مركـز المستشـار الوطنـي للتدريـب
National Consultant Centre For Training
YOUR GATE TO HANDS-ON TRAINING

**5-Day Cement Industry Training Course**
**In**

# BASIC CEMENT CHEMISTRY (SITE VISIT)

**Cairo - Egypt, 26 – 30 Jan. 2026**

**COURSE LEVEL: BASIC**

## COURSE OVERVIEW:

Basic Cement Chemistry provides an essential introduction to the chemical transformations that define the production and performance of cement. This course defines the chemical composition of raw materials, such as calcium carbonate and silica, and explains how they react under intense heat to form the four primary clinker minerals. By understanding these fundamental reactions, participants can appreciate the precision required to produce a product that meets global construction standards.

The scope of this training includes the study of the kiln's internal chemistry, specifically the calcination and sintering processes. It covers the role of minor elements and fluxes in lowering the reaction temperatures and the chemical impact of different fuels on the clinker. Additionally, the course explores the hydration process, explaining how cement reacts with water to gain strength and durability, which is vital for understanding the final application of the product in concrete.

Coverage extends to the laboratory environment, where participants will learn about the chemical analysis techniques used to ensure product consistency. The course addresses the importance of the Lime Saturation Factor, Silica Modulus, and Alumina Modulus in controlling the manufacturing process. Through an interactive site visit to the quality control laboratory, attendees will see firsthand how X-ray fluorescence and chemical titration are used to monitor and maintain the chemical integrity of the cement production line.

## COURSE OBJECTIVES:

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

- Identify the primary chemical elements and oxides in cement raw materials.
- Explain the chemical stages of the clinkering process in the rotary kiln.
- Describe the four main clinker minerals: C3S, C2S, C3A, and C4AF.
- Understand the role of gypsum in controlling the chemical hydration of cement.
- Calculate the basic cement modules used in raw mix design.
- Explain the impact of MgO and free lime on cement soundness.
- Describe how minor elements like alkalis and chlorides affect the process.
- Identify the chemical differences between various types of cement.
- Understand the basics of X-ray Fluorescence (XRF) analysis.
- Interpret a chemical analysis report from a cement laboratory.
- Explain the hydration reactions that lead to the setting and hardening of concrete.
- Recognize the importance of chemical consistency for plant operational stability.

## TARGET AUDIENCE:

This course is suitable for Laboratory Technicians, Process Operators, Raw Material Supervisors, Quality Control Staff, and any personnel requiring a fundamental understanding of the chemistry behind cement.

## 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: ATOMS, MOLECULES, AND CEMENT OXIDES

- Introduction to basic chemistry symbols used in the industry.
- The standard oxide notation (C, S, A, F, M, K, S, N).
- Common chemical bonds and reactions in industrial minerals.
- Understanding the Periodic Table in the context of cement raw materials.
- Definitions of acids, bases, and salts in mineral processing.

### MODULE 2: RAW MATERIAL CHEMISTRY

- Limestone: Calcium carbonate and its impurities.
- Clays and shales: The sources of silica, alumina, and iron.
- Chemical role of corrective materials: sand, iron ore, and bauxite.
- Moisture content and its impact on chemical preparation.
- Sampling techniques for representative chemical analysis.

### MODULE 3: RAW MIX DESIGN AND CONTROL MODULES

- Understanding the Lime Saturation Factor (LSF).
- The role of the Silica Modulus (SM) in burnability.
- The Alumina Modulus (AM) and its effect on melt formation.
- Calculating the target raw meal composition.
- Balancing chemical cost versus kiln performance.

**MODULE 4: THERMAL CHEMISTRY IN THE KILN**

- The drying and pre-heating stages: physical vs. chemical changes.
- Calcination: The dissociation of CaCO3 into CaO and CO2.
- Solid-state reactions and the beginning of mineral formation.
- The liquid phase: formation of the "melt" and its importance.
- Sintering: The birth of Alite (C3S) and Belite (C2S).

**MODULE 5: THE FOUR MAJOR CLINKER MINERALS**

- Alite (C3S): The contributor to early strength.
- Belite (C2S): The contributor to late-age strength.
- Aluminate (C3A): Influence on setting time and heat of hydration.
- Ferrite (C4AF): The role of iron in the fluxing process.
- Bogue's equations for calculating potential mineral phases.

**MODULE 6: MINOR ELEMENTS AND THEIR EFFECTS**

- Alkalis (Na2O, K2O) and their impact on concrete durability.
- Chlorine and sulfur cycles: the formation of internal coatings.
- Magnesium oxide (MgO) and the risk of delayed expansion.
- Free Lime: Testing for incompletely reacted calcium oxide.
- Phosphorus and heavy metals in clinker chemistry.

**MODULE 7: HYDRATION CHEMISTRY**

- What happens when cement meets water: the chemical stages.
- Formation of Calcium Silicate Hydrate (C-S-H) gel.
- The role of Ettringite in the initial setting process.
- Factors affecting the rate of chemical hydration.
- Heat of hydration and its significance in mass concrete.

**MODULE 8: THE CHEMISTRY OF ADMIXTURES AND ADDITIVES**

- How gypsum (calcium sulfate) regulates the C3A reaction.
- Chemical impact of fly ash and slag on cement properties.
- Grinding aids: surface chemistry and mill efficiency.
- Water reducers and accelerators in concrete chemistry.
- Carbonation: the chemical reaction between concrete and air.

**MODULE 9: LABORATORY ANALYSIS TECHNIQUES**

- Sample preparation: grinding, fusing, and pressing pellets.
- Principles of X-ray Fluorescence (XRF) for elemental analysis.
- Using X-ray Diffraction (XRD) for mineralogical phase analysis.
- Wet chemistry methods: titration and insoluble residue.
- Quality assurance and calibration of laboratory equipment.

**MODULE 10: SUSTAINABILITY AND GREEN CHEMISTRY**

- Reducing CO2 emissions through chemical optimization.

- The chemistry of low-clinker cements (ternary blends).
- Alternative raw materials: industrial by-products as chemical feeds.
- The impact of alternative fuels on the chemical balance of the kiln.
- Future of carbon-neutral binders and geopolymer chemistry.

**MODULE 11: SITE VISIT: THE QC LABORATORY**

- Demonstration of automated sampling systems.
- Tour of the XRF and XRD analysis rooms.
- Observing physical testing for setting time and fineness.
- Reviewing the data management system (LIMS).
- Discussion with the Chief Chemist on daily quality challenges.

**MODULE 12: COURSE REVIEW AND ASSESSMENT**

- Summary of key chemical concepts in cement making.
- Quiz and final assessment of chemical knowledge.
- Group discussion on real-world chemical problems.
- Closing remarks and future learning paths.
- Certification ceremony.