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Compressive Strength of Concrete at Seabrook Station



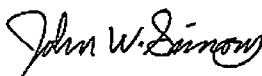
This appendix includes MPR Calculation 0326-0062-CLC-02, *Compressive Strength Values for Concrete at Seabrook Station*, Revision 0.



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CALCULATION TITLE PAGE

Client: NextEra Energy Seabrook, LLC	Page 1 of 8 plus Appendix A
Project: Approach for Estimating Through-Wall Expansion from Alkali-Silica Reaction at Seabrook Station	Task No. 0326-1405-0074
Title: Compressive Strength Values for Concrete at Seabrook Station	Calculation No. 0326-0074-CLC-02

Preparer / Date	Checker / Date	Reviewer & Approver / Date	Rev. No.
 David H. Bergquist January 28, 2015	 Christina Hamm January 28, 2015	 John W. Simons January 28, 2015	0



QUALITY ASSURANCE DOCUMENT

This document has been prepared, checked, and reviewed/approved in accordance with the QA requirements of 10CFR50 Appendix B and/or ASME NQA-1, as specified in the MPR Nuclear Quality Assurance Program.



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RECORD OF REVISIONS

Calculation No. 0326-0074-CLC-02		Prepared By 	Checked By 	Page: 2
Revision	Affected Pages	Description		
0	All	Initial Issue		

Note: The revision number found on each individual page of the calculation carries the revision level of the calculation in effect at the time that page was last revised.



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1.0 PURPOSE

This calculation evaluates available 28-day compressive strength values determined from concrete cylinders during the original construction of Seabrook Station. These values are then displayed on a histogram to show the data distribution, mean, and standard deviation. Additionally, the data are separated by location and by the strength class of the concrete (i.e. specified compressive strength).

2.0 SUMMARY OF RESULTS

All available 28-day compressive strength data points were compiled to form the histogram given in Figure 1. The average 28-day compressive strength is 5456 psi and the standard deviation is 568 psi. Seventy-five percent of the data fall within one standard deviation of the mean and ninety-four percent of the data fall within two standard deviations of the mean.

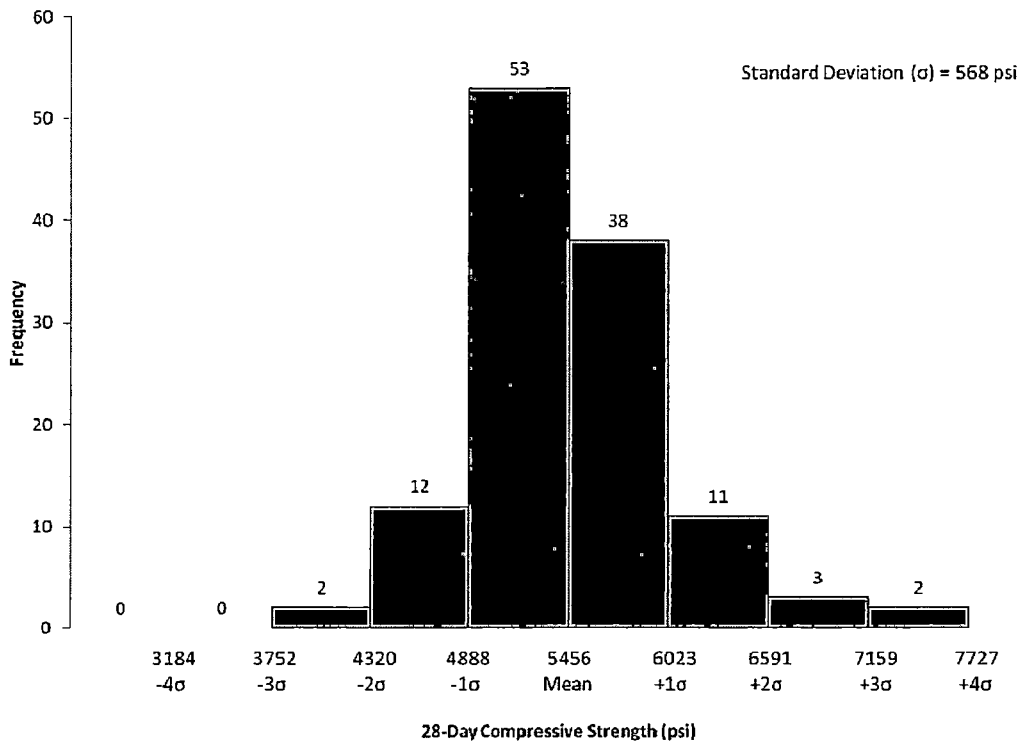


Figure 1. 28-Day Compressive Strength Values for Concrete Cylinders at Seabrook Station



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Table 1 shows the data presented in Figure 1 along with the data categorized by room at Seabrook and by concrete strength class.

Table 1. 28-Day Compressive Strength Data for Seabrook Station

	Mean	Standard Deviation (σ)	No. Of Data Points	Min	Max	% of data within 1 σ	% of data within 2 σ
All Data	5456	568	121	4240	7360	75%	94%
3000 PSI Strength Class	5621	691	50	4270	7360	74%	96%
4000 PSI Strength Class (Note 1)	5339	430	71	4240	6150	70%	99%
Containment Enclosure Building	5426	380	24	4880	6080	67%	100%
RHR Equipment Vault	5503	491	35	4240	6150	63%	97%
EFW Pump House Stairway A	5390	269	12	4950	5870	67%	100%
RCA Walkway	4891	404	12	4270	5450	50%	100%
B EDG Building	5197	371	21	4600	5840	62%	100%
B Electrical Tunnel	6163	705	17	5220	7360	65%	100%



Note 1: The strength class of 9 samples from the RHR Equipment Room cannot be identified with certainty due to poor resolution of the reference document. These samples are most likely 4000 psi strength class samples based on their proximity to other 4000 psi strength class samples. See Appendix A for more details.

3.0 BACKGROUND

MPR is developing a methodology to determine the through-thickness expansion of concrete structures at Seabrook Station due to the Alkali-Silica Reaction (ASR). The through-thickness expansion is related to the reduction in elastic modulus of the concrete over time. One approach for estimating the original elastic modulus is to calculate it from the 28-day compressive strength of the concrete using an equation from ACI 318 (Reference 1).



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4.0 METHODOLOGY

Seabrook Foreign Print No. 100629 and United Engineers Calculation No. CD-20 (References 2 and 3) include 28-day compressive strength results for concrete used in original construction for the following buildings at Seabrook Station:

- Containment Enclosure Building
- RHR Equipment Vault
- EFW Pump House Stairway A
- RCA Walkway
- B Diesel Generator Building
- B Electrical Tunnel



These references provide the 121 data points used in this calculation. These 28-day compressive strength data points are included in Appendix A.

5.0 RESULTS

The average 28-day compressive strength of all data points is 5456 psi and the standard deviation is 568 psi. Seventy-five percent of the data fall within one standard deviation of the mean and ninety-four percent of the data fall within two standard deviations of the mean. Therefore, the mean is a representative value for the 28-day compressive strength of all concrete used at Seabrook. See Section 2.0 for a histogram of all data points as well as a table of the compressive strength data by room and concrete strength class. Figures 2 and 3 display the data for the 3000 psi and 4000 psi strength class concrete cores, respectively.



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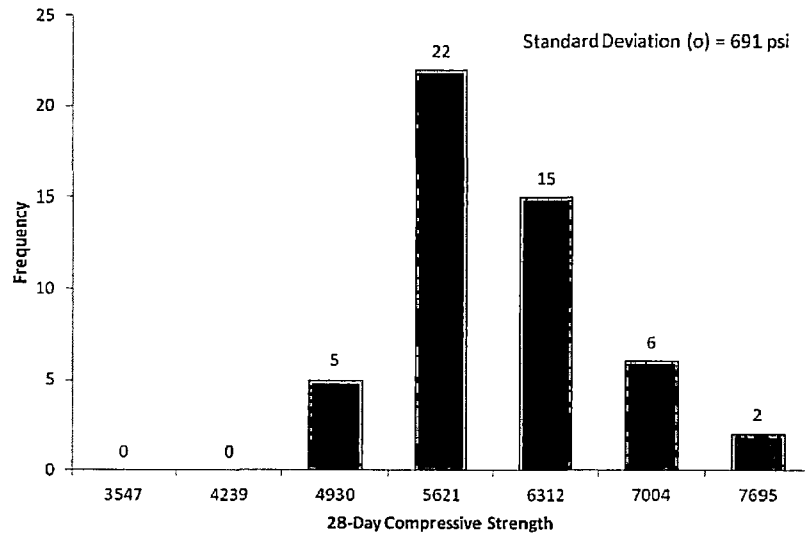


Figure 2. 28-Day Compressive Strength Values for 3000 psi Strength Class Concrete Cores

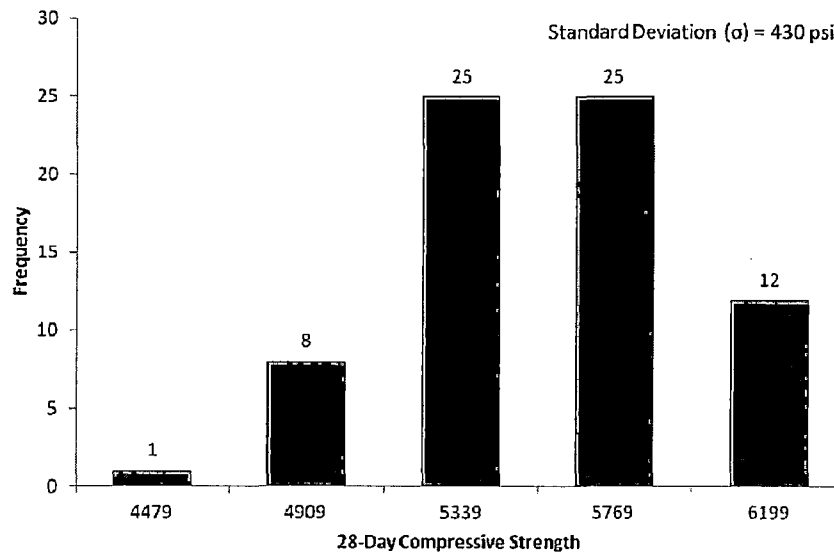




Figure 3. 28-Day Compressive Strength Values for 4000 psi Strength Class Concrete Cores



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6.0 REFERENCES

1. ACI 318-71, "Building Code Requirements for Structural Concrete," American Concrete Institute, 1971.
2. Seabrook Foreign Print No. 100629, "Concrete Test Report," Revision 0.
3. United Engineers Calculation No. CD-20, "Design of Mats at El. 20' 0" and 0' 0" and Walls Below Grade for Electrical Tunnels and Control Building," Revision 4.



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A

Compressive Strength Data

Table A-1 contains the 28-day compressive strength data for concrete cores at Seabrook Station.

Table A-1: 28-Day Compressive Strengths for Concrete Cores at Seabrook Station

Room	Sample No.	Compressive Strength (psi)	Strength Class (psi)
Containment Enclosure Building (Reference 2)	4405	5130	4000
	4406	5200	4000
	4407	5620	4000
	4405A	6080	4000
	4406A	5700	4000
	4407A	5410	4000
	4641	5200	4000
	4642	5060	4000
	4643	5410	4000
	4641A	5980	4000
	4642A	6050	4000
	4643A	6010	4000
	4648	5020	4000
	4649	5090	4000
	4650	4950	4000
	4655	5380	4000
	4656	5240	4000
	4657	4880	4000
	4648A	5020	4000
	4649A	5160	4000
	4650A	5360	4000
	4655A	5780	4000
	4656A	5730	4000
	4657A	5770	4000



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Table A-1: 28-Day Compressive Strengths for Concrete Cores at Seabrook Station

Room	Sample No.	Compressive Strength (psi)	Strength Class (psi)
RHR Equipment Vault (Reference 2)	94	6070	3000
	95	5780	3000
	96	5710	3000
	101	5800	3000
	102	5730	3000
	103	5700	3000
	108	6140	3000
	109	5960	3000
	110	6030	3000
	430	5020	4000 ¹
	431	4990	4000 ¹
	432	5060	4000 ¹
	430A	5450	4000
	431A	5480	4000
	432A	5380	4000
	437	6010	4000
	438	5620	4000
	439	5980	4000
	437A	6010	4000
	438A	6150	4000
	439A	6120	4000
	unknown	4670	4000
	unknown	4740	4000
	unknown	5660	4000
	unknown	5450	4000
	unknown	5480	4000
	unknown	5620	4000
	unknown	5700	4000
	unknown	5700	4000
	unknown	4600	4000 ¹
	unknown	5130	4000 ¹
	unknown	4240	4000 ¹
	unknown	5270	4000 ¹
	unknown	5240	4000 ¹

¹ Concrete strength class cannot be determined with certainty due to poor resolution of reference document.



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Table A-1: 28-Day Compressive Strengths for Concrete Cores at Seabrook Station

Room	Sample No.	Compressive Strength (psi)	Strength Class (psi)
RHR Equipment Vault	unknown	4920	4000 ¹
EFW Pump House Stairway A (Reference 2)	590	5700	3000
	591	5700	3000
	592	5590	3000
	590A	4950	3000
	591A	5200	3000
	592A	5240	3000
	597A	5290	3000
	598A	5870	3000
	599A	5380	3000
	604A	5180	3000
	605A	5340	3000
	606A	5240	3000
RCA Walkway (Reference 2)	489	5310	3000
	490	4440	3000
	491	4950	3000
	489A	5200	3000
	490A	5450	3000
	491A	4880	3000
	484	4470	3000
	485	4270	3000
	486	4370	3000
	484A	5040	3000
	485A	5090	3000
	486A	5220	3000
B EDG Building (Reference 2)	unknown	4620	4000
	unknown	4700	4000
	unknown	4600	4000
	unknown	5150	4000
	unknown	5660	4000
	unknown	5200	4000
	315	5520	4000
	316	5590	4000
	317	5470	4000
	315A	5840	4000



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Table A-1: 28-Day Compressive Strengths for Concrete Cores at Seabrook Station

Room	Sample No.	Compressive Strength (psi)	Strength Class (psi)
B EDG Building (Reference 2)	316A	5110	4000
	317A	5640	4000
	unknown	4600	4000
	unknown	4950	4000
	unknown	4950	4000
	unknown	5380	4000
	unknown	5310	4000
	unknown	5040	4000
	unknown	5340	4000
	unknown	5040	4000
	unknown	5430	4000
B Electrical Tunnel (Reference 3)	427	5410	3000
	428	5220	3000
	426A	6560	3000
	427A	6490	3000
	428A	6100	3000
	433	5470	3000
	434	5550	3000
	435	5890	3000
	433A	7000	3000
	434A	7220	3000
	435A	7360	3000
	440	5730	3000
	441	5480	3000
	442	5390	3000
	440A	6330	3000
	441A	6810	3000
	442A	6760	3000