted burlap, a layer of plastic film, 6 inches of straw and another layer of plastic film. The temperature of the concrete was maintained in accordance with the specifications. The deck concrete temperature ranged from 59°F. to 71°F. to 68°F. to 54°F. the third day after this portion of the deck was placed.

The concrete placed on the deck worked very well under the double oscillating screed finishing machine and responded to vibration very well. The surface condition after passage of the finishing machine appeared to be very moist and have a glossy appearance. The contractor utilized a wood mop drawn across the surface just prior to texturing which seemed to work very well. The glossy appearance was not due entirely to bleed water but seemed to contain a lot of air bubbles which is a property of the HRWR. The vibrators attached to the front screed were turned off after a couple of hours because the crown was being lost due to the concrete slumping toward the gutters. The deletion of vibration from the front screed had very little effect on the concrete surface finish or screeding action.

The most obvious problem during the first day's work was the reduction in slump from the first part of the load in the ready mix truck to the last ½ to 3/4 C.Y. About midway through the placement, the loads were reduced from 7 C.Y. to 6 C.Y. per truck with some success. It was concluded that the blades in the ready mix trucks were not in the best of condition which led to insufficient distribution of the HRWR throughout the load. Our batching procedures introduced the HRWR at the last moment in the double batch at the plant so this was probably a contributing factor to the high slump provided by the HRWR for the first part of the load. Eight loads on the first day were batched in two complete 3 C.Y. batches (including HRWR for each 3 C.Y.) but no significant change in the slump loss was evident.

The next day (Wednesday), work resumed and no different problems occurred. We did try a different scheme of mixing to help solve the slump difference in the 6 C.Y. load by agitating the load on the way to the job site and doing the mixing (60 revolutions) at the job site while waiting to unload. This didn't change or solve the problem, so the original scheme of batching and mixing was resumed.

The air temperature ranged from 35° to 37°F and the concrete temperature ranged from 58°F to 63°F during the deck placement. The deck concrete temperature ranged from 74°F to 58°F the second day after the balance of the deck was placed.

One problem was the continuing creep upward of the entrained air content and a 30% reduction in the addition of Protex made only a ½ to 1 unit reduction in the air content.

EVALUATION

The concrete using high range water reducer exhibited the same qualities as the concrete produced in the Highway Research Board project HR-192. It seemed to crust over quite fast and remain plastic for some time which causes difficulty in hand finishing in the gutter area and around gutter drains.

The time limit of 45 minutes from batching to depositing on the deck was verified as a limiting factor. No problem was exhibited using this time frame. Most of the loads were discharged within 25 to 30 minutes the first day and 20 to 25 minutes the second day. Most of the loads were emptied in 12 to 15 minutes after arriving at the site. It was found that any delay in discharging after arriving at the site contributed to an early slump loss for the last portion of the load.

No problems were exhibited using the double oscillating screed finishing machine and it did a fine job of handling and striking off the concrete. However, the riding quality of the floor is rough due to the start and stop operation with the finishing machine caused in part by slow delivery of concrete to the deck.

The method of swinging concrete to the deck using 2 - 1½ C.Y. buckets was not very efficient. A conveyor system would be the best system for this concrete and a pump would probably have worked satisfactorily although the air content of 7 to 9% might have caused some problems.

The ready mix trucks might have discharged their loads easier if the front axle had been raised on a ramp allowing the bowl to become more horizontal. The lack of enough slope in the truck discharge chute also made the flow of concrete in the last 1½ C.Y. from each truck much slower. It seemed that every time the truck mixer bowl was stopped to wait for another concrete bucket to fill, the mix would tend to stiffen. A continuous discharge from the truck mixer bowl would probably have decreased the problem of slump loss. There is some indication that the truck mixer blades were worn to the point of contributing to the less than adequate dispersion of the HRWR.

Tests on the 4 beams cast for this project will be as follows:

(1) Break 1-20" and 1-33" test beam @ 56 days

(2) Break 1-20" and portion of the 33" beam @ 6 months

(3) Break 1-20" beam at one year

The modulus of rupture for each of the above breaks will be determined.

In addition to the above each beam will be cored after breaking to determine strength, air content and density. A chloride sample from each broken end will be determined.

In general, the strength results of the test beams and cyclinders were a little disappointing. The test results were quite erratic and didn't indicate an appreciable increase in strength at 7 and 28 days over conventional bridge deck concrete (D-57-6).

CONCLUSIONS

The use of a high range water reducer in a thin slab with crown still has some nagging problem, but some benefits are readily discernable.

The use of transit truck mixers for mixing after a dry batch operation creates problems of inconsistent air content and variable slump. This requires constant testing and instant adjustments to control these two variables which lends to confusion and extra burdens for the normal inspection force and contractor's crews.

The tight restrictions on time of use from batching to finishing do not lend the use of HRWR to structures located more than one half hour haul from the batch plant when the admixture is introduced at the proportioning plant.

The finishing and texturing required on our bridge floors using hand methods are more difficult to obtain because of the false slump, early surface crusting and extended plasticity of the concrete.

Retempering the plastic concrete using HRWR was done twice to increase the slump but this practice has been avoided because control of maximum slump is impossible at the construction site. If the slump gets too high, the finishing machine tends to wipe the crown out of the finished surface.

The obvious benefits of using HRWR are the higher strengths and increased density but the added cost and difficulty in mixing and handling may offset the benefits. Only after a period of several years can these benefits be measured and the most desirable end result is the prevention of chloride intrusion to the level of the top mat of reinforcing steel.

The next possible step in the process of adapting HRWR to general use in bridge floor concrete is the addition of the HRWR on the job site from a suitable vessel. It may be difficult to mix and transport ½" to 1" slump concrete in a truck transit mixer for any distance but adding the HRWR at the last possibly moment before placing the concrete would provide the best possible utilization of a HRWR.

An alternate for utilizing a HRWR on structures would be to require a mobile mixer at each site. This would provide the ultimate control of the final product being placed on the deck.

RECOMMENDATIONS

I would recommend that a period of testing and evaluation be continued on the two structures now existing with decks containing high range water reducer (HRWR) before any additional projects of this type be attempted. This will enable us to determine a valid cost benefit ratio.

I would also recommend that truck transit mixers not be used in conjunction with concrete containing a high range water reducer (HRWR) if used again on bridge floors unless a more efficient and complete mixing operation by a truck transit mixer is developed. If a truck transit mixer can transport ½" to 1" slump to a project requiring an hour haul and the HRWR can be dispensed accurately into the truck mixer bowl just prior to being placed on the deck, the use of HRWR might be considered again.

APPENDIX

IOWA DEPARTMENT OF TRANSPORTATION

Ames, Iowa

SPECIAL PROVISION

for

CONCRETE BRIDGE FLOOR

Cass FN-173-1(3)--21-15

June 20, 1978

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

220.01 BRIDGE FLOOR CONCRETE. This bridge floor concrete is to contain a high-range water reducer (HRWR), and the following high-range water reducing admixtures are approved for use:

Admixture	Dosage
Melment	35-40 fluid ounces per 100 pounds of cement
Sikament	24 fluid ounces per 100 pounds of cement
Mighty 150	14½ fluid ounces per sack (94 pounds) of cement
FX-34	3/4 fluid ounce per sack (94 pounds) of cement

Concrete for the bridge floor shall be Mix No. D57-HR or Mix D57-6HR as listed below.

Basic Absolute Volumes of Materials Per Unit Volume of Concrete

	Mix D57-HR	Mix D57-6HR
Cement	0.134209	0.134209
Fine Aggregate	0.335529	0.398830
Coarse Aggregate	0.335529	0.272228
Water	0.134733	0.134733
Air	0.06	0.06

Approximate Quantities of Materials Per Cubic Yard of Concrete

	Pounds	Pounds
Cement	710	710
Fine Aggregate	1498	1781
Coarse Aggregate	1498	1215
Water	227	227

These quantities are based on the following assumptions:

Specific gravity of cement	3.14
Specific gravity of fine and coarse aggregate	2.65
Weight of Water	62.4 pounds per cubic foot

Design W/C ratio = 0.32 pound per pound (total water)
Maximum W/C ratio = 0.37 pound per pound

The target water-cement ratio is 0.32 pound per pound, with a maximum water-cement ratio of 0.37.

The standard slump test will be used only for a check on consistency and will not be used as an acceptance test.

The target slump at the time of concrete placement will be 4 inches.

220.02 MIXING AND PLACING. The finishing machine shall comply with requirements of the second paragraph of Article 2412.06, 1977 Standard Specifications. In addition, one of the oscillating screeds shall be equipped with vibrators to provide vibrations that are perceptible throughout the entire width of the concrete being placed. Rotating-drum finishers will not be approved.

The mixing time after introduction of all the materials into a truck mixer shall be between 50 and 70 revolutions at mixing speed. The agitation during transporting to the job site shall be held to a minimum.

The concrete shall be deposited on the bridge floor within 45 minutes from the time of batching and shall be vibrated, screeded, and finished within 10 minutes of being deposited on the floor.

Note: The use of a continuous mixer in conjunction with volumetric proportioning may be considered for the concrete floor if a placement rate of 25 cubic yards per hour can be maintained. The mixer shall also be equipped with a positive control of water flow which shall be indicated by a recording water meter.

COST CENTER 611000 OBJECT 878

PROJ NO FN-173-1(3)--21-15 COUNTY CASS

RES ENGR WILLIAM BURGAN 524500 ADDRESS RED OAK, IOWA

LETTING DATE JUNE 20, 1978 LIQUIDATED DAMAGES #1 $140.00

SPECIAL PROV 1/31/78 #823, 5/25/76 #788, 10/11/77 #815,
6/20/78 SP-220

DATE STARTED ______ FIELD COMP ______ CERT COMP ______

TIES ON BACK

FORM 650019 6-77 M-3878

CONTRACT NO. 15028

TYPE OF WORK STRUCTURES PROJECT NO FN-173-1(3)--21-15

MILES ______ COST CENTER 611000 OBJECT 878

COUNTY CASS

ON IOWA 83 APPROX. 1 MILE NORTHWEST OF ATLANTIC OVER BUCK CREEK

THIS AGREEMENT MADE AND ENTERED BY AND BETWEEN THE IOWA DEPARTMENT OF TRANSPORTATION ROBERT R RIGLER, STEPHEN GARST, DONALD K GARDNER, ALLAN THOMS, W. F. MCGRATH, BARBARA DUNN, & L. STANLEY SCHOELERMAN PARTY OF THE FIRST PART AND A.M. COHRON & SON, INC. OF ATLANTIC, IOWA 08500

PARTY OF THE SECOND PART

WITNESSETH THAT THE PARTY OF THE SECOND PART FOR AND IN CONSIDERATION OF $ $$$$292,168.85 PAYABLE AS SET FORTH IN THE SPECIFICATIONS CONSTITUTING A PART OF THIS CONTRACT, HEREBY AGREES TO CONSTRUCT VARIOUS ITEMS OF WORK AND/OR TO SUPPLY VARIOUS MATERIALS OR SUPPLIES IN ACCORDANCE WITH THE PLANS AND SPECIFICATIONS THEREFOR AND IN THE LOCATIONS DESIGNATED IN THE NOTICE TO BIDDERS AS FOLLOWS:

ITEM NO	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	180'6" X 36' PRETEN. PRESTR. CONC. BEAM BRIDGE AND APPROACHES				
	GRP 1 DESIGN 175				
1	CONCRETE, STRUCTURAL	327.200	CU. YDS.	198.00	64,785.60
2	STEEL, REINFORCING	35,261	LBS.	.30	10,578.30
3	STEEL, REINFORCING, EPOXY COATED	33,707	LBS.	.55	18,538.85
4	BEAMS, PRETENSIONED PRESTRESSED CONCRETE, B 55 R	12	ONLY	3,500.00	42,000.00
5	BEAMS, PRETENSIONED PRESTRESSED CONCRETE, B 67 R	6	ONLY	4,200.00	25,200.00
6	PILING, FURNISH STEEL BEARING HP 12 X 53	880	LIN. FT.	17.00	14,960.00
7	PILING, DRIVE STEEL BEARING HP 12 X 53	880	LIN. FT.	2.50	2,200.00
8	PILING, ENCASE STEEL BEARING HP 12 X 53	506	LIN. FT.	42.00	21,252.00
9	PILING, FURNISH STEEL BEARING HP 10 X 42	624	LIN. FT.	13.00	8,112.00
10	PILING, DRIVE STEEL BEARING				

PARTY OF THE SECOND PART CERTIFIES BY HIS SIGNATURE ON THIS CONTRACT, UNDER PAIN OF PENALTIES FOR FALSE CERTIFICATION, THAT HE HAS COMPLIED WITH 324.17.5 OF THE 1975 CODE OF IOWA AS AMENDED IF APPLICABLE.

SAID SPECIFICATIONS AND PLANS ARE HEREBY MADE A PART OF AND THE BASIS OF THIS AGREEMENT, AND A TRUE COPY OF SAID PLANS AND SPECIFICATIONS IS NOW ON FILE IN THE OFFICE OF THE PARTY OF THE FIRST PART UNDER DATE OF JUNE 15, 1978

THAT IN CONSIDERATION OF THE FOREGOING, THE PARTY OF THE FIRST PART HEREBY AGREES TO PAY THE PARTY OF THE SECOND PART, PROMPTLY AND ACCORDING TO THE REQUIREMENTS OF THE SPECIFICATIONS THE AMOUNTS SET FORTH, SUBJECT TO THE CONDITIONS AS SET FORTH IN THE SPECIFICATIONS.

THE PARTIES HERETO AGREE THAT THE NOTICE AND INSTRUCTIONS TO BIDDERS, THE PROPOSAL FILED HEREIN, THE GENERAL SPECIFICATIONS OF THE IOWA DEPARTMENT OF TRANSPORTATION FOR 1977 TOGETHER WITH SPECIAL PROVISIONS ATTACHED, TOGETHER WITH THE GENERAL AND DETAILED PLANS, IF ANY, FOR SAID PROJECT FN-173-1(3)--21-15 TOGETHER WITH SECOND PARTY'S PERFORMANCE BOND, ARE MADE A PART HEREOF, AND TOGETHER WITH THIS INSTRUMENT CONSTITUTE THE CONTRACT BETWEEN THE PARTIES HERETO.

THAT IT IS FURTHER UNDERSTOOD AND AGREED BY THE PARTIES OF THIS CONTRACT THAT THE ABOVE WORK SHALL BE COMMENCED OR COMPLETED IN ACCORDANCE WITH THE FOLLOWING SCHEDULE

	APPROX. OR SPECIFIED STARTING DATE OR NUMBER OF WORKING DAYS	SPECIFIED COMPLETION DATE OR NUMBER OF WORKING DAYS
GROUP 1	90 WORKING DAYS	APR. 27, 1979

THAT TIME IS THE ESSENCE OF THIS CONTRACT AND THAT SAID CONTRACT CONTAINS ALL OF THE TERMS AND CONDITIONS AGREED UPON BY THE PARTIES HERETO.

IN WITNESS WHEREOF THE PARTIES HERETO HAVE SET THEIR HANDS FOR THE PURPOSE HEREIN EXPRESSED TO THIS AND THREE OTHER IDENTICAL INSTRUMENTS AS OF THE ______ DAY OF ______ 19____

IOWA DEPARTMENT OF TRANSPORTATION JUN 28 1978

BY ______
PARTY OF THE FIRST PART

A.M. COHRON & SON, INC. OF ATLANTIC, IOWA

BY ______
PARTY OF THE SECOND PART

CONTRACT NO. 15028 PROJECT FN-173-1(3)--21-15 PAGE 2

ITEM NO	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	HP 10 X 42	624	LIN. FT.	2.00	1,248.00
11	BACKFILL, GRANULAR	108	CU. YDS.	9.00	972.00
12	REMOVAL OF PRESENT BRIDGE		LUMP SUM		16,000.00
13	RAIL, CONCRETE BARRIER	396	LIN. FT.	27.00	10,692.00
14	SUBDRAIN, AS PER PLAN	136	LIN. FT.	2.00	272.00
15	PREBORED HOLES - AS PER PLAN	128	LIN. FT.	9.00	1,152.00
16	EXCAVATION, CLASS 20	60	CU. YDS.	25.00	1,500.00
17	EXCAVATION, CLASS 10, ROADWAY & BORROW	2,574	CU. YDS.	4.90	12,612.60
18	EXCAVATION, CLASS 10, CHANNEL	2,900	CU. YDS.	4.00	11,600.00
19	REVETMENT, CLASS D RIPRAP	650	TONS	15.00	9,750.00
20	REMOVAL OF PAVEMENT	478	SQ. YDS.	3.00	1,434.00
21	CULVERT, CORR. METAL ROADWAY PIPE, 24 IN. DIA.	44	LIN. FT.	18.00	792.00
22	CULVERT, CORR. METAL ROADWAY PIPE, 36 IN. DIA.	122	LIN. FT.	32.00	3,904.00
23	CULVERT, CORR. METAL ROADWAY PIPE, 84 IN. DIA.	80	LIN. FT.	90.00	7,200.00
24	APRONS, METAL, 24 IN. DIA.	1	ONLY	150.00	150.00
25	APRONS, METAL, 36 IN. DIA.	2	ONLY	325.00	650.00
26	BARRICADES	2	ONLY	400.00	800.00
27	FILTER CLOTH	545	SQ. YDS.	2.70	1,471.50
28	EXCAVATION, CLASS 20, FOR ROADWAY PIPE CULVERT	172	CU. YDS.	6.00	1,032.00
29	SURFACING, GRANULAR, CLASS A CRUSHED STONE - ON ROAD	131	TONS	10.00	1,310.00
				GRP 1 TOTAL	$292,168.85
				GRAND TOTAL	$292,168.85

TEST DATA

Load No.	Size C.Y.	Air %	Slump inch	Temp. Air	°F conc	HRWR dosage oz/cy	Concrete Strength (psi) Flexure 7 days	Compression 3 day	7 day	21 day	28 day
		NOVEMBER 14, 1978									
1	3½	6.2	½	-	-	109½					
2	7	-	-	47	63	109½					
3	7	5.3	5	-	-	146					3,843*
4	7	8.0	4¼	-	-	146		4,434			
5	7	9.0	5¼	40	57	137	737		4,239		
8	7	7.6	5¼	-	-	137				4,302	
10	7	7.6	5	-	-	137					7,667
11	7	7.3	2¾	-	-	146		3,346			
14	7	8.3	6	36	63	146			4,566		
17	6	9.0	6	37		146				5,220	
23	6	8.1	-	33	65	146					
		NOVEMBER 15, 1978									
1	6	7.2	5	37	58	146		4,302			
2	6	7.9	5¼	-	63	146	634				
4	6	7.4	4¼	37	63	146					5,094*
5	6	7.4	4¼	-	-	146			5,101		
7	6	7.8	8¼	37	62	146					
10	6	7.2	8	37	63	146				6,773	
13	6	7.2	7½	38	61	146					
16	6	8.4	8¾	35	60	146					

*No apparent explanation of the low 28 day cylinder strengths is known. All the cylinders appeared the same when tested.

DRY BATCH WEIGHTS - 1 C.Y.

Fine Aggr. -	1787 lb.
Coarse Aggr.	1225 lb.
Cement -	710 lb.
Mighty 150 -	146 oz.
Water in Coarse -	8 lb.
Water in Fine -	76 lb.
Water Added -	164 lb.