# STRUCTURAL CONCRETE SUBDIVISION JUNE 1973

# 5000 PSI CONCRETE

PRELIMINARY INVESTIGATION OF MIX DESIGN

#### Introduction

This concrete investigation was initiated at the request of the Bridge Design Division to provide basic information for design and construction of cost in place post-tensioned bridge members. The concrete proportions were selected on the basis of strength, durability, and place-ability required for this type of construction.

#### MATERIALS

Following are listed the materials used in this investigation and their sources:

#### Aggregates:

3/4" Stone and Sand

Lebanon Crushed Stone, Inc. West Lebanon, New Hampshire

#### Cement:

Type I

Glens Falls Portland Cement Co. Glens Falls, New York

#### Water Reducing-Retarding Admixture:

Plastiment

Sika Chemical Corp. Passaic, New Jersey

#### Air Entraining Admixture:

NVX

Hercules Powder Co. Wilmington, Delaware

#### Procedures

The procedures used in designing the mixes closely followed those outlined in ACI Standard 211.1-70 (recommended practice for selecting proportions for normal weight concrete). The mix designs and data used in establishing them are noted in the following table.

	Mix Design #1	Mix Design #2
Coarse Aggregate lbs/cu.yd. (dry)	1862	1947
Fine Aggregate lbs/cu.yd. (dry)	1147	1067
Ratio Fine Aggregate to Total Aggregate (%)	39.6	36.9
Cement	725	725
Water-Cement Ratio	.40	.40
Slump (inches)	2-3	2=3
Air Content (percent)	6	6
Compressive Strength at 28 days, (psi)	5000	5000
Water Reducing-Retarding Admixture (oz/sk)	2½	2½

Three batches of each design were mixed in a Lancaster open pan mixer and the concrete was tested for consistency, air content, relative yield, and compressive strength. Standard 6x12 inch cylinders, cast in treated cardboard molds, were continuously moist cured and tested in compression at ages of 3, 7, 14, and 28 days.

#### Results

#### Consistency:

Air contents of all batches ranged from  $5\frac{1}{2}$  to 6 percent as measured by the Chace Air Indicator. These results correlated closely with the Standard pressure meter test which was occasionally used for confirmation.

#### Relative Yield:

The weight per cubic foot and relative yield of the two mix designs compared closely with the following results being obtained:

	Mix Design #1	Mix Design #2
Weight Per Cubic Foot (lbs)	150.58	150.30
Relative Yield (%)	99.9	100.2

#### Compressive Strength:

Compressive strength results are shown in the accompanying tables.

Mix Design #1									
	3 Days	7 Days	14 Days	28 Days					
Batch A	4368	5049	5368	5854					
Batch B	4483	5438	5739	5987					
Batch C	4112	4810	5085	5597					
		der ein sem für ein stelle der eine stelle der der ein	-angbusing emmonstronggressroom) -emm						
Average	4321	5099	5397	5813					

Mix Design #2									
	3 Days	7 Days	14 Days	28 Days					
Batch A	3979	4855	5359	5615					
Batch B	4253	4695	5385	5730					
Batch C	4067	4828	5359	5615					
Average	4100	4793	5368	5653					

#### Summary

The concrete designed for 5000 psi proved satisfactory with laboratory results exhibiting an average strength of 5733 psi.

Both the slump and air content were within anticipated tolerances.

#### Conclusions & Recommendations

The mix design used in this investigation is satisfactory for field use provided rigid control be maintained relative to slump and air content. Due to the higher strengths involved, it would not be detrimental to durability to lower the air content to 5%. This would further increase compressive strength.

It should be noted that if variations in materials are anticipated, relative to cement or aggregate sources and admixture manufacturers, further investigations should be conducted in the laboratory. Also, if construction practices result in lower strengths, provisions should be made in the specifications for necessary adjustments.

Although very stiff mixes are commonly used in both pre-stressed and post tensioned concrete, complete and thorough vibration in the forms is necessary to insure proper consolidation. 642 bay

## CREENDER TEST REPORT

Date March 14, 73

						7	101 21	4 8		
Coarse Agg.	. Source		Magyantagy aport foliativ dis distinguis charms	Comerc (		N	of thea:	> / ·		en against en anna ann ann a ann an ann ann ann an
Pine Arr. 3	Source			free	- September		And the second s			
	Gradation	% Passing	,	1	E Borro	0 6	THEC C	126m 163		
] !!		3/8"	er anazonja uznoja odkorani i pakilika i	Prode N		4	1 <i>11A</i>	COLUMN STREET CONTRACTOR STREET		
3/411		1//4		Chemica	1 17700	-				
3/8"		1#16		Mir Are	at Sour	ce	YDY M	-	1 1 -+	DAA
74		1//30		Trade N	ame		110/-		1 4/	111174
7 <u>4</u> 85		14:50			С	las	s MA Mix :	<u> </u>	<u>13.</u>	_4
Flats %		#100		Whights	del	Pe	r Yard	2000	Loc .	tabdar
Practures ;	7/2	FM Color	2	140 Ston		1/3	U55	1993	1955	1955
Fine Arg.		A second contract to the contr		band	/189		43	12.49	1249	12.49
Coarse Agr				Coment			11	16.11	611	611
Dwador	Inant Mine	eral Composi	tion	Mater			140	240	227	223
Coarse Agg		72 ((2 ()()))	0.1.071	The same	\$		5.5		4042	4038
	<del></del>			LADDA.			<u> </u>	1	1 7500	and and the second
Fine Agg.				Yield	12		01	11025	101	102.5
				Unit He	· ch-		49.87	1146.84		145,84
				0.11.0 110		-	COLLEC 003/4			topotopione comment of the same
77 - 11 - 37 -	Toursday	Dayataatia		ncrete Te ontent						and the second s
Bacth No.		Penetration			Annual		Slump			Strength
RBE	500) psi	4000 psi	Per	cent	Degree	es	Inches	3 Day	7 Day	28; Day
Retarder	Hrs.	Hrs.	41/4					1		
1			5340	144 5 /4P			3/2			
2			6	6 /4/1			33/4			:
3										
Average										
Reference										
41			16/20				3			
82			16/20	c 692.11	55		3 3/3/			
6										
Average						)		,		
	tent (Ave.	% of reduct	iom du	しっか le to R	DA	-	6 %		1	
Comp. Str	noth Avg	. % of incre	ase du	e to Reta	rder)		3 Day	***	jay	28 Day
Time of S	atte or (Av	ro. % of Davi	ation	due to Re	starder	)		Inde 1		Final
Mimo of S	attion (Ax	g. Increase	in Hac	duo to	Ratando	227		Initial		Final
TIME OF DE	O U BELLES (AV	9. THOTETOR	ALL ALL FO	b and bo	LIC BOLL CE	J. 1/		44444		
Notes:										
									A	
1										
										4-04-00-00-00-00-00-00-00

7609

#### RETARDER TEST REPORT

Date March 14, 73

Coarse Agg	. Source				Source /	Vortheas					
Fine Acr.	Source			Type I							
	Gradation	% Passing		Source WRDA GRACE Chemical							
]"		3/8"		) Trade N		RDA					
3/4"		W.L		Chemica							
3/8"					nt Source			***************************************			
# <u>4</u> 48		1//30		divide !		REF			IRPA,		
		₩50				ass/ Al Mix		12			
Flats %		⊮100		Whights		Per Yard	(Care).		serder		
Fractures		IPM Colo	r	1 #2 Star	The state of the s	1889	1888	1888	1888		
Rine Arr.				I for aid	1142	17.09	11209	1209	12.09		
Coarse Arr	. Sp. Gr.	1 0		1 Coment		658	658	658	6.58		
		eral Composi	tion	Moter	internal angles of	253	263	126	22/		
Coarse Agg						4008	4018	3981	3.278		
Fine Agg.		والمعاولة والمواجعة والمعادمة المنطق المعاولة المواجعة والمائمة المواجعة والمعادمة والمعادمة والمعادمة والمعادمة		<i>LAKP</i>   Yiéld	703/.52ck	50.0 - 167	1 100 2	9.9,6	199.8		
				Unit We	a ab a	59.8 c 6/2/40 149.14	149,6		147.57		
				Yield	Carrect	ted to		70 A	16		
			Co	ncrete Te	ests		99.6	99.4			
Bacth No.		Penetration	Air C	ontent	Temp.	Slump	Compa	ressive	Strength		
REPerence	500 psi	4000 psi	Per	cent	Degrees	Inches	3 Day	/  7 Da	y 28 Day		
Retarder	Hrs.	Hrs.									
- Company			6/4 44	cc 5/2 P/c	ig.	3/2					
2			65	5/4/1	950	3					
<i>3</i>			-								
Average						_					
Reference		-	1,	E 277.7		<del></del>					
# J 5 2			6 % C	**************************************	·	23/4					
6	Capital da	-	6/2 0	6/41	1655	2219					
			<del> </del>				-				
Average	<u> </u>		1	1,,	DDA	_1					
Water Con	tent (Avg.	% of reduct	iom du	e to Bet	PPA	Tiguing.	3 %				
Comp. Stre	ength (AV	3. % of incre	ase du	e to Reta	arder)	3 Day	7	Day	28 Day		
		vg. % of Devi				J Day	Initial	Day	Final		
		vg. Increase				.);			Final		
	3 6 6 22 6	194 11101.0000		78 QUC 60	TIC VOLUCE		Initial	·	rindi		
Wada - a											
Notes:			<del></del>								
					1						
1											
						-					
				. •							

7/2

#### RETARDER TEST REPORT

Date March 14, 23

Coarse Agg	. Source				Source	Northeur					
Fine Arr.				Troe I							
	Gradation	% Passing		Robardor Source Chace Chemical							
7.11		3/811		Trade Ache WRDA							
3/4" 3/8"		// L		Chemical Type							
3/8#		l¥16		Alm Am	ant <del>Sourc</del>	e NVX					
7 <u>4</u> 48		₩30		2- sdc :		N. T					
48		₩50			G2	Las KALOK		, WR	DA V		
Flats %		<b>#100</b>	***************************************	l Whight	3 dit. 1	Ger Yara	14(2)	063/	. Hattyr		
Fractures	j 10	FM Color	-	1,2 Stc	1965	1/823	1823	1823	1823		
Fine Arr.	Sp. Gr.			l i sid	1109	1160	11165	1/6.5	1165		
Coarse Arr	. Sp. Gr.		1. No. 1	1 O. mare		705	70,5	705	705		
Predou	Inent Mind	aral Composi	tion	Filter		1.49	245	240	240		
Coarse Atr				Widen Lineard		3942	79/1/	3,933	39.33		
Fine Agg.		effectively and source they are described amount and accommission of the		- Commence of the Commence of	WR DA	and the state of t					
		Miller (film) (Miller of the American Service on the English of the Service on the Service on the Service of th	**************************************	Yield	· · · · · · · · · · · · · · · · · · ·		B837/	99.5	99 %		
				Unit I	siaht	**************************************	149.55		148,06		
			\$ 2		· · · · · · · · · · · · · · · · · · ·	A-2 / 6			<u></u>		
			y 1	1816 Co	FREE TE "	to 6%	2 % 9	11-			
				ncrete To	ອຣຽຣ 						
Bacth No.		Penetration	-		Temp.		Compre	essive S	Strength		
REF	500) psi	4000 psi	Per	cent	Degree	s Inches	3 Day	7 Day	28 Day		
Retarder	Hrs.	Hrs.		-							
l 1				184 5/2P		334					
2			5/4 01	ure <u>572 f</u>	252	3			:		
<i>\$</i>				·							
Average Reference				The second secon							
# /			6 1/2, Che.	cr 6/2 P	12	-3					
52			5/2 de	10 6 M	× 5.4	3 1/2					
6											
Average	30072										
Water Conf	ent (Avg.	% of reduct	iom du	e to Ret	DA <del>sede</del> r)	. 25					
Comp. Str	ngth (Avs	o to Or micre	ase que	e to ket	arder)	3 Day		)ay	28 Day		
Time or Se	tting (Av	g. % of Devi	<u>ation (</u>	due to R	<u>etarder)</u>		Initial		Final		
Time of Se	etting (Av	g. Increase	<u>in Hrs</u>	odue to	Retarde:	r)	<u>Initial</u>		Final		
Notes:											

Age	Ref.	12_ WRDA	76	Ref	7 WRDA	7/2	Ref	75 WRDA	376	
5	3356	3568	124	3339	3573	107	3449	3613	105	
14	3347	3700		3798	4333	114	4019	4010	100 44.8	
28	3802	4311	113	4240	4762	112	4541	4528	100 997	

Aggregate - Lebonon Crushed Stone Inc. Cement - Northeast Type I Admixture - WRDA HIGH

Air - NVX

HIGH COMPRESSIVE STRENGTH CONCRETE

A	nΕ		REFER	ENCE M	lıx				~	VATER REI	риста Мі	*		
OF			SACKS OF CEMENT PER YARD											
	RETE	6	1/2	7		74	2		61/2	?	7		7%	2.
11	١.	Mix	Mix	MIX	Mix	Mix	Mix	X	Mix	MIX	- Mix	MIX	Mix	Mix
DAY	45	Nol	No 2	Nol	No2	NoI	No 2	$\times$	Nal	No2	No I	No Z	Not	Na 2
-	LBS	78,760	69,750	90,750	98,000	95,750	99,250	X	93,750	90,500	99,250	102,750	100,000	104,250
5	PSI	2776	2467	3210	3467	3387	3511	X	3316	3201	3510	3635	3537	3688
r	LBS	95,000	94,750	95,250	103,000	162,250	103,750	X	105,750	94,000	112,250	116,500	109,250	106,750
	PSI	3360	3351	3369	3,643	3617	3670	X	3740	3395	3970	4120	3864	3176
	LRS	97,750	91,500 Horizontal Break	103,500	111,250	117,250	116,000	X	103,250	166,500	118,500	126,500	117,250	109,500
14	PSI	3457	3236	3661	3935	3935	4163	X	3652	3747	4191	4474	4147	3873
0	LBS	114,000	101,000	116,250	123,500	129,500	127,260	$\langle \! \rangle$	124,000	119,750	135,750	133,500	129,750	126,250
29	S PSI	4032	3572	4112	4368	4580	4501	$\bigotimes$	4386	4236	4802	4722	4589	4466

Date March 12, 73

### Laboratory Calculated Concrete Design

Class	Concrete	; Item			
For use on all projects in Concrete Mix from	area using t	his source	<b>0</b> . 7.6 。 > 大、	Car C	
Aggregate from:		1			
# 1 Stone / Cha	hon Che	5481 S	SPecific Gr	avity	Pod widzielośł Einpolizieloślowanowojącogo
# 2 Stone Les. 1	86 hN	4	SPecific Gr	avity	294
Sand			SPecific Gr	avity	271
Design:	Mayorage of the Control of the Contr	an agus feirig fha an t-fhallaid i an t-fhallaid fhail an t-fhail an t-fhallaid an t-fhallaid an t-fhallaid an		Control Address, and Address of the Control of the	elitel digeneric aglescoppingspip digen de Lagrapezza Estrat
Bags of Cemer 40 % Sand to to 8 % Air Entrain 100 % Pea Stone to 5 23 Gallons H <sub>2</sub> O H	tal aggregate nment to total stone	e volume			
Air Entrainment Cement	6 /5 3.15	х 94 х 62.4	e. 3, 108 C	F, = 6/	// lbs.
25 Gallons H <sub>2</sub> O Per Bag Cen	nent 65	x 525	= 4.562C	.F.=37	///25 Gals
5 % Air Entrainment	65%x	27.000	= 1.755C	F.	
Sand (40% Sand to total	aggregate vo	lume )	=7:030C	Colonia de Colonia de	
# 2 Stone (/00 % of total	L stone volume	e)	= 10.395C		
# 1 Stone			≥ :: C	ir aspat	
			27.0000	A Salaran Annie	
Dry Weights:	,				
Sand = 7.030	x 27/	X62.4=	1189	Lbs,	6
#2 Stone = 10,595	x 294	X62.4=	1335	Lbs.	
#1 Stone =	Х	X62.4=	Ton Branch & Constitution of the State of th	Lbs,	
Mix:					
" Stone	<b>=</b>	Lbs.		61	6.05
" Stone	=	Lbs.		10	7.5
Sand	22	Lbs.		10	
Cement		Lbs.			
Gallons-H <sub>2</sub> O Per Yd.	Accordance Control Accidence and Control Accidence	mennessers my Addurfe			

Adjust for Moisture

Date Manch 12

# Laboratory Calculated Concrete Design

Class	A Concrete; Item	501,20
For use on all projects in Concrete Mix from	area using this sou	YCO
Aggregate from:	•	
# 1 Stone	da salamitar salaming salam dika salam salamiga salam dipinikan dan ya palim salami ingalam dikan dikan dikan d	SPecific Gravity
# 2 Stone Leban	of Charles Sto	20 SPecific Gravity 294
Sand Co.L	Charles in the contract of the	SPecific Gravity 27/
Design:		
6.5% Air Entrai	tal aggregate volume nment to total stone volum	6
Air Entrainment Cement	$\frac{7 \times 94}{3.15 \times 62.4}$	:3,348 C.F.= 658 lbs.
25 Gallons H <sub>2</sub> O Per Bag Cen	ment 7.0 x 5 25	= 4.913 C.F.= 36.75 Gals
5 % Air Entrainment	65 ½ x 27.000	_/,7530.F.
Sand (40% Sand to total	aggregate volume )	=6.794 C.F.
# 2 Stone (100 % of tota	l stone volume)	=10,130 C.F.
# 1 Stone		27,000C,F,
Dry Weights:		
Sand = 6.794	x 2.7/ x62.4	= <u>//49</u> Lbs.
#2 Stone = 10.190	x 299 x62.4	= 1870 Lbs.
#1 Stone =	X X62.4	Lbs .
Mix:		erij
" Stone		s. 54nd 63.8
" Stone	Lb:	s. 54nd 63.8 103.9
Sand	=Lb:	
Cement	= Lb:	5.
Gallons-H <sub>2</sub> O Per Yd.		•

Adjust for Moisture

Date March 12

Lehoretory	Calculated	Concrete	Design
THEORY SOLA	Carculated	COMPLETE	Depten

Labora	tory Calculated	Concrete D	esign		
Clas	s A Concrete	; Item	ngalakkan galakkala		
For use on all projects Concrete Mix from	in area using t	his source	State Company Company		
Aggregate from:					
# 1 Stone	s er dit. Disk som klimiker er erländelle, sillere erlän virk, sellen virk, som ett beskriveriskere.	S	Pecific	Gravity	Self .
# 2 Stone / C	Sayon Che	54615765	Pecific	Gravity 2.24	فسف
				Gravity 27/	
Design:					
Bags of Central Report of Stand to Stand to Stand to Stand to Stand Stan	total aggregate ainment e to total ston	e volume			
Air Entrainment Cement	7.5	х 94 х 62,4	3,530	C.F,= 704 1b	5.
Gallons H <sub>2</sub> O Per Bag (	Cement 7.5 7.	х <i>5</i> 23 48	.5.269	/C.F.= 39.375 G	als
5% Air Entrainment	6.5% x	27.000	. 1.75	C.F.	
Sand (40% Sand to total	al aggregate vo	lume )	= 6,5%	%C,F.	
# 2 Stone ( /00% of to	tal stone volum	e)	= 9.83	7C.F.	
# 1 Stone			27.00		
Dry Weights:	<del>V</del>				
Sand = $6.558$	X 27/	X62.4=	1100	Dbs.	
#2 Stone = 9 \$37	x 2 94	X62.4=	180	5 Lbs.	
#1 Stone =		X62.4=		Lbs.	
Mix:					
" Stone	a	Lbs.		61.6	
11 Stone	ende med pop-manages felocialization/paper/paper/mid-settle-patien/sel-set-	Lbs.		61.6	
Sand	princip princip National Africano, production and continues and continues are supplying to the contract of the	Lbs.		100	
Cement	tor	Lbs.			

Adjust for Moisture

Gallons-H<sub>2</sub>O Per Yd.