Analyzing cement using XRF spectroscopy

XRF quickly detects differences in the composition of cement.

The annual demand for cement is almost 5bn tons and is growing steadily.

A key building material and one of the ingredients of concrete, cement comprises limestone and clay, usually mined from nearby quarries close to manufacture plants.

On site tests, including XRF analysis, are performed at the quarry to ensure chemical composition of the rock meets requirements.

The raw rock is then crushed and heated above 1000 °C in a kiln to become clinker. The clinker is also subjected to analysis by XRF.

In the next stage, the clinker is ground into a fine powder and mixed with sulphate rich gypsum in varying amounts, to produce different grades of cement, such as Portland cement for industrial construction or Ready-to-use cement for lighter jobs. A final XRF test is carried out.

This note shows how XRF analysis can help to ensure your cement product quality is within specification and complies with standards like ASTM C114 or ISO/DIS 29581-2.

The Specac Atlas® Presses and Dies are perfect for quick and easy XRF sample preparation.

Results

Specimens of Portland cement and a pre-mixed 'Ready-to-use' cement were ground using the P6 ball mill at 300 rpm for 10 mins to ensure a fine powder (<60 microns).

6g of the fine powders from each sample were mixed with 1.5g of paraffin binder.

The resulting mixtures were pressed into pellets using the Atlas® 25 Ton Manual Press and a 32mm die.

This Table shows the complete list of elements detected using XRF.

	% WT of elements in samples	
	Portland	Ready-to-use
SiO_2	18.47	60.89
TiO_2	0.32	0.29
Al_2O_3	4.25	5.55
Fe_2O_3	3.28	6.84
MnO	0.08	0.08
MgO	0.99	0.36
CaO	65.14	18.74
Na_2O	0.19	0.45
K_2O	1.19	0.93
P_2O_5	0.20	0.23
SO_3	5.36	4.74
Cl	0.074	0.027
Cr	0.040	0.026
Ni	0.017	0.008
Cu	0.013	0.01
Zn	0.018	0.022
Rb	0.008	0.006
Sr	0.109	0.02
Zr	0.011	0.028
Pb	0.008	0.012
Total %	**99.90**	**99.30**

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> Portland cement has a higher amount of CaO SO_3 than ready-to-use cement

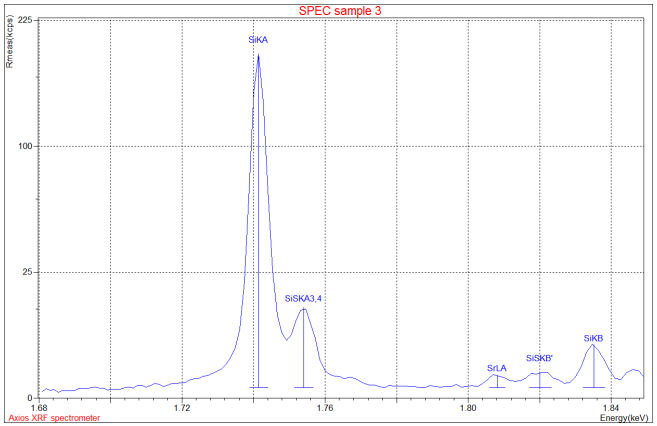

Figure 1. XRF spectrum of silicon signal in Portland cement

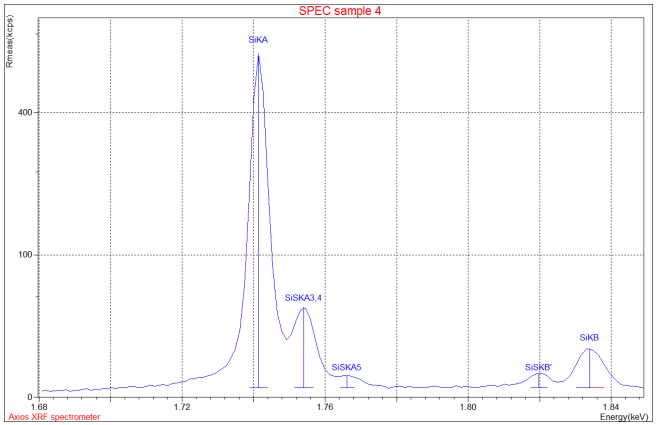

Figure 2. XRF spectrum of silicon signal in Ready-to-Use cement

Figures 1 and 2 show the XRF Spectra of the Portland and Ready-to-use cements respectively, focusing on the silicon signal.

There is a higher silicon signal in the Ready-to-use cement (~61%) because it has been premixed with sand, which contains SiO2.

Portland cement has a higher amount of CaO and SO3 than Ready-to-use cement because it contains calcium sulphate and free lime. Monitoring these elemental groups during production is important for quality control of the final cement.

Conclusions

XRF analysis is routinely used in the cement industry at several stages of production:

- Testing quarry sites to quickly determine mining suitability
- Assessing intermediate products like clinker
- Quality assessing the final cement to international standards such as ASTM C114

Different cements are produced to suit a variety of applications. Portland cement is a good standard for construction but changing the chemical makeup of the cement can make products like Ready-to-use cement.

The difference in the composition for these samples was quickly detected by XRF. The Atlas® 25 Ton manual press used to prepare the pellet samples for analysis is simple to use and requires little user training.

Acknowledgement

Dr. Tom Knott, XRF Geochemist, School of Geography, Geology and the Environment, University of Leicester, LE1 7RH, UK

References

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ASTM, Standard C 114-08, “Standard Test Methods for Chemical Analysis of Hydraulic Cement”, Annual Book of ASTM Standards, Volume 04.01, ASTM International, West Conshohocken, PA, 2008, pp. 150–157.

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