



October 4, 2017
Project No. 2892097

Mr. Phil Castaneda
3D CONCRETE, INC.
600 South 21st Street
Sparks, Nevada 89431

RE: Research of Hot Weather Concrete Cylinder Curing Methods

Dear Mr. Castaneda:

The purpose of the research program was to determine compressive strength differences when utilizing different curing methods during the elevated summer heat. The concrete was batched at your Sparks batch plant and concrete cylinders were molded from a single 5 cubic yard load of concrete. The concrete was a typical 0.45 water/cementitious ratio city sidewalk mix at a 4 inch slump and a target 6% air content. The initial cylinder curing methods tested were as follows:

1. Laboratory Cured
2. Field Cured in a Cure Box with Water and Ice
3. Field Cured in a Cure Box with Water
4. Field Cured in an Insulated Wood Cure Box

After molding, the concrete cylinders were placed randomly in each cure box. Intellirock temperature loggers were installed in each cure box in order to observe internal cure box temperatures. An ambient outside temperature that ranged from 70 to 113 °F was recorded. The ambient logger and field cure boxes were placed outside next to the 3D Concrete laboratory. Ambient temperatures greater than the actual maximum ambient temperature of 97 °F were recorded due to the heat reflecting off of the building. Outlined in ASTM C31, the initial curing temperatures should be maintained between 60 to 80°F. The only curing method to meet this requirement was the laboratory cured specimens. The water and ice field cure box maintained a 24 hour temperature close to the initial high temperature of the requirements. Attachment C is a graphical presentation of the ambient and cure box temperature loggers.

After 24 hours the cylinders were returned to our laboratory for laboratory curing and compressive strength testing. Compressive strength tests were performed at 3, 7, 14 and 28 days. Attachment A is a summary of the compressive strength results and the maximum and minimum temperatures recorded for each curing method. Attachment B shows a graphical summary of the strength gain for the different curing methods. As shown on Attachment A and Attachment B, the 28 day compressive strength for the water and ice curing method produced the highest 28 day compressive strength with the laboratory cured 28 compressive strength the next highest. Outlined below is a summary of the 28 day compressive strength and strength differential with respect to the curing method:

1. Water and Ice Field Cure Box	5180 PSI	0 PSI
2. Laboratory Cured	4810 PSI	-370 PSI
3. Water Field Cure Box	4520 PSI	-660 PSI
4. Insulated Wood Field Cure Box	4020 PSI	-1160 PSI

As shown above, the difference of the water and ice cure box and the insulated wood cure box was 1160 PSI which is a significant difference. The difference in strength has the potential to fail a 4000 PSI mix due to the curing conditions and may not represent the actual strength of the mix. The data shows that in hot weather excessive curing temperatures will reduce the ultimate 28 day compressive strength.

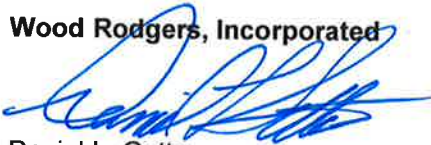
Mr. Phil Castaneda
3D CONCRETE, INC.
October 4, 2017
Page 2

This research program was performed in hot weather conditions and as the season temperatures change, the curing method should be adjusted to obtain the required 60 to 80 °F initial curing requirements of ASTM C31. Higher strength concrete, concrete specified 6000 PSI or greater, should have an initial cure of 68 to 78 °F. The temperatures should be monitored by a maximum/minimum thermometer to verify the initial curing temperatures meet ASTM C31 requirements.

If you have any questions or require further information, please do not hesitate to contact us.

Sincerely,

Wood Rodgers, Incorporated



Daniel L. Gotta
Project Manager

Brian T Clark, PE
Laboratory Manager
RE Number 23118
Expires 12/31/2018



Enclosures

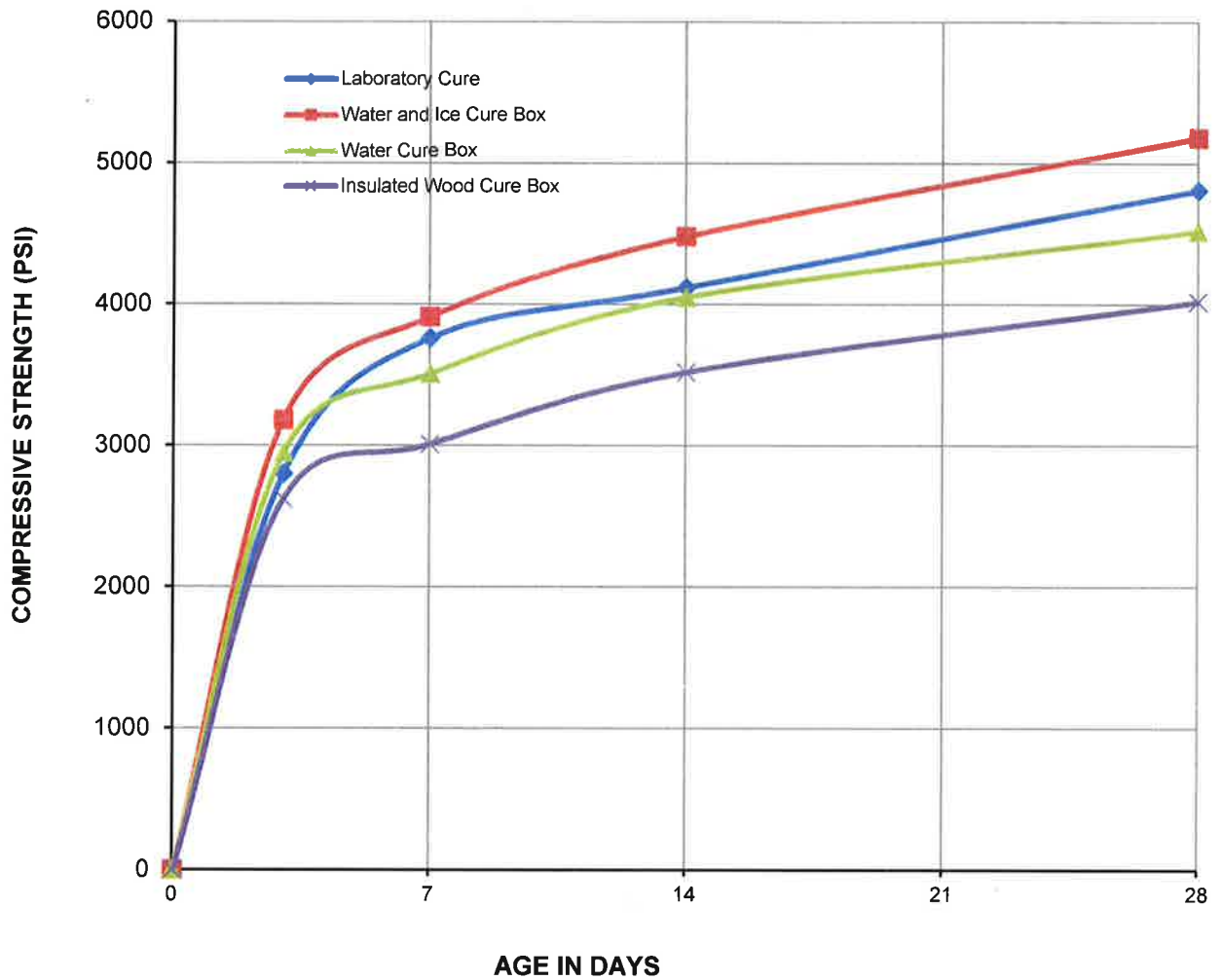
10-4-17

ATTACHMENT A

TRIAL BATCH				
Water/Cement and Pozzolan Ratio	0.45			
	One Cubic Yard Weights			
Cement - Nevada Type II (lbs)	564			
Pozzolan - Nevada Class N (lbs)	47			
Water (lbs)	275			
No. 67 Stone - Dayton Materials Pit (lbs)*	1205			
No. 67 Stone - Trico Pit (lbs)*	400			
Fine Aggregate - Dayton Materials Pit (lbs)*	1261			
Euclid AirMac 12 (6.0%) (oz)**	3.7			
Eucon X15 (oz)	49			
Theoretical Unit Weight (pcf)	139.1			
*Aggregate weights are shown in a SSD condition.				
**This quantity may require adjustment to obtain the desired air content.				
TEST RESULTS:				
Slump (ASTM C143) (inches)	4			
Air Content (ASTM C231) (%)	5.7			
Unit Weight (ASTM C138) (pcf)	139.4			
Aggregate Correction Factor (ASTM C231) (%)	0.3			
Compressive Strengths (ASTM C39) (Average Compressive Strength)				
	Laboratory Cure	Water and Ice Cure Box	Water Cure Box	Insulated Wood Cure Box
3 day (PSI)	2800	3180	2950	2620
7 day (PSI)	3760	3910	3510	3010
14 day (PSI)	4120	4480	4050	3520
28 day (PSI)	4810	5180	4520	4020
Cure Temperature Monitoring				
Maximum - F (> 1 Hour Monitoring)	79	86	104	122
Time - (hrs)	7.25	14.5	9.5	9.75
Minimum - F (> 1 Hour Monitoring)	70	73	73	83
Time - (hrs)	20.75	1.25	1.25	1.25

ATTACHMENT B

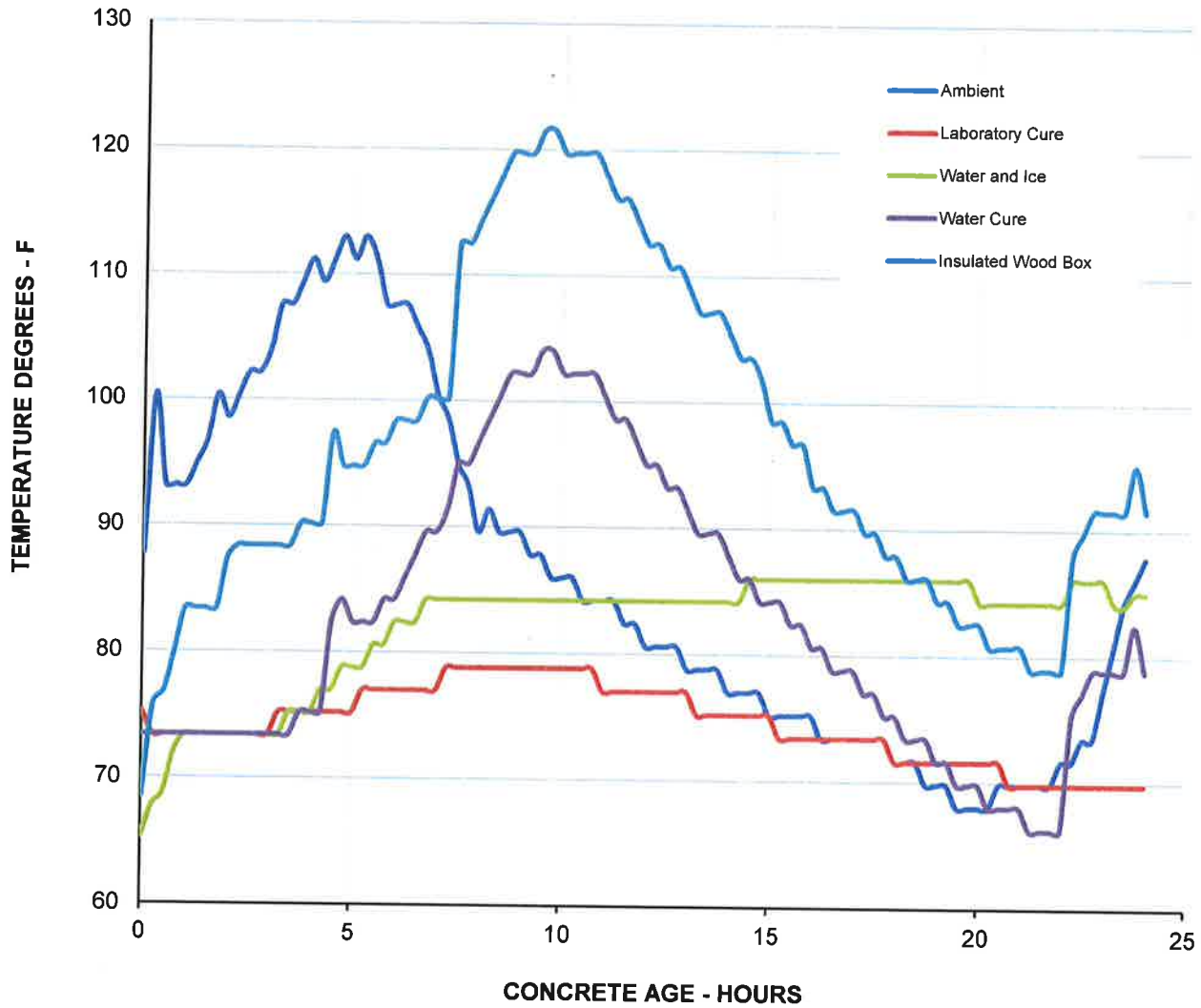
VARIOUS CURING METHODS - COMPRESSIVE STRENGTH / AGE IN DAYS



Cement - Nevada Type II
Pozzolan - Nevada Class N
No. 67 Stone - Dayton Materials Pit
No. 67 Stone - Trico Pit
Fine Aggregate - Dayton Materials Pit
Euclid AirMac 12
Eucon X15

Project No.: 2892.097

ATTACHMENT C
VARIOUS CURING METHODS - TEMPERATURE VERSUS TIME





CURING METHODS RESEARCH

Molding Cylinders
2892.097
Date: 10/04/2017

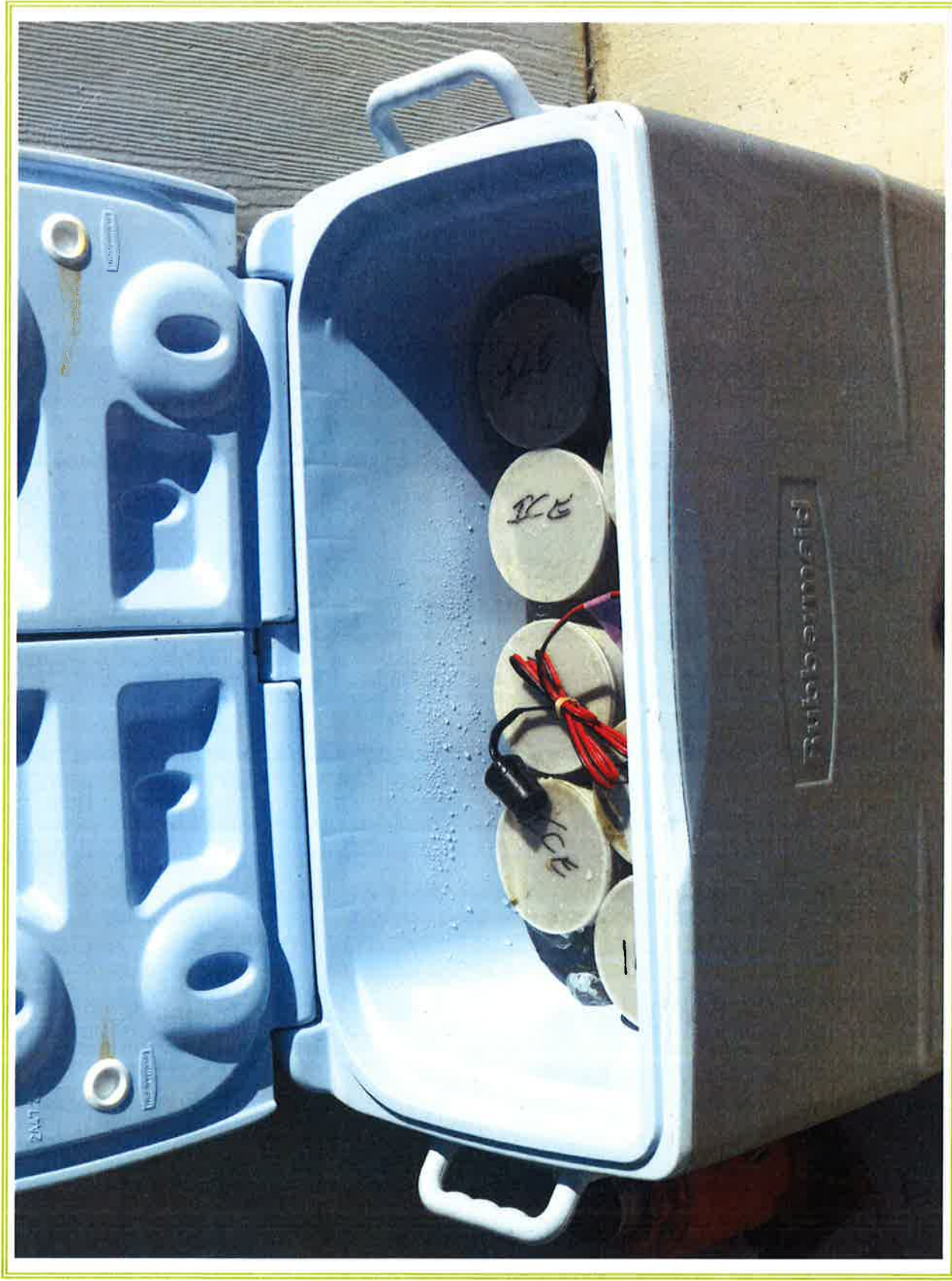


WOOD RODGERS
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1361 Corporate Boulevard
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CURING METHODS RESEARCH

Laboratory Cure
2892.097
Date: 10/04/2017



CURING METHODS RESEARCH

Water and Ice Cure Box
2892.097
Date: 10/04/2017



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BUILDING RELATIONSHIPS ONE PROJECT AT A TIME
1361 Corporate Boulevard
Tel: 775.823.4068



CURING METHODS RESEARCH

Water Cure Box
2892.097
Date: 10/04/2017



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CURING METHODS RESEARCH

Insulated Wood Cure Box
2892.097
Date: 10/04/2017



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MIX DESIGN COMPRESSIVE STRENGTH SUMMARY REPORT

REPORT TO:	MIX NUMBER:	Laboratory Cured
3D Concrete	PROJECT NUMBER:	2892.097
Mr. Phil Castaneda	DATE BATCHED:	18-Aug-17
600 South 21st Street	BATCHED BY:	3D Concrete Plant
Sparks, Nevada 89431	TESTED BY:	Clark
Description: 0.45 Water/Cementitious Ratio Air Entrained - Laboratory Cured		

TRIAL BATCH DATA

CONCRETE	X	GROUT		MORTAR		OTHER	
UNIT WEIGHT (ASTM C 138):	139.4 PCF					AIR CONTENT (ASTM C173):	5.7 %
SLUMP (ASTM C143):	4 Inches					MIX TEMPERATURE:	80 °F

COMPRESSIVE STRENGTH DATA

SAMPLE I.D.:	2954 A	2954 B	2954 C	2954 D	2954 E	2954 F
DATE TESTED:	8/21/2017	8/21/2017	8/21/2017	8/25/2017	8/25/2017	8/25/2017
AGE, DAYS:	3	3	3	7	7	7
DIAMETER, INCHES:	4.00	4.00	4.00	4.01	4.01	4.01
AREA, SQUARE INCHES:	12.57	12.57	12.57	12.63	12.63	12.63
TYPE OF CAP:	Unbonded	Unbonded	Unbonded	Unbonded	Unbonded	Unbonded
ULTIMATE LOAD - LBS.:	34,884	34,832	35,728	47,971	48,124	46,410
TYPE OF FRACTURE:*	1	1	1	1	1	5
COMPRESSIVE STRENGTH, PSI:	2,780	2,770	2,840	3,800	3,810	3,670
AVERAGE STRENGTH, PSI	2,800			3,760		

SAMPLE I.D.:	2954 G	2954 H	2954 I			
DATE TESTED:	9/1/2017	9/1/2017	9/1/2017			
AGE, DAYS:	14	14	14			
DIAMETER, INCHES:	4.01	4.01	4.01			
AREA, SQUARE INCHES:	12.63	12.63	12.63			
TYPE OF CAP:	Unbonded	Unbonded	Unbonded			
ULTIMATE LOAD - LBS.:	52,063	52,202	51,834			
TYPE OF FRACTURE:*	1	5	5			
COMPRESSIVE STRENGTH, PSI:	4,120	4,130	4,100			
AVERAGE STRENGTH, PSI	4,120					

SAMPLE I.D.:	2954 J	2954 K	2954 L	2954 M	2954 N	
DATE TESTED:	9/15/2017	9/15/2017	9/15/2017	9/15/2017	9/15/2017	
AGE, DAYS:	28	28	28	28	28	
DIAMETER, INCHES:	4.00	4.00	4.00	4.00	4.00	
AREA, SQUARE INCHES:	12.57	12.57	12.57	12.57	12.57	
TYPE OF CAP:	Unbonded	Unbonded	Unbonded	Unbonded	Unbonded	
ULTIMATE LOAD - LBS.:	61,118	60,357	58,642	61,952	59,978	
TYPE OF FRACTURE:*	5	1	1	1	1	
COMPRESSIVE STRENGTH, PSI:	4,860	4,800	4,670	4,930	4,770	
AVERAGE STRENGTH, PSI	4,810					

*Types of Fractures: Type 1 = Cone; Type 2 = Cone & Split; Type 3 = Cone & Shear; Type 4 = Shear; Type 5 = Side @ Top or Bottom; Type 6 = Both Sides @ Top, End Pointed

Testing and Sampling were performed in accordance with ASTM C39, C78, C143, C172, C173, C192, C231, C1064, C1231 and C617 Standards as Applicable



WOOD RODGERS

1361 Corporate Boulevard, Reno, Nevada 89502

Phone 775.823.4068 Fax 775.823.4066

Daniel L. Gotta
Project Manager

MIX DESIGN COMPRESSIVE STRENGTH SUMMARY REPORT

REPORT TO: 3D Concrete Mr. Phil Castaneda 600 South 21st Street Sparks, Nevada 89431	MIX NUMBER: Ice and Water Cure Box PROJECT NUMBER: 2892.097 DATE BATCHED: 18-Aug-17 BATCHED BY: 3D Concrete Plant TESTED BY: Clark
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Description: 0.45 Water/Cementitious Ratio Air Entrained - Ice and Water Cure Box

TRIAL BATCH DATA

CONCRETE	X	GROUT		MORTAR		OTHER	
UNIT WEIGHT (ASTM C 138):				139.4 PCF		AIR CONTENT (ASTM C173): 5.7 %	
SLUMP (ASTM C143):				4 Inches		MIX TEMPERATURE: 80 °F	

COMPRESSIVE STRENGTH DATA

SAMPLE I.D.:	2957 A	2957 B	2957 C	2957 D	2957 E	2957 F
DATE TESTED:	8/21/2017	8/21/2017	8/25/2017	8/25/2017	9/1/2017	9/1/2017
AGE, DAYS:	3	3	7	7	14	14
DIAMETER, INCHES:	4.00	4.00	4.01	4.01	4.01	4.01
AREA, SQUARE INCHES:	12.57	12.57	12.63	12.63	12.63	12.63
TYPE OF CAP:	Unbonded	Unbonded	Unbonded	Unbonded	Unbonded	Unbonded
ULTIMATE LOAD - LBS.:	40,130	39,667	49,599	49,117	55,957	57,092
TYPE OF FRACTURE:*	1	1	1	1	5	1
COMPRESSIVE STRENGTH, PSI:	3,190	3,160	3,930	3,890	4,430	4,520
AVERAGE STRENGTH, PSI	3,180		3,910		4480	


SAMPLE I.D.:	2957 G	2957 H	2957 I			
DATE TESTED:	9/15/2017	9/15/2017	9/15/2017			
AGE, DAYS:	28	28	28			
DIAMETER, INCHES:	4.00	4.00	4.00			
AREA, SQUARE INCHES:	12.57	12.57	12.57			
TYPE OF CAP:	Unbonded	Unbonded	Unbonded			
ULTIMATE LOAD - LBS.:	65,005	63,906	66,546			
TYPE OF FRACTURE:*	1	1	1			
COMPRESSIVE STRENGTH, PSI:	5,170	5,080	5,290			
AVERAGE STRENGTH, PSI	5,180					

*Types of Fractures: Type 1 = Cone; Type 2 = Cone & Split; Type 3 = Cone & Shear; Type 4 = Shear; Type 5 = Side @ Top or Bottom; Type 6 = Both Sides @ Top, End Pointed

Testing and Sampling were performed in accordance with ASTM C39, C78, C143, C172, C173, C192, C231, C1064, C1231 and C617 Standards as Applicable



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 1361 Corporate Boulevard, Reno, Nevada 89502
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Daniel L. Gotta
 Project Manager

MIX DESIGN COMPRESSIVE STRENGTH SUMMARY REPORT

REPORT TO:	MIX NUMBER:	Water Cure Box
3D Concrete	PROJECT NUMBER:	2892.097
Mr. Phil Castaneda	DATE BATCHED:	18-Aug-17
600 South 21st Street	BATCHED BY:	3D Concrete Plant
Sparks, Nevada 89431	TESTED BY:	Clark

Description: 0.45 Water/Cementitious Ratio Air Entrained - Water Cure Box

TRIAL BATCH DATA

CONCRETE	X	GROUT		MORTAR		OTHER	
UNIT WEIGHT (ASTM C 138):	139.4 PCF					AIR CONTENT (ASTM C173):	5.7 %
SLUMP (ASTM C143):	4 Inches					MIX TEMPERATURE:	80 °F

COMPRESSIVE STRENGTH DATA


SAMPLE I.D.:	2955 A	2955 B	2955 C	2955 D	2955 E	2955 F
DATE TESTED:	8/21/2017	8/21/2017	8/25/2017	8/25/2017	9/1/2017	9/1/2017
AGE, DAYS:	3	3	7	7	14	14
DIAMETER, INCHES:	4.00	4.00	4.01	4.01	4.01	4.01
AREA, SQUARE INCHES:	12.57	12.57	12.63	12.63	12.63	12.63
TYPE OF CAP:	Unbonded	Unbonded	Unbonded	Unbonded	Unbonded	Unbonded
ULTIMATE LOAD - LBS.:	36,876	37,233	44,588	43,933	52,996	49,126
TYPE OF FRACTURE:*	1	1	1	1	1	1
COMPRESSIVE STRENGTH, PSI:	2,930	2,960	3,530	3,480	4,200	3,890
AVERAGE STRENGTH, PSI	2,950		3,510		4050	

SAMPLE I.D.:	2955 G	2955 H	2955 I			
DATE TESTED:	9/15/2017	9/15/2017	9/15/2017			
AGE, DAYS:	28	28	28			
DIAMETER, INCHES:	4.00	4.00	4.00			
AREA, SQUARE INCHES:	12.57	12.57	12.57			
TYPE OF CAP:	Unbonded	Unbonded	Unbonded			
ULTIMATE LOAD - LBS.:	56,648	57,014	56,624			
TYPE OF FRACTURE:*	1	1	1			
COMPRESSIVE STRENGTH, PSI:	4,510	4,540	4,510			
AVERAGE STRENGTH, PSI	4,520					

*Types of Fractures: Type 1 = Cone; Type 2 = Cone & Split; Type 3 = Cone & Shear; Type 4 = Shear; Type 5 = Side @ Top or Bottom; Type 6 = Both Sides @ Top, End Pointed

Testing and Sampling were performed in accordance with ASTM C39, C78, C143, C172, C173, C192, C231, C1064, C1231 and C617 Standards as Applicable


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 Daniel L. Gotta
 Project Manager

MIX DESIGN COMPRESSIVE STRENGTH SUMMARY REPORT

REPORT TO: 3D Concrete Mr. Phil Castaneda 600 South 21st Street Sparks, Nevada 89431	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%;">MIX NUMBER:</td> <td>Insulated Wood Cure Box</td> </tr> <tr> <td>PROJECT NUMBER:</td> <td>2892.097</td> </tr> <tr> <td>DATE BATCHED:</td> <td>18-Aug-17</td> </tr> <tr> <td>BATCHED BY:</td> <td>3D Concrete Plant</td> </tr> <tr> <td>TESTED BY:</td> <td>Clark</td> </tr> </table>	MIX NUMBER:	Insulated Wood Cure Box	PROJECT NUMBER:	2892.097	DATE BATCHED:	18-Aug-17	BATCHED BY:	3D Concrete Plant	TESTED BY:	Clark
MIX NUMBER:	Insulated Wood Cure Box										
PROJECT NUMBER:	2892.097										
DATE BATCHED:	18-Aug-17										
BATCHED BY:	3D Concrete Plant										
TESTED BY:	Clark										

Description: 0.45 Water/Cementitious Ratio Air Entrained - Insulated Wood Cure Box

TRIAL BATCH DATA

CONCRETE	X	GROUT	MORTAR	OTHER	
UNIT WEIGHT (ASTM C 138):					139.4 PCF
SLUMP (ASTM C143):					4 Inches
AIR CONTENT (ASTM C173):					5.7 %
MIX TEMPERATURE:					80 °F

COMPRESSIVE STRENGTH DATA

SAMPLE I.D.:	2956 A	2956 B	2956 C	2956 D	2956 E	2956 F
DATE TESTED:	8/21/2017	8/21/2017	8/25/2017	8/25/2017	9/1/2017	9/1/2017
AGE, DAYS:	3	3	7	7	14	14
DIAMETER, INCHES:	4.00	4.00	4.01	4.01	4.01	4.01
AREA, SQUARE INCHES:	12.57	12.57	12.63	12.63	12.63	12.63
TYPE OF CAP:	Unbonded	Unbonded	Unbonded	Unbonded	Unbonded	Unbonded
ULTIMATE LOAD - LBS.:	35,185	30,624	40,229	35,628	45,797	43,068
TYPE OF FRACTURE:*	1	1	1	1	5	1
COMPRESSIVE STRENGTH, PSI:	2,800	2,440	3,190	2,820	3,630	3,410
AVERAGE STRENGTH, PSI	2,620		3,010		3520	

SAMPLE I.D.:	2956 G	2956 H	2956 I			
DATE TESTED:	9/15/2017	9/15/2017	9/15/2017			
AGE, DAYS:	28	28	28			
DIAMETER, INCHES:	4.00	4.00	4.00			
AREA, SQUARE INCHES:	12.57	12.57	12.57			
TYPE OF CAP:	Unbonded	Unbonded	Unbonded			
ULTIMATE LOAD - LBS.:	52,687	47,700	51,422			
TYPE OF FRACTURE:*	1	5	5			
COMPRESSIVE STRENGTH, PSI:	4,190	3,790	4,090			
AVERAGE STRENGTH, PSI	4,020					

*Types of Fractures: Type 1 = Cone; Type 2 = Cone & Split; Type 3 = Cone & Shear; Type 4 = Shear; Type 5 = Side @ Top or Bottom; Type 6 = Both Sides @ Top, End Pointed

Testing and Sampling were performed in accordance with ASTM C39, C78, C143, C172, C173, C192, C231, C1064, C1231 and C617 Standards as Applicable



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 Project Manager