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

5-Day Cement Industry Training Course
In

PHYSICO-CHEMISTRY OF CEMENT (SITE VISIT)

Cairo - Egypt, 30 Mar. – 03 Apr. 2026

COURSE LEVEL: INTERMEDIATE

COURSE OVERVIEW:

The physico-chemistry of cement is the fundamental science that dictates how raw minerals transform into a complex hydraulic binder and eventually into a hardened structure. This course defines the molecular interactions, mineralogical phases, and physical properties that govern the quality and performance of cement products. It serves as a bridging discipline between chemical theory and the practical realities of a large-scale industrial manufacturing plant.

The scope of this training focuses on the four primary mineral phases Alite, Belite, Aluminate, and Ferrite—and their specific roles in strength development. It covers the kinetics of hydration, the impact of particle size distribution on reactivity, and the chemical role of gypsum in controlling setting time. Furthermore, the course addresses the influence of minor elements and additives on the overall durability and workability of the final cementitious product.

Coverage includes hands-on modules in the plant laboratory, focusing on X-Ray Fluorescence (XRF) and X-Ray Diffraction (XRD) techniques for mineralogical analysis. Participants will explore the physical testing of cement, including Blaine fineness, setting time, and compressive strength development over time. Through a guided site visit, attendees will observe how process parameters in the kiln and mill directly influence the chemical fingerprint of the clinker and cement.

COURSE OBJECTIVES:

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

- Explain the Bogue equations and their application in clinker mineralogy.
- Identify the four major clinker phases and their individual properties.
- Understand the chemical reactions occurring in the kiln's sintering zone.
- Describe the mechanism of cement hydration and the formation of C-S-H gel.
- Evaluate the role of gypsum and its impact on the aluminate phase.
- Interpret XRF and XRD data for quality control and process adjustment.
- Correlate particle size distribution (PSD) with cement reactivity.
- Understand the impact of free lime and MgO on cement soundness.
- Assess the influence of secondary materials like fly ash and slag.
- Perform standard physical tests for fineness and setting time.
- Analyze the effects of minor oxides on the clinker liquid phase.
- Relate chemical composition to the long-term durability of concrete.

TARGET AUDIENCE:

This course is intended for Quality Control Technicians, Laboratory Chemists, Process Engineers, Production Managers, and R&D Specialists.

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: CHEMICAL COMPOSITION OF RAW MATERIALS

- Analysis of Limestone, Clay, Silica Sand, and Iron Ore.
- Calculating the Lime Saturation Factor (LSF) and Silica Ratio (SR).
- Impact of raw meal homogeneity on chemical reactivity.
- Minor elements: Alkalis, Chlorides, and Sulfates.
- Preparation of laboratory samples for chemical analysis.

MODULE 2: THERMAL TRANSFORMATIONS IN THE KILN

- Decarbonization and the formation of intermediate phases.
- The chemistry of the liquid phase in clinker formation.
- Role of temperature and residence time in Alite growth.
- Volatile cycles and their impact on clinker chemistry.
- Cooling rates and their influence on mineral crystal size.

MODULE 3: CLINKER MINERALOGY AND MICROSCOPY

- Detailed study of Alite (C3S) and Belite (C2S).
- Understanding the Aluminate (C3A) and Ferrite (C4AF) phases.
- Introduction to clinker microscopy and point counting.
- Identifying "Free Lime" and its causes in the process.
- Impact of mineralogy on clinker grindability.

MODULE 4: CEMENT HYDRATION KINETICS

- The induction period and the onset of hardening.
- Formation of Calcium Silicate Hydrate (C-S-H) and Portlandite.
- The role of Ettringite in the early stages of setting.
- Heat of hydration: Measurement and significance.
- Factors affecting the rate of chemical reactions.

MODULE 5: THE CHEMISTRY OF GYPSUM AND SETTING CONTROL

- Solubility of different types of gypsum (Dihydrate, Hemihydrate).
- Interaction between gypsum and the Aluminate phase.
- Preventing "False Set" and "Flash Set" in the mill.
- Optimizing SO3 levels for strength and stability.
- Laboratory simulation of setting time variations.

MODULE 6: PHYSICAL PROPERTIES AND FINENESS

- Relationship between surface area (Blaine) and reactivity.
- Impact of Particle Size Distribution (PSD) on water demand.
- Measuring residue on sieves and its process implications.
- Understanding the density and specific gravity of cement.
- Role of grinding aids in physical property modification.

MODULE 7: LABORATORY ANALYTICAL TECHNIQUES (SITE VISIT)

- Practical demonstration of XRF for elemental analysis.
- Using XRD for phase identification and quantification.
- Operation of the laser diffraction analyzer for PSD.
- Chemical titration methods for Free Lime and SO3.
- Maintenance and calibration of laboratory instruments.

MODULE 8: SOUNDNESS AND VOLUME STABILITY

- Chemistry of Magnesium Oxide (Periclase) expansion.
- The Le Chatelier and Autoclave tests for soundness.
- Impact of coarse free lime on concrete cracking.
- Identifying the causes of chemical unsoundness.
- Mitigation strategies for high-MgO raw materials.

MODULE 9: SUPPLEMENTARY CEMENTITIOUS MATERIALS (SCM)

- Pozzolanic reactions: Fly ash and natural pozzolans.
- Latent hydraulic properties of Ground Granulated Blast Furnace Slag.
- Chemistry of limestone-blended cements.
- Impact of SCMs on chemical resistance and durability.
- Synergistic effects in ternary cement blends.

MODULE 10: QUALITY ASSURANCE AND FINAL PRODUCT SPECIFICATIONS

- Review of international standards (ASTM, EN, ISO).
- Correlating laboratory data with plant process parameters.
- Handling non-conforming chemical batches.

- Environmental chemistry: Managing Carbon Dioxide emissions.
- Final product compliance and certification procedures.