CEMENT APPLICATION

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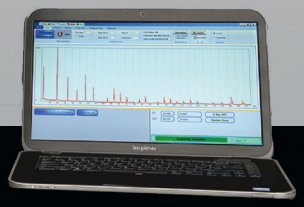
Concrete is the single most prevalent building material used worldwide; with over 2 billion tonnes being produced each year. Concrete is created by mixing hydraulic cement with water and some type of coarse particulate material, such as sand or gravel. Hydraulic cement acts as a binder and sets and hardens when exposed to water. The most common type of hydraulic cement used around the world is Portland cement, which is classified based on its phase composition as type I,II,III,IV,V using ASTM C150 standards, or as CEM I, II, III, IV, V using European EN 197 standards.

The performance characteristics of the cement are directly related to its phase composition, for example, ASTM Type III cement develops high early strength and is characterized by having a larger mass fraction of Alite. In comparison, ASTM Type IV cement is known to have a low heat of hydration and is characterized by having a much lower mass fraction of Alite. Therefore, having prior knowledge of the phases in a cement mixture and their relative amounts allows one to have control over the physical characteristics of the final product.

Traditionally used methods of phase composition analysis include microscopy, chemical analysis and the Bogue calculation. However, none of these methods allow for rapid and accurate multi-phase identification and quantification of a sample. X-ray powder diffraction (XRD) is the only direct method for qualitative and quantitative multi-phase analysis of a cement sample.

Quantitative Phase Analysis – Rietveld Refinement

- Portland cement
- Blended cements
- Limestone
- Gypsum
- Clinker
- Aluminate cements
- Blast furnace slag
- Silicates
- Fly ash
- Free lime



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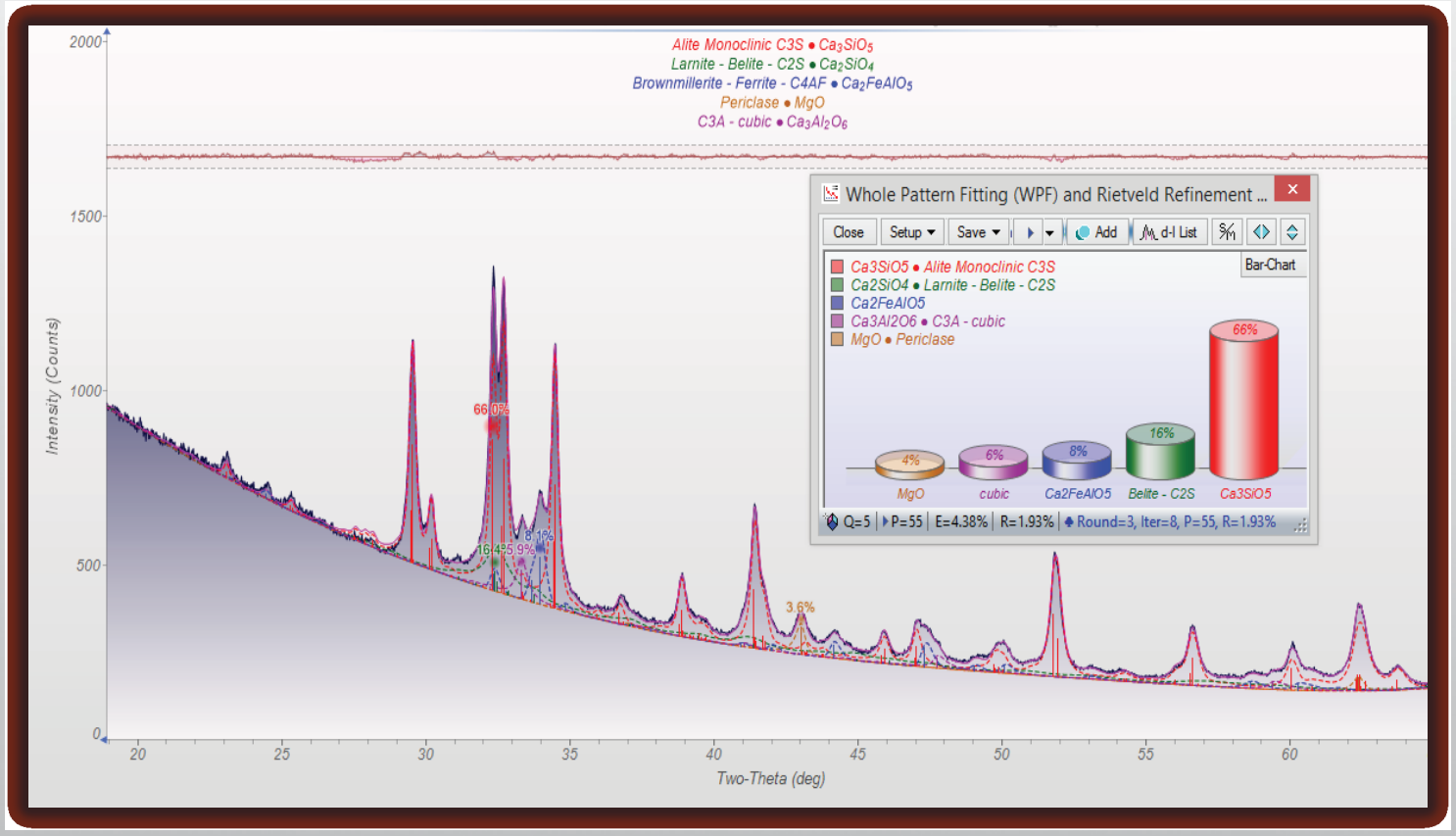
Portland cement is composed of four major phases; Alite (C_3S), Belite (C_2S), Ferrite (C_4AF), and Aluminate (C_3A) in addition to several other potential minor components such as Gypsum, free lime, Periclase, Arcanite, etc. Each phase/mineral in the sample produces its own characteristic diffraction pattern with the intensity of each pattern being proportional to the relative amount in the sample. In combination with powerful JADE powder diffraction software one can easily identify the phases within a complex mixture and quantify their amounts.

Clinker Analysis using JADE Powder XRD Software



Through the use of our economical bench-top AXRD unit coupled with powerful JADE powder diffraction software one can perform quantitative phase analysis utilizing whole pattern fitting and Rietveld refinement to determine the composition of various types of raw feed materials to ensure optimal properties of the produced final product.

Common Clinker and Cement Phases	
Phase	Chemical Formula
Alite (C_3S)	Ca_3SiO_5
Belite (C_2S)	Ca_2SiO_4
Ferrite (C_4AF)	Ca_2FeAlO_5
Calcium Aluminate (C_3A)	$Ca_3Al_2O_6$
Periclase	MgO
Free Lime	CaO
Arcanite	K_2SO4
Limestone	$CaCO_3$
Gypsum	$CaSO_4 \cdot 2H_2O$