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Concrete Foundation Samples Analysis Report

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Introduction

This report provides the results of the sampling event with the following information. Images of the sampling locations are provided in the Appendix.

Sampling address	**123 Main Steert, Town, CT**
Sampling date	January 1st, 2021
Number of samples collected	5
Sampling conducted by	John Doe
Laboratory analysis conducted by	Jane Doe

Field Notes: Two samples were collected from the sidewall with no obvious discoloration. Two samples were collected from the back wall with no obvious discoloration as well. One sample was collected from the slab.

Lab Notes: None

Methodology

Sampling

Samples are collected from the walls and slab of the foundation using a 1-inch diameter vacuum drill. The drill advances to between 4 and 6 inches depth and the resulting powder is collected in the attached holder by vacuum suction. Approximately 25 g of powdered concrete samples are collected per hole and stored in plastic bags for laboratory analysis. The holes are filled using rapid set concrete patching material (images in the Appendix).

Testing

The University of Connecticut has developed a robust method to independently measure sulfur concentrations in concrete and specifically three parameters: total sulfur (S_T) using an elemental analyzer and two ratios using a Wavelength Dispersive X-ray Fluorescence (WD-XRF) method: sulfate-to-total sulfur ratio ($\frac{S^{6+}}{S_T}$) and total sulfide-to-total sulfur ratio ($\frac{S^{2-}}{S_T}$). Each parameter is measured separately in triplicate samples and the average and standard deviation of each parameter are calculated.

The relationship $\frac{S^{6+}}{S_T} + \frac{S^{2-}}{S_T} = 1$ applies when there is no other type of sulfur in the sample and serves as an independent validation of the WDXRF calibration curves.

Sulfide is the sulfur species present in the pyrrhotite mineral (Fe_7S_8) that causes expansion and deterioration of the concrete. The average sulfide in concrete is calculated as:

$$S^{2-} = \left(\frac{S^{2-}}{S_T}\right)_{avg} \times (S_T)_{avg} \; .$$

1 gram of pyrrhotite mineral contains on average 0.3767 grams of sulfide so that the measured sulfide content can be translated to percent pyrrhotite *assuming* that all measured sulfide is present in pyrrhotite mineral.

Details on the testing method are provided in the journal reference [1].

The detection limit $DL_{\frac{S^{2-}}{S_T}}$ of the WD-XRF sulfide analysis method is dependent on the total sulfur concentration and has been determined to be $DL_{\frac{S^{2-}}{S_T}} = 0.037$.

Results

Table 1 shows the results for the five samples collected. The percent pyrrhotite is calculated as $y = \frac{S^{2-}}{0.3767}$ based on an average formula of Fe_7S_8 for pyrrhotite.

Table 1: Sulfur analysis results for the collected samples

Sample ID	Total Sulfur (ST) wt%	Sulfate-to-total sulfur $(\frac{S^{6+}}{S_T})$	Sulfide-to-total sulfur $(\frac{S^{2-}}{S_T})$	Sulfide average (S^{2-}) wt%	Pyrrhotite average ($Fe_{1-x}S$) wt.%
S1 (wall)	0.739 ± 0.005	0.619 ± 0.028	0.380 ± 0.029	0.281	0.746
S2 (wall)	**…**	…	…	…	…
S3 (wall)	**…**	…	…	…	**…**
S4 (wall)	**…**	…	…	…	**…**
S5 (slab)	0.2300 ± 0.003	1.02 ± 0.10	<0.037[1]	<0.008	<0.021

[1] Detection limit of WD-XRF sulfide analysis

Conclusions

The total sulfur concentrations in the four wall samples ranged from x to y wt.% and the slab sample had z wt.%. The sulfide concentration ranged from x to y wt.%, which correspond to a pyrrhotite concentration from z to w wt. %.

The concentration of ST in the slab sample is in the range of the expected total S concentration of "clean" concrete (0.16 wt. % to 0.26 wt. %) that contains gypsum ($CaSO_4 \cdot 2H_2O$) as a basic constituent of Portland cement (see reference [1]). Thus, the total S does not support the presence of pyrrhotite in the slab sample. The WDXRF results confirmed these conclusions, with sulfate S^{6+} being the only sulfur species presence, again related to gypsum as a constituent of "clean" concrete. Sulfide and the corresponding pyrrhotite were below the detection limit of the method in the slab sample.

This report only provides an analysis of the tested samples, and the information, data and conclusions herein are only applicable to such samples. This report does not provide information, data, conclusions, or inferences regarding any other portions of the foundation or any samples not actually tested, nor with respect to any information, data, conclusions or inferences regarding the past, present or future condition of the foundation. Any use and/or reliance on the Information in this report is at your sole risk.

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References

[1] Cruz-Hernandez, Y., Chrysochoou, M., Wille, K., "Wavelength Dispersive X-ray Fluorescence Method to Estimate the Oxidation Reaction Progress of Sulfide Minerals in Concrete". Elsevier, Spectrochimica Acta part B 172 (2020) 105949.

Appendix

Figure 1: Location of sample #1

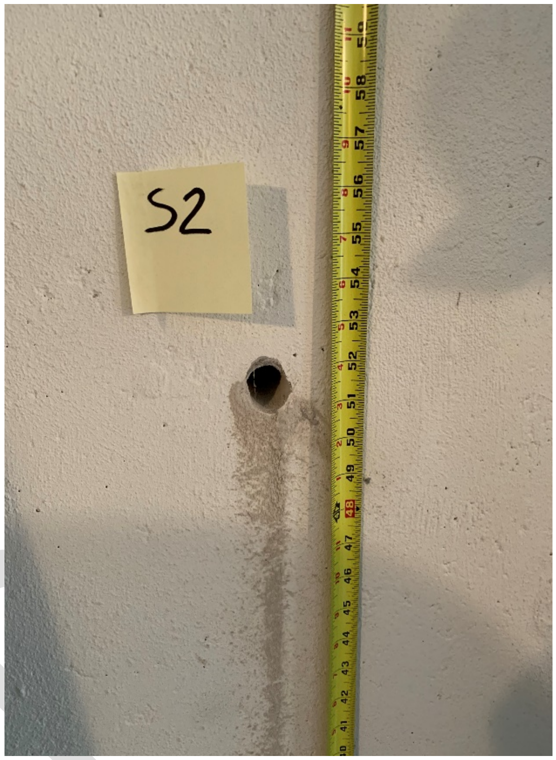

Figure 2: Location of sample #2