مركز المستشار الوطني للتدريب
National Consultant Centre For Training
YOUR GATE TO HANDS-ON TRAINING

5-Day Cement Industry Training Course
In

CHEMISTRY OF CEMENT (SITE VISIT)

Cairo - Egypt, 12 – 16 Oct. 2026

COURSE LEVEL: INTERMEDIATE

COURSE OVERVIEW:

The chemistry of cement is a dynamic study of mineralogy and chemical kinetics that governs the transition from raw materials to a solidified binder. This course defines the molecular structure of clinker phases and the complex hydration reactions that occur when cement is mixed with water. By mastering the chemical principles of cement, participants will understand how to manipulate the product's performance for various construction applications.

The scope of this training includes an advanced look at the kiln's internal chemistry, focusing on the liquid phase formation and the crystallization of Alite and Belite. It covers the chemical impact of supplementary cementitious materials (SCMs) and the role of chemical admixtures in altering the setting time and workability of concrete. Furthermore, the course addresses the chemical durability of cement, exploring how it resists external threats like sulfate attack and carbonation.

Coverage includes the use of X-ray Diffraction (XRD) for phase analysis, the calculation of Bogue compounds, and the study of the heat of hydration. Through a specialized site visit to a central laboratory and the kiln control center, participants will see how chemical theory is applied to manage real-world production. Attendees will gain the analytical skills required to troubleshoot chemical deviations and to develop innovative, high-performance cement formulations.

COURSE OBJECTIVES:

After completion of this course, the participants will be able to:

- Describe the chemical composition of the four primary clinker minerals.
- Explain the thermodynamics of the clinkering process in the rotary kiln.
- Calculate the potential mineral phases using the Bogue equations.
- Understand the role of the liquid phase in the development of Alite crystals.
- Explain the chemical hydration stages: induction, acceleration, and deceleration.
- Analyze the impact of gypsum types (dihydrate vs. hemihydrate) on setting.
- Identify the chemical causes of "flash set" and "false set."
- Evaluate the chemical benefits of adding slag, fly ash, and silica fume.
- Explain the mechanism of chemical admixtures like plasticizers and retarders.
- Assess the resistance of different cements to chemical sulfate attack.
- Interpret XRD and XRF data to monitor clinker quality.
- Predict the heat of hydration based on the mineralogical profile of the cement.

TARGET AUDIENCE:

This course is designed for Process Chemists, Quality Control Engineers, Laboratory Supervisors, R&D Specialists, and Civil Engineers focusing on material science.

TRAINING COURSE METHODOLOGY:

A highly interactive combination of lectures, discussion sessions, and case studies will be employed to maximize the transfer of information, knowledge, and experience. The course will be intensive, practical, and highly interactive. The sessions will start by raising the most relevant questions and motivating everybody to find the right answers. The attendants will also be encouraged to raise more of their questions and to share in developing the right answers using their analysis and experience. There will also be some indoor experiential activities to enhance the learning experience. Course material will be provided in PowerPoint, with necessary animations, learning videos, and general discussions.

The course participants shall be evaluated before, during, and at the end of the course.

COURSE CERTIFICATE:

National Consultant Centre for Training LLC (NCC) will issue an Attendance Certificate to all participants completing a minimum of 80% of the total attendance time requirement.

COURSE OUTLINE / COURSE CONTENT:

MODULE 1: THE MOLECULAR BASIS OF CEMENT

- Review of oxide chemistry and cement chemist notation.
- The chemistry of limestone calcination and the CO_2 cycle.
- Introduction to the Ternary Phase Diagram: CaO - SiO_2 - Al_2O_3.
- The role of temperature in chemical reaction kinetics.
- Overview of chemical bonding in hydraulic minerals.

MODULE 2: CLINKER FORMATION CHEMISTRY

- Solid-state reactions: the formation of Belite (C_2S).
- The critical role of the "Melt" or liquid phase in C_3S formation.
- Factors affecting the viscosity and surface tension of the melt.
- Crystallization of the interstitial phases: C_3A and C_4AF.
- Chemical impact of cooling rates on clinker mineralogy.

MODULE 3: QUANTITATIVE CHEMICAL ANALYSIS

- Advanced Bogue calculations and their limitations.
- Correcting for free lime and minor elements in calculations.
- Introduction to the Rietveld refinement method for XRD.
- Chemical titration methods for specific ion determination.
- Correlating chemical analysis with physical performance.

MODULE 4: CHEMISTRY OF MINOR ELEMENTS

- The behavior of magnesium oxide (MgO) and periclase formation.
- Alkalis (Na_2O, K_2O) and the alkali-sulfate balance.
- Chlorine and sulfur cycles: formation of spurrite and syngenite.
- Influence of trace metals (Zn, Pb, Cr) on chemical setting.
- Managing the "alkali equivalent" for concrete durability.

MODULE 5: HYDRATION KINETICS: FROM PASTE TO ROCK

- The dissolution-precipitation mechanism of hydration.
- Formation of Calcium Silicate Hydrate (C-S-H) and Portlandite ($Ca(OH)_2$).
- Chemistry of the induction period: why cement stays fluid.
- The role of Ettringite in the early-age structure.
- Chemical impact of water-to-cement ratio on pore structure.

MODULE 6: GYPSUM AND SETTING CONTROL

- The chemical interaction between Gypsum and C3A.
- Forms of calcium sulfate: Gypsum, Bassanite, and Anhydrite.
- Chemical causes of "cement-admixture incompatibility."
- Optimizing SO3 levels for strength and stability.
- Identifying the chemical signatures of "over-grinding."

MODULE 7: SUPPLEMENTARY CEMENTITIOUS MATERIALS (SCM)

- The Pozzolanic reaction: converting Portlandite to C-S-H.
- Chemistry of Ground Granulated Blast Furnace Slag (GGBFS).
- Fly ash: Class F vs. Class C chemical characteristics.
- The role of Silica Fume in high-strength chemical bonding.
- Multi-component blends: ternary and quaternary systems.

MODULE 8: CHEMICAL ADMIXTURES AND THEIR MECHANISMS

- Superplasticizers: steric hindrance and electrostatic repulsion.
- The chemistry of set retarders and accelerators.
- Air-entraining agents: surface-active chemistry.
- Corrosion inhibitors and water-repellent chemicals.
- Impact of admixtures on the heat of hydration.

MODULE 9: DURABILITY CHEMISTRY

- Sulfate attack: Ettrigite and Thaumasite formation.
- Carbonation: the reaction between concrete and atmospheric CO2.
- Alkali-Silica Reaction (ASR): the "concrete cancer" chemistry.
- Chloride ingress and the corrosion of reinforcing steel.
- Designing "Low Heat" cement for mass concrete.

MODULE 10: ALTERNATIVE FUELS AND CLINKER CHEMISTRY

- Impact of fuel ash on the chemical moduli of the clinker.
- Volatile cycles and their chemical impact on kiln operation.
- Trace element immobilization in the clinker lattice.

- Chemical adjustments to the raw mix for alternative fuel usage.
- Environmental chemistry of kiln emissions.

MODULE 11: SITE VISIT: ADVANCED CHEMICAL ANALYSIS

- Observation of the XRD and XRF operation and calibration.
- Review of clinker microscopy and phase identification.
- Tour of the hydration testing area and isothermal calorimetry.
- Discussion with the Chief Chemist on chemical troubleshooting.
- Practical review of raw meal chemical control loops.

MODULE 12: COURSE ASSESSMENT AND FUTURE OF CEMENT CHEMISTRY

- Case study: Analyzing a chemical failure in a concrete structure.
- Final examination on cement and hydration chemistry.
- Introduction to "Low Carbon" chemistry: Geopolymers and Belite-rich cements.
- Summary of key chemical concepts and course wrap-up.