Mixture Proportions to Satisfy Specifications

Engineering from Project Specifications

Minneapolis MN

April 15, 2013

Standard 211 Methodology

- Spec review leads to 211 design sequencing to satisfy basic strength requirements
- Gather necessary aggregate information

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- Determine appropriate slump

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- Spec review leads to 211 design sequencing to satisfy basic strength requirements
- Gather necessary aggregate information
- Determine appropriate slump
- Estimate the water demand from table or experience along with air based on CAgg size

Standard 211 Methodology

- Knowing strength, pick w/cm

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- Knowing strength, pick w/cm
- With selected water demand, calculate powder content

Standard 211 Methodology

- Knowing strength, pick w/cm
- Using estimated water demand, calculate powder content
- Using the Table 6.3.6, determine coarse aggregate content from sand fm, CA size and dry rodded volume

Standard 211 Methodology

- Knowing strength, pick w/cm
- Estimate water demand and air %, calculate powder content
- Determine coarse aggregate content from sand fm, CA size and dry rodded volume
- Add up all AbsVols of knowns and subtract from 27 cf. Remainder = sand

Completed Mix

MIX NUMBER:	1			W/C RATIO:	0.500		
PLANT	1			SACK CONT.			
DESCRIPTION:	4000			UNIT WT:	146.22	LBS./CU.FT.	

MATERIAL		UNITS	SP.GRAV.	VOLUME
CEMENT		510	3.15	2.595
SAND	0.1	1353	2.62	8.276
GRAVEL(LI)		1830	2.52	11.638
WATER	30.58	255	1	4.087
AIR %		1.5	0.27	0.405
TOTALS				27.00

CASE 1

- Specification requires:

- Portland cement only
- 4000 PSI
- .40 W/C
- <3% Air

Completed Mix

MIX NUMBER:		1			W/C RATIO:	0.500	
PLANT		1			SACK CONT.		
DESCRIPTION:		4000			UNIT WT:	146.22	LBS./CU.FT.
MATERIAL		UNITS	SP.GRAV.	VOLUME			
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TOTALS				27.00			

Case 1

- Where to begin?
- Technical as well as moral question

Case 1

- Where to begin?
- Technical as well as moral question
- We have to be competitive…
- What's the other guy thinking?

Case 1

- Where to begin?
- Strength isn’t the issue
- How do we economize with low w/c
- HRWR??

MIX NUMBER:	140			W/C RATIO:			#DIV/0!
PLANT	1			SACK CONT.			0.00
DESCRIPTION:	4000 .40			UNIT WT:	56.77	LBS./CU.FT.	
ASH %	#DIV/0!			CU. FT. LTW		0	
SLAG %	**#DIV/0!**						
MATERIAL		UNITS	SP.GRAV.	VOLUME	TON COST	# COST	YD. COST
CEMENT		0	3.15	0.000	100.00	0.0500	$0.00
FLYASH		0	2.7	0.000	50.00	0.0250	$0.00
SLAG		0	2.89	0.000	90.00	0.0450	$0.00
SAND	**3680**	0	2.62	0.000	12.00	0.0060	$0.00
GRAVEL		0	2.52	0.000	22.00	0.0110	$0.00
LIMESTONE		0	2.38	0.000	31.77	0.0159	$0.00
PEA GRAVEL		0	2.52	0.000	24.70	0.0124	$0.00
LIGHTWEIGHT		0	1.48	0.000	0.00	0.0000	$0.00
WATER	30.58	255	1	4.087	0.00		$0.00
W R A	1	0.00	OZS./CY	0.000	3.16	0.0247	$0.00
AIR %		1.5	0.27	0.405	0.00		$0.00
AEA		0	**********	0.000	3.10	0.0242	$0.00
TOTALS				4.49			$0.00
HRWR		0		0.00	8.00	0.0625	**$0.00**

- Calculate Cement Content
- 255# water / .40 = 638# portland

Cost of spec mix at 4” slump

MIX NUMBER:		140			W/C RATIO:		0.400
PLANT		1			SACK CONT.		6.79
DESCRIPTION:		4000 .40			UNIT WT:	147.02	LBS./CU.FT.
ASH %		0.00			CU. FT. LTW		0
SLAG %		0.00					
MATERIAL		UNITS	SP.GRAV.	VOLUME	TON COST	# COST	YD. COST
CEMENT		638	3.15	3.246	100.00	0.0500	$32.22
FLYASH		0	2.7	0.000	50.00	0.0250	$0.00
SLAG		0	2.89	0.000	90.00	0.0450	$0.00
SAND	0	1247	2.62	7.627	12.00	0.0060	$7.93
GRAVEL		1830	2.52	11.638	22.00	0.0110	$20.53
LIMESTONE		0	2.38	0.000	31.77	0.0159	$0.00
PEA GRAVEL		0	2.52	0.000	24.70	0.0124	$0.00
LIGHTWEIGHT		0	1.48	0.000	0.00	0.0000	$0.00
WATER	30.58	255	1	4.087	0.00		$0.00
W R A	1	19.14	OZS./CY	0.000	3.16	0.0247	$0.47
AIR %		1.5	0.27	0.405	0.00		$0.00
AEA		0	**********	0.000	3.10	0.0242	$0.00
TOTALS				27.00			$61.16
HRWR		0		0.00	8.00	0.0625	**$0.00**

Cost of original mix

MIX NUMBER:		1			W/C RATIO:		0.500
PLANT		1			SACK CONT.		5.43
DESCRIPTION:		4000 .40			UNIT WT:	146.22	LBS./CU.FT.
ASH %		0.00			CU. FT. LTW		0
SLAG %		0.00					
MATERIAL		UNITS	SP.GRAV.	VOLUME	TON COST	# COST	YD. COST
CEMENT		510	3.15	2.595	100.00	0.0500	$25.76
FLYASH		0	2.7	0.000	50.00	0.0250	$0.00
SLAG		0	2.89	0.000	90.00	0.0450	$0.00
SAND	0	1353	2.62	8.276	12.00	0.0060	$8.61
GRAVEL		1830	2.52	11.638	22.00	0.0110	$20.53
LIMESTONE		0	2.38	0.000	31.77	0.0159	$0.00
PEA GRAVEL		0	2.52	0.000	24.70	0.0124	$0.00
LIGHTWEIGHT		0	1.48	0.000	0.00	0.0000	$0.00
WATER	30.58	255	1	4.087	0.00		$0.00
W R A	1	15.30	OZS./CY	0.000	3.16	0.0247	$0.38
AIR %		1.5	0.27	0.405	0.00		$0.00
AEA		0	**********	0.000	3.10	0.0242	$0.00
TOTALS				27.00			$55.27
HRWR		0		0.00	8.00	0.0625	**$0.00**

Competitor mix at 4” slump

MIX NUMBER:		1			W/C RATIO:		0.400
PLANT		**1**			SACK CONT.		5.43
DESCRIPTION:		4000 .40			UNIT WT:	149.29	LBS./CU.FT.
ASH %		0.00				CU. FT. LTW	0
SLAG %		**0.00**					
MATERIAL		UNITS	SP.GRAV.	VOLUME	TON COST	# COST	YD. COST
CEMENT		510	3.15	2.595	100.00	0.0500	$25.76
FLYASH		0	2.7	0.000	50.00	0.0250	$0.00
SLAG		0	2.89	0.000	90.00	0.0450	$0.00
SAND	**0**	1487	2.62	9.095	12.00	0.0060	$9.46
GRAVEL		1830	2.52	11.638	22.00	0.0110	$20.53
LIMESTONE		0	2.38	0.000	31.77	0.0159	$0.00
PEA GRAVEL		0	2.52	0.000	24.70	0.0124	$0.00
LIGHTWEIGHT		0	1.48	0.000	0.00	0.0000	$0.00
WATER	24.5	204	1	3.269	0.00		$0.00
W R A	1	15.30	OZS./CY	0.000	3.16	0.0247	$0.38
AIR %		1.5	0.27	0.405	0.00		$0.00
AEA		0	**********	0.000	3.10	0.0242	$0.00
TOTALS				27.00			$56.12
HRWR		0		0.00	8.00	0.0625	**$0.00**

Our costs with SuperP @ 6-8”

MIX NUMBER:	140			W/C RATIO:	0.400		
PLANT	1			SACK CONT.	6.12		
DESCRIPTION:	4000 .40			UNIT WT:	148.13	LBS./CU.FT.	
ASH %	0.00			CU. FT. LTW	0		
SLAG %	0.00						
MATERIAL		UNITS	SP.GRAV.	VOLUME	TON COST	# COST	YD. COST
CEMENT		575	3.15	2.925	100.00	0.0500	$29.04
FLYASH		0	2.7	0.000	50.00	0.0250	$0.00
SLAG		0	2.89	0.000	90.00	0.0450	$0.00
SAND	0	1364	2.62	8.343	12.00	0.0060	$8.68
GRAVEL		1830	2.52	11.638	22.00	0.0110	$20.53
LIMESTONE		0	2.38	0.000	31.77	0.0159	$0.00
PEA GRAVEL		0	2.52	0.000	24.70	0.0124	$0.00
LIGHTWEIGHT		0	1.48	0.000	0.00	0.0000	$0.00
WATER	27.58	230	1	3.686	0.00		$0.00
W R A	1	17.25	OZS./CY	0.000	3.16	0.0247	$0.43
AIR %		1.5	0.27	0.405	0.00		$0.00
AEA		0	**********	0.000	3.10	0.0242	$0.00
TOTALS				27.00			$58.67
HRWR		6		34.50	8.00	0.0625	**$2.16**
							$60.83

Summation

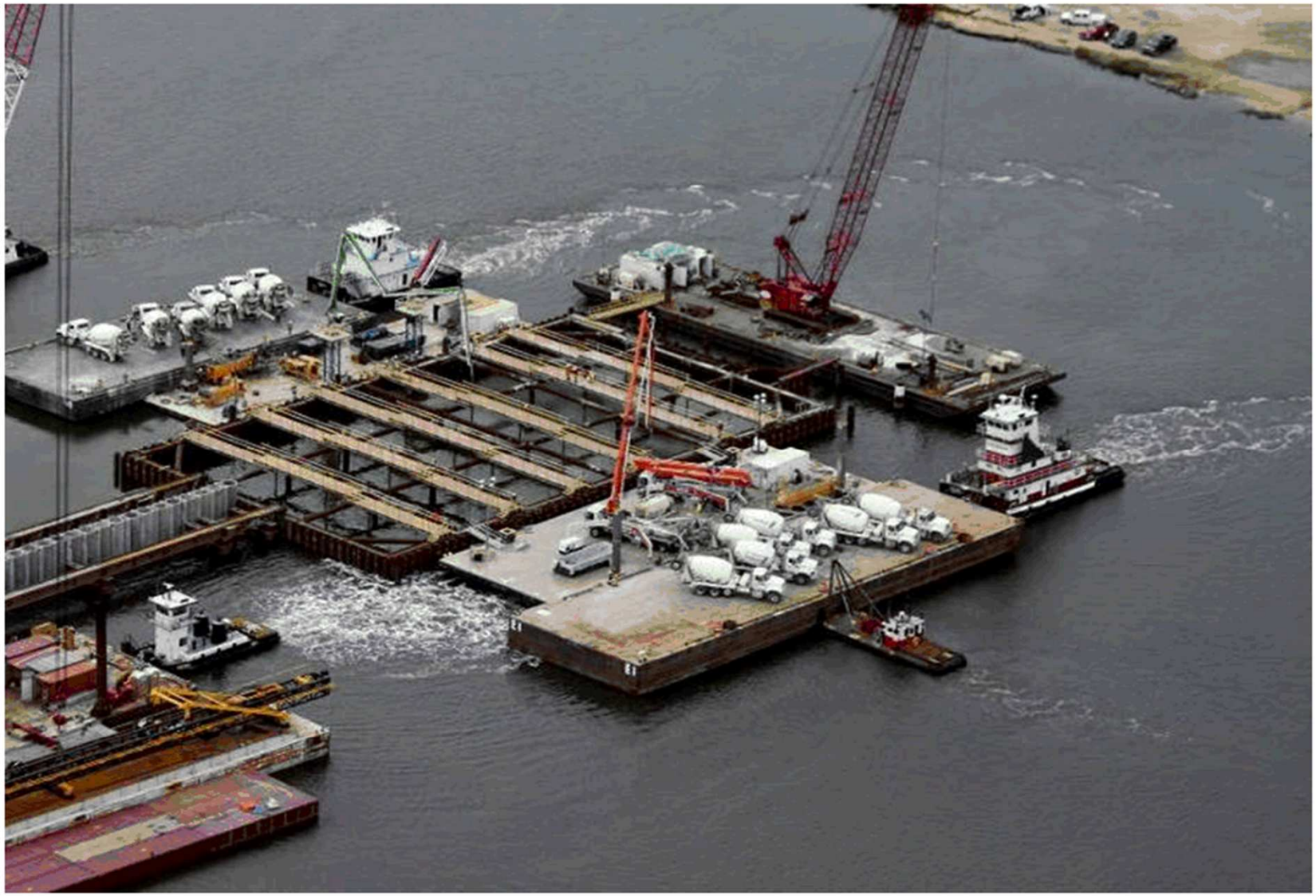
- Original mix of 4000 psi $55.27
- Spec mix cost .40 w/c $61.16
- ReadyMix R Us .40 w/c $56.12
- Super Option .40 w/c $60.83

CASE 2
UNDERWATER CONCRETE

- First consideration of UW concrete is placing procedure
- Designer must anticipate pump placement, primarily with tremie
- Highly flowable, self consolidating
- Is there a washout test required? %?

LAFARGE

bringing materials to life



Agilia

Inner Harbor Navigation Canal Lake Borgne Surge Barrier Project

Typical USACE UW Specification

2.2.9 Underwater Concrete

All concrete to be placed underwater shall contain anti-washout admixture at the manufacturer's recommended dosage rate.

2.2.9.1 Washout

The maximum allowable washout determined in accordance with COE CRD-C 61 for the underwater concrete shall be 8 percent.

2.2.9.2 Cementitious Materials Content

For underwater concrete the cementitious materials content shall be at least 600 pounds per cubic yard of concrete.

2.2.9.3 Fine Aggregate Content

For underwater concrete fine aggregate shall comprise approximately 45 to 55 percent by volume, of the total aggregate.

Start with Minimum Powder

MIX NUMBER:		UWAW			W/C RATIO:		0.400
PLANT		1			SACK CONT.		6.38
DESCRIPTION:		4000			UNIT WT:	112.40	LBS./CU.FT.
ASH %		33.33				CU. FT. LTW	0
SLAG %		0.00					
MATERIAL		UNITS	SP.GRAV.	VOLUME	CA/FA Ratio		
CEMENT		400	3.15	2.035			
FLYASH		200	2.7	1.187			
SLAG		0	2.89	0.000			
SAND	3192	0	2.62	0.000			
GRAVEL		0	2.52	0.000			
LIMESTONE		0	2.38	0.000			
PEA GRAVEL		0	2.52	0.000			
LIGHTWEIGHT		0	1.48	0.000			
WATER	28.78	240	1	3.846			
W R A	1	0.00	OZS./CY	0.000			
AIR %		1.5	0.27	0.405			
AEA		0	**********	0.000			
TOTALS				7.47			
HRWR		0		0.00			
Anti-Washout		0		0.00			

Aggregates Volumes

- Pick the mid range of allowance for fine to coarse aggregate ratio
- Paste vol is 7.473 cf leaving 19.527 cf
- 19.527 X 50% = 9.762 cf

Aggregate Weights

- 9.762 X 2.62 X 62.4 = 1596# FA
- 1596# / SpGr FA X SpGr CA = ???

Remaining Aggregate

- 1596/ 2.62 X 2.52 = 1535 #
- Are you sure about that???
- It will QUICKLY calculate the equivalent mass of two differing gravity materials

MIX NUMBER:	UWAW				W/C RATIO:		0.400
PLANT	1				SACK CONT.		6.38
DESCRIPTION:	4000				UNIT WT:	147.09	LBS./CU.FT.
ASH %	33.33					CU. FT. LTW	0
SLAG %	0.00						
MATERIAL		UNITS	SP.GRAV.	VOLUME	CA/FA Ratio		
CEMENT		400	3.15	2.035			
FLYASH		200	2.7	1.187			
SLAG		0	2.89	0.000			
SAND	0	1596	2.62	9.762			
GRAVEL		1535	2.52	9.762			
LIMESTONE		0	2.38	0.000			
PEA GRAVEL		0	2.52	0.000			
LIGHTWEIGHT		0	1.48	0.000			
WATER	28.78	240	1	3.846			
W R A	1	0.00	OZS./CY	0.000			
AIR %		1.5	0.27	0.405			
AEA		0	**********	0.000			
TOTALS				27.00			
HRWR		0		0.00			
Anti-Washout		0		0.00			

Next Step for this process

- We've got the basic mix design
- How do we determine the anti-washout capability?

- Experience has taught that ¾" or 1" CAgg flows okay at 9" to 10"
- But it's always better to use smaller CAgg and do a true SCC – 30" Flow

Check with the product manufacturer for dosage ideas

MIX NUMBER:		UWAW			W/C RATIO:		0.400
PLANT		1			SACK CONT.		6.38
DESCRIPTION:		4000			UNIT WT:	147.09	LBS./CU.FT.
ASH %		33.33				CU. FT. LTW	0
SLAG %		0.00			CA/FA		
MATERIAL		UNITS	SP.GRAV.	VOLUME	Ratio		
CEMENT		400	3.15	2.035			
FLYASH		200	2.7	1.187			
SLAG		0	2.89	0.000			
SAND	0	1596	2.62	9.762			
GRAVEL		1535	2.52	9.762			
LIMESTONE		0	2.38	0.000			
PEA GRAVEL		0	2.52	0.000			
LIGHTWEIGHT		0	1.48	0.000			
WATER	28.78	240	1	3.846			
W R A	1	0.00	OZS./CY	0.000			
AIR %		1.5	0.27	0.405			
AEA		0	**********	0.000			
TOTALS				27.00			
HRWR		**6**		**36.00**			
Anti-Washout		**10**		**60.00**			

May 19, 2009

Mr. B.J. Eckholdt III
Lafarge Corporation
3320 Airline Highway
Metairie, LA 70001

Re: Test Method for Determining the Resistance of Freshly Mixed Concrete to Washing Out in Water
BTI Project No. 2103

Dear Mr. Eckholdt:

At your request, Mark A. Cheek, P.E. of Beta Testing & Inspection, LLC, traveled to your Airline plant on April 30, 2009. Subsequent to arrival, Mr. Cheek conducted two wash out tests on Mix No. 77 & 1Agvert. The tests were conducted in accordance with CRD-C 61-89A (Test Method for Determining the Resistance of Freshly Mixed Concrete to Washing Out in Water).

Tests Results:

Mix No. 77		Mix No. 1 AGVERT	
Trial	% Washout	Trial	% Washout
D_1	0.00	D_1	2.34
D_2	0.00	D_2	4.38
D_3	1.41	D_3	6.35

Case 3
Designing for Reduced Permeability

- We’re bidding on a Petro-chemical plant with a sizable bridge

- Our specification is asking for a mix where the application demands Exposure Category P, Class P1

Designing for Reduced Permeability

- Our specification is asking for a mix where the application demands Exposure Category P, Class P1
- It further requests that the “Chloride Ion Penetrability” be Very Low as stated in ASTM C1202

Designing for Reduced Permeability

- Our specification is asking for a mix where the application demands Exposure Category P, Class P1
- It further requests that the "Chloride Ion Penetrability" be Very Low as stated in ASTM C1202
- That's the Rapid Chloride Permeability test value reported as "coulombs" ranging from 100 - 1000

Designing for Reduced Permeability

- The only guidance we have for starters is, ACI 318 Table 4.3.1 gives us a w/c of .50 as a maximum

- A little digging into 201 Durability reminds us that optimum w/cm for thorough hydration is .40 which breaks up the capillary pores

Designing for Reduced Permeability

- The only guidance we have for starters is, ACI 318 Table 4.3.1 gives us a w/c of .50 as a maximum
- A little digging into 201 Durability reminds us that optimum w/cm for thorough hydration is .40 which breaks up the capillary pores
- 6.4.3 mentions SCMs as helpful

Designing for Reduced Permeability

- So what's available
- Silica fume tops the chart, but it's expensive and a challenge to use
- If available, Class F ash is beneficial
- C 989 GGBFS is excellent
- Class C ash is another option but results vary

Designing for Reduced Permeability

- We have to find a superior aggregate
- Preferably dense, angular, well graded
- Run a theoretical combined aggregate curve and seek to reduce voids

Designing for Reduced Permeability

- If GGBFS is available, Grade 100 or 120, start trials at 50% replacement
- Anticipate HRWR to keep Powder down
- Get to lowest water content that will pump and place and finish well
- Do we need AIR?

Designing for Reduced Permeability

- Do we need AIR?
- For Freeze Thaw durability, YES
- For F0 climates????
- Personal preference

MIX NUMBER:		PermaKill			W/C RATIO:			0.400
PLANT		1			SACK CONT.			6.38
DESCRIPTION:		5500/ 56 DAYS			UNIT WT:	150.33	LBS./CU.FT.	
ASH %		0.00				CU. FT. LTW		0
SLAG %		**50.00**						
MATERIAL		UNITS	SP.GRAV.	VOLUME	TON COST	# COST		YD. COST
CEMENT		300	3.15	1.526	100.00	0.0500		$15.15
FLYASH		0	2.7	0.000	50.00	0.0250		$0.00
SLAG		300	2.89	1.664	90.00	0.0450		$13.64
SAND	**0**	1289	2.62	7.884	12.00	0.0060		$8.20
GRAVEL		0	2.52	0.000	22.00	0.0110		$0.00
LIMESTONE		1575	2.68	9.418	28.00	0.0140		$22.49
PEA GRAVEL		355	2.52	2.258	18.00	0.0090		$3.26
LIGHTWEIGHT		0	1.48	0.000	0.00	0.0000		$0.00
WATER	28.78	240	1	3.846	0.00			$0.00
W R A	1	18.00	OZS./CY	0.000	3.16	0.0247		$0.44
AIR %		1.5	0.27	0.405	0.00			$0.00
AEA		0	**********	0.000	3.10	0.0242		$0.00
TOTALS				27.00				$63.18
HRWR		6		36.00	8.00	0.0625		**$2.25**
								$65.43

RCP Results @ 56 Days

Batch No.	1	3
Age at Test (days)	56	56
Cyl 1 top	404	370
Cyl 2 top	354	444
Cyl 3 top	454	293
Average Coulombs	404	369
Chloride Ion Penetrability	Very Low	Very Low

TABLE	
>4000	High
2000 - 4000	Moderate
1000 - 2000	low
100 -1000	very low
<100	Negligible

Any Questions

Thank You