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COMPENDIUM OF INDIAN STANDARDS ON TESTS METHODS FOR CEMENT

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INTRODUCTION

Hydraulic cement, a cornerstone material in modern construction, gains strength through a chemical reaction with water and is integral to the durability and performance of infrastructure. In India, the quality, safety, and consistency of hydraulic cement are governed by a series of well-defined standards issued by the **Bureau of Indian Standards (BIS)**. These standards specify the methods for testing various physical and chemical properties of cement to ensure its conformity to performance criteria under diverse environmental and structural conditions.

This **Compendium of Indian Standards on Tests of Hydraulic Cement** serves as a comprehensive reference for professionals in the construction, civil engineering, and quality control sectors. It brings together key Indian Standards (IS) that outline test methods for parameters such as fineness, setting time, compressive strength, soundness, consistency, and chemical composition. The compendium aims to facilitate uniform interpretation and application of these standards, promoting quality assurance across manufacturing, testing laboratories, and construction sites. The standards for testing of cement are as follows:

IS No.	*Title*
IS 4031	Methods of Physical Tests for Hydraulic Cement:
Part 1 : 1996	Part 1 Determination of Fineness by Dry Sieving (*Second Revision*)
Part 2 : 1999	Part 2 Determination of fineness by Blaine air permeability method (*Second Revision*)
Part 3 : 1988	Part 3 Determination of Soundness (*First Revision*)
Part 4 : 1988	Part 4 Determination of Consistency of Standard Cement Paste (*First Revision*)
Part 5 : 1988	Part 5 Determination of Initial and Final Setting Times (*First Revision*)
Part 6 : 1988	Part 6 Determination of Compressive Strength of Hydraulic Cement other than Masonry Cement (*First Revision*)
Part 7 : 1988	Part 7 Determination of Compressive Strength of Masonry Cement (*First Revision*)
Part 8 : 1988	Part 8 Determination of Transverse and Compressive Strength of Plastic Mortar using Prism (*First Revision*)
Part 9 : 1988	Part 9 Determination of Heat of Hydration (*First Revision*)
Part 10 : 1988	Part 10 Determination of Drying Shrinkage (*First Revision*)
Part 11 : 1988	Part 11 Determination of Density (*First Revision*)
Part 12 : 1988	Part 12 Determination of Air Content of Hydraulic Cement Mortar (*First Revision*)
Part 13 : 1988	Part 13 : Measurement of Water Retentivity of Masonry Cement (*First Revision*)
Part 14 : 1989	Part 14 Determination of False Set (*First Revision*)
Part 15 : 1991	Part 15 Determination of Fineness by Wet Sieving (*First Revision*)
IS 4032 : 1985	Method of Chemical Analysis of Hydraulic Cement (*First Revision*)
IS 12803 : 1989	Methods of Analysis of Hydraulic Cement by X-ray Fluorescence Spectrometer
IS 12813 : 1989	Method of Analysis of Hydraulic Cement by Atomic Absorption Spectrophotometer

By consolidating these standards in one volume, this document supports practitioners in maintaining regulatory compliance and advancing best practices in material testing. It also aids educational and research institutions by providing structured access to the foundational methodologies that underpin cement testing in India.

1. IS 4031 (Part 1) : 1996 – Method of Physical Tests for Hydraulic Cement – Determination of Fineness by Dry Sieving

Scope:

This standard prescribes the procedure for determining the fineness of hydraulic cement by dry sieving through a 90-micron IS sieve.

The fineness of cement is an important physical property, as it affects the rate of hydration, strength development, and overall performance of the cement in concrete. This test helps in assessing the particle size distribution by measuring the percentage of cement retained on the specified sieve, thus indicating the coarseness or fineness of the material.

Key Provisions:

a) To Establish a Standard Method for Measuring Fineness — Define a uniform procedure for determining the fineness of cement by dry sieving through a 90-micron IS sieve, ensuring consistency across laboratories and testing agencies.
b) To Assess the Particle Size of Cement — Fineness reflects the particle size distribution of cement, which directly affects its rate of hydration**,** strength development, and workability.
c) To Control Cement Quality — Ensure that cement meets the minimum fineness requirements specified in relevant IS codes, which helps maintain the quality and performance of cement in concrete and mortar.
d) To Improve Performance Characteristics — Finer cement typically offers faster strength gain, better bonding, and improved durability. This test helps manufacturers and users verify that cement meets these performance expectations.
e) To Provide a Basis for Comparison — Allow comparison between different cement batches or sources, helping users select the appropriate material for specific applications.
f) To Support Research and Development — Provide reliable data for R&D activities focused on improving cement formulations, production processes, and performance outcomes.

2. IS 4031 (Part 2) : 1999 - Method of Physical Tests for Hydraulic Cement – Determination of Fineness by Blaine Air Permeability Method

Scope:

This part of IS 4031 specifies the method for determining the fineness of hydraulic cement using the Blaine air permeability apparatus.

The method is based on the principle of measuring the specific surface area (i.e., total surface area per unit mass) of cement particles by evaluating the rate of airflow through a compacted bed of cement.

Key Provisions:

a) To Determine the Fineness of Cement by Surface Area — Measure the specific surface area of cement (in cm^2/g), which is an indicator of particle size and fineness.
b) To Provide a More Precise Alternative to Sieving — Offer a more accurate and scientific method than dry sieving [as in IS 4031 (Part 1], especially for finer cements.
c) To Assess Cement Reactivity — Help predict the rate of hydration and early strength development, as finer cement typically reacts faster with water.
d) To Ensure Uniformity in Testing — Establish a standardized procedure using the Blaine air permeability apparatus, ensuring consistency across laboratories and manufacturers.
e) To Facilitate Quality Control — Assist cement manufacturers and users in monitoring and controlling product quality during production and delivery.
f) To Enable Compliance with BIS Standards — Ensure that cement complies with fineness requirements specified in relevant Indian Standards (e.g., IS 269, IS 1489, IS 455).
g) To Support Performance Evaluation — Provide critical data used in designing mixes, research and development, and performance benchmarking of cement.
h) To Improve Cement Performance — Help in optimizing cement workability, strength gain, and durability through better control over particle size distribution.

3. IS 4031 (Part 3) : 1988 - Method of Physical Tests for Hydraulic Cement – Determination of Soundness

Scope:

This part of IS 4031 specifies the procedure for determining the soundness of hydraulic cement. The soundness test ensures that cement does not undergo undesirable expansion after setting, which could cause cracking or disintegration of hardened concrete or mortar.

Key Provisions:

a) To Determine the Soundness of Hydraulic Cement — Ensure that cement does not undergo undesirable expansion after setting, which could lead to cracking or failure in concrete and mortar.
b) To Detect Excess Free Lime or Magnesia — Identify the presence of excessive free CaO (lime) or MgO (magnesia), which are the primary causes of delayed and harmful expansion in hardened cement.
c) To Assess Dimensional Stability — Confirm the volume stability of cement paste over time, which is critical for the durability and structural integrity of cement-based construction.
d) To Standardize Testing Procedures — Provide a uniform and reliable method (such as the Le Chatelier method) for determining the soundness of different types of hydraulic cements.
e) To Prevent Structural Defects — Minimize the risk of cracking, disintegration, or deformation in concrete structures due to unsound cement.
f) To Aid in the Selection of Cement for Specific Applications — Support engineers and builders in choosing the right type of cement with verified soundness for projects requiring high durability and long service life.

4. IS 4031 (Part 4) : 1988 - Method of Physical Tests for Hydraulic Cement – Determination of Consistency of Standard Cement Paste

Scope:

This part of IS 4031 specifies the method for determining the standard consistency of cement paste. Standard consistency is the amount of water required to prepare a cement paste of standard (normal) viscosity that is used in further tests like setting time, soundness, and compressive strength.

Key Provisions:

a) To Determine the Standard Consistency of Cement Paste — Establish the optimum quantity of water (expressed as a percentage of cement weight) required to prepare a cement paste of standard (normal) consistency**.**

b) To Provide a Basis for Other Cement Tests — The standard consistency value is essential for performing other tests such as:
   - Initial and final setting time (IS 4031 Part 5)
   - Soundness (IS 4031 Part 3)
   - Compressive strength (IS 4031 Part 6)

   Ensures that all these tests are conducted under uniform moisture conditions.

c) To Standardize the Consistency Testing Method — Use of a Vicat apparatus to determine penetration of the plunger under a specific condition, ensuring accuracy and repeatability.

d) To Aid in Quality Control and Mix Design-
   Helps manufacturers and quality control labs ensure that cement batches behave consistently, and assists engineers in designing concrete mixes with reliable workability and performance.

5. IS 4031 (Part 5) : 1988 - Method of Physical Tests for Hydraulic Cement – Determination of Initial and Final Setting Times

Scope:

This part of IS 4031 specifies the method for determining the initial and final setting time of hydraulic cement using the Vicat apparatus.

Key Provisions:

a) To Determine the Initial and Final Setting Time of Hydraulic Cement — Establish how long cement remains workable (plastic) (initial setting time) and how long it takes to completely set and harden (final setting time) under standard conditions.

b) To Ensure Usability During Mixing and Placement — Confirm that cement allows sufficient working time for mixing, transporting, placing, and finishing before it begins to set.

c) To Assess Suitability for Different Applications — Help select appropriate cement types based on their setting characteristics, especially important in varying weather conditions or for specific structural needs.

d) To Provide a Standardized Testing Method — Use the Vicat apparatus to ensure a uniform, reproducible, and reliable approach to determining setting times across laboratories and projects.

e) To Serve as a Reference for Further Tests — Use setting time data to guide or schedule related procedures, such as formwork removal, finishing, and curing operations.

6. IS 4031 (Part 6) : 1988 - Method of Physical Tests for Hydraulic Cement – Determination of Compressive Strength of Hydraulic Cement Other than Masonry Cement

Scope:

This part of IS 4031 specifies the method for determining the compressive strength of hydraulic cement, except masonry cement, by testing cement mortar cubes under standard conditions.

Key Provisions:

a) To Determine the Compressive Strength of Hydraulic Cement — Assess the ability of cement to withstand loads by measuring the compressive strength of standard mortar cubes at specified intervals (typically 3, 7, and 28 days).
b) To Evaluate the Quality and Performance of Cement — Ensure the cement provides the desired mechanical strength for safe and durable construction.
c) To Support Compliance with BIS Specifications — Verify that cement meets the minimum compressive strength requirements outlined in relevant Indian Standards such as:

- IS 269 (OPC)
- IS 1489 (PPC)
- IS 8041 (Rapid Hardening Cement), etc.

d) To Enable Uniform and Standardized Testing —Provide a consistent procedure for mixing, moulding, curing, and testing cement-sand mortar cubes, ensuring repeatability and comparability of results.
e) To Assist in Cement Grading and Classification — Help determine whether the cement falls into grades like 33, 43, or 53 grade, based on its strength development over time.
f) To Provide Data for Mix Design and Structural Calculations — Offer key input for designing concrete and mortar mixes, ensuring the final structure meets the required load-bearing capacity.
g) To Ensure Long-Term Durability and Safety — By testing strength at various curing ages, this test provides insight into both early-age and long-term performance of cement.

7. IS 4031 (Part 7) : 1988 - Method of Physical Tests for Hydraulic Cement – Determination of Compressive Strength of Masonry Cement

Scope:

This part of IS 4031 lays down the method for determining the compressive strength of masonry cement by testing cement-sand mortar cubes under specified conditions.

Key Provisions:

a) To Determine the Compressive Strength of Masonry Cement — Evaluate the load-bearing capacity of mortar made from masonry cement through compressive strength testing of standard mortar cubes.
b) To Assess the Suitability of Masonry Cement for Construction Use — Ensure that masonry cement possesses adequate strength for plastering, rendering, and masonry works.

c) To Verify Compliance with IS 3466 — Confirm that the tested masonry cement meets the minimum compressive strength requirements specified in the Indian Standard IS 3466.
d) To Standardize the Testing Method for Masonry Cement — Provide a uniform, reliable, and reproducible procedure for testing mortar cubes made from masonry cement using standard sand, consistent curing, and defined test ages (usually 7 and 28 days).
e) To Differentiate Masonry Cement from Other Cements — Establish specific testing criteria for masonry cement, which contains additives for improved workability, unlike OPC or PPC.

8. IS 4031 (Part 8) : 1988 - Method of Physical Tests for Hydraulic Cement – Determination of Transverse and Compressive Strength of Plastic Mortar using Prism

Scope:

This part of IS 4031 specifies the method for determining both transverse (flexural) and compressive strength of plastic mortar made with hydraulic cement, by testing prism specimens.

Key Provisions:

a) To Determine the Transverse (Flexural) Strength of Plastic Mortar — Assess how well the mortar made from hydraulic cement can withstand bending stresses, which is important for applications where flexural performance is critical (e.g. plaster, masonry joints).
b) To Measure Compressive Strength of Plastic Mortar — After breaking the prism in flexure, the two halves are tested for compressive strength, providing additional insight into the crushing resistance of the same material.
c) To Evaluate Combined Mechanical Properties in One Test — Enables assessment of both flexural and compressive strength from a single prism specimen, enhancing testing efficiency and material evaluation.
d) To Support Quality Control and Material Development — Useful for manufacturers, researchers, and engineers to evaluate and improve mortar mixes in terms of mechanical performance.
e) To Simulate Realistic Mortar Behaviour — Prism specimens better replicate the actual stress conditions in plaster or masonry applications compared to cube specimens.

9. IS 4031 (Part 9) : 1988 - Method of Physical Tests for Hydraulic Cement – Determination of Heat of Hydration

Scope:

This part of IS 4031 covers the method of determining the heat of hydration of hydraulic cement. The test is applicable primarily to Portland cement, including ordinary, rapid-hardening, low heat, and Portland slag cements.

Two methods are prescribed:

a) Method A – Direct Method (Adiabatic Calorimeter Method): Suitable for measuring heat of hydration at shorter intervals, such as 7 days or less.
b) Method B – Indirect Method (Vacuum Flask or Semi-Adiabatic Method): Suitable for measurements at longer intervals, like 7 days and 28 days, and more common in routine cement testing.

Key Provisions:

a) To determine the heat of hydration of hydraulic cement — The standard provides procedures to measure the amount of heat released during the hydration process when cement reacts with water.
b) To assess cement performance in mass concrete applications — Heat of hydration is a critical factor in mass concrete structures (like dams or large foundations) where excessive heat can lead to thermal cracking.
c) To evaluate and control the thermal characteristics of different cement types — Helps in distinguishing between ordinary, rapid-hardening, and low-heat cements.
d) To provide standardized test methods (Method A and B)-

- Method A (Direct method – Adiabatic calorimeter): for precise measurement over shorter periods.
- Method B (Indirect method – Vacuum flask): commonly used in practice for longer durations (7 and 28 days).

10. IS 4031 (Part 10) : 1988 - Method of Physical Tests for Hydraulic Cement- Determination of Drying Shrinkage

Scope:

This part of IS 4031 specifies the procedure for determining the drying shrinkage of a hardened cement paste or mortar, prepared and cured under specified conditions. It is applicable to all hydraulic cements.

Key Provisions:

a) To determine the drying shrinkage of hardened cement paste or mortar — The test measures the linear reduction in length of a standard specimen when it loses moisture under controlled conditions.
b) To evaluate the dimensional stability of hydraulic cement — Drying shrinkage is a key indicator of how much a cement product will shrink over time, which can affect durability and structural integrity.
c) To assess the quality and performance of different types of cement — Useful for comparing Ordinary Portland Cement, Portland Pozzolana Cement, and other types in terms of their shrinkage characteristics.
d) To support cement selection for different construction applications — Ensures that cement used in plastering, masonry, precast elements, and large structural members does not exhibit excessive shrinkage that could cause cracking or warping.
e) To provide a standardized method for shrinkage measurement — Establishes a uniform procedure and controlled testing environment, so results can be reliably compared across laboratories and production batches.

f) To help in quality control during cement manufacturing — Shrinkage values are used by manufacturers and construction engineers to monitor consistency and conformity to standards.

11. IS 4031 (Part 11) : 1988 - Method of Physical Tests for Hydraulic Cement– Determination of Density

Scope:

This part of IS 4031 specifies the method for the determination of the density of hydraulic cement. It is applicable to all hydraulic cements.

Key Provisions:

a) To determine the density (specific gravity) of hydraulic cement — Measures the absolute density of cement using a Le Chatelier flask or similar apparatus.
b) To support accurate cement mix design — Density is used in concrete and mortar mix calculations to convert weight-based proportions to volume-based ones.
c) To ensure quality and consistency in cement batches — Helps identify variations in composition, such as unburnt material or excess additives, that can affect performance.
d) To aid in volume correction during batching — Ensures correct proportions of materials by accounting for the true volume occupied by cement in a mix.
e) To detect adulteration or contamination — Abnormally low or high density values can indicate impurities**,** moisture absorption, or incorrect blending**.**

12. IS 4031 (Part 12) : 1988 - Method of Physical Tests for Hydraulic Cement– Determination of Air Content of Hydraulic Cement Mortar

Scope:

This part of IS 4031 specifies the method for the determination of air content in a standard mortar prepared and tested under prescribed conditions using hydraulic cement. It is applicable to all hydraulic cements.

Key Provisions:

a) To determine the air content in freshly mixed hydraulic cement mortar — This test measures the percentage of air (entrapped or entrained) present in the mortar mix under standardized conditions.
b) To evaluate the effect of air on the properties of mortar and concrete — Air content influences workability**,** durability, and resistance to freezing and thawing.
c) To assess the quality and consistency of cement — Ensures the cement does not unintentionally cause excessive air entrainment, which can weaken the final product.
d) To control mortar properties for specific construction needs — Helps tailor the mortar for applications that may require controlled air content, such as in exterior structures exposed to freeze-thaw cycles.
e) To support the performance evaluation of air-entraining agents — The test helps verify the effectiveness of admixtures designed to introduce or control air in the mortar.
f) To provide a standardized testing method — Establishes a uniform procedure so results are consistent and comparable across laboratories and manufacturers.

13. IS 4031 (Part 13) : 1988 - Method of Physical Tests for Hydraulic Cement– Measurement of Water Retentivity of Masonry Cement

Scope:

This part of IS 4031 specifies the procedure for the determination of water retentivity of masonry cement using a standard laboratory test method.

It is applicable specifically to masonry cement and not to other types of hydraulic cement like OPC or PPC.

Key Provisions:

a) To determine the water retentivity of masonry cement mortar — Measures the mortar's ability to retain water when subjected to suction, ensuring it doesn't dry out too quickly during application.
b) To assess the suitability of masonry cement for masonry construction — Ensures the cement provides sufficient water for hydration and bonding with bricks, blocks, or other masonry units.
c) To prevent issues related to poor water retention — Helps avoid problems like weak bonds**,** reduced strength, and increased permeability in masonry work due to rapid water loss.
d) To standardize quality control in masonry cement production — Offers a uniform test method to ensure consistent performance characteristics in different cement batches.
e) To evaluate the effect of additives or blending materials — Helps assess how admixtures or fillers used in masonry cement influence water retention behaviour.

14. IS 4031 (Part 14) : 1989 - Method of Physical Tests for Hydraulic Cement– Determination of False Set

Scope:

This part of IS 4031 specifies the method for the determination of false set in hydraulic cement, using the penetration resistance method. It is applicable to all hydraulic cements.

Key Provisions:

a) To determine the false set of hydraulic cement — Measures the premature stiffening of a cement paste shortly after mixing**,** without significant heat evolution**.**
b) To distinguish false set from flash set — False set is reversible upon remixing (without additional water), while flash set is irreversible and accompanied by heat. This test helps identify and differentiate the two.
c) To assess the workability and handling properties of cement — Ensures that the cement remains plastic and workable long enough for proper mixing, placing, and finishing in construction applications.
d) To identify manufacturing or storage issues — Helps detect problems such as inadequate gypsum content, improper grinding, or exposure to moisture, which may cause false setting.

15. IS 4031 (Part 15) : 1991 - Method of Physical Tests for Hydraulic Cement– Determination of Fineness by Wet Sieving

Scope:

This part of IS 4031 specifies the procedure for the determination of finely divided minerals in hydraulic cement, particularly those retained on a 45-micron (No. 325 IS) sieve by wet sieving. It is applicable to all hydraulic cements.

Key Provisions:

a) To determine the quantity of coarser particles in hydraulic cement — The test identifies the percentage of cement particles retained on a 45-micron (No. 325 IS) sieve using the wet sieving method**.**
b) To evaluate the fineness of cement — Fineness affects the rate of hydration**,** strength development, and workability of cement.
c) To assess the uniformity of cement grinding — Detects any variation in the particle size distribution, which can affect performance characteristics.
d) To help predict the performance of cement in concrete — Excessive coarse particles can lead to slower setting, lower early strength, and reduced durability.
e) To provide a standardized testing procedure — Establishes a uniform and repeatable method for determining fineness using wet sieving, ensuring consistency across laboratories and test results.

16. IS 4032 : 1985 - Method of Chemical Analysis of Hydraulic Cement

Scope:

IS 4032:1985 specifies the methods for the chemical analysis of all types of hydraulic cements.

This standard lays down procedures for determining the chemical composition of cement by specifying test methods for:

- Loss on ignition (LOI)
- Insoluble residue
- Silica (SiO_2)
- Alumina (Al_2O_3)
- Iron oxide (Fe_2O_3)
- Lime (CaO)
- Magnesia (MgO)
- Sulphur trioxide (SO_3)
- Alkalies (Na_2O and K_2O)
- Chlorides
- And other constituents as required

Key Provisions:

a) To establish standardized procedures for chemical analysis of cement — Provides uniform and reliable methods for determining the chemical composition of various types of hydraulic cement.
b) To assess the quality and suitability of cement for construction — Helps determine whether a cement sample is safe, durable, and effective for intended applications.
c) To determine key chemical constituents of cement —

Includes procedures to measure:

- Silica (SiO_2)
- Alumina (Al_2O_3)
- Iron oxide (Fe_2O_3)
- Calcium oxide (CaO)
- Magnesium oxide (MgO)
- Sulphur trioxide (SO_3)
- Alkalies (Na_2O, K_2O)
- Loss on ignition (LOI)
- Chlorides, etc.

d) To support cement manufacturing and quality control — Enables cement producers and quality labs to monitor and control the chemical uniformity and performance-related properties of cement.
e) To detect harmful or undesirable constituents — Helps identify excessive amounts of compounds (e.g., MgO, alkalis, chlorides) that could negatively impact durability, soundness, or setting behaviour.

17. IS 12803 : 1989 - Method of Analysis of Hydraulic Cement by X-Ray Fluorescence Spectrometer

Scope:

This standard covers X-ray fluorescence spectrometric procedure for chemical analysis of different hydraulic cements and clinkers. This standard covers the determination of SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, SO_3, Na_2O, K_2O, Mn_2O_3, P_2O_5, TiO_2, Cl, and Cr_2O_3.

Key Provisions:

a) Faster than conventional gravimetric/volumetric methods (e.g., IS 4032:1985).
b) Suitable for both online and offline analysis, enabling real-time process control.
c) Sample Preparation Techniques —
    a. Pressed Pellet: Grinding cement to <20 μm, compacted into pellets.
    b. Fused Bead: Fusing sample with flux to form a glass bead.
d) Instrumentation —
    a. Requires an XRF spectrometer with detectors, collimators, crystals, and calibration facilities.
    b. Use of auxiliary systems: chilling unit, vacuum pump, gas supply (argon/methane).
e) Reproducibility — Specifies acceptable variation limits for each oxide to ensure analytical consistency.
f) Calibration —
    a. Performed using certified reference cement samples with known compositions.
    b. Calibration curves correlate XRF intensity (CPS) to oxide concentration.
g) Interferences — Accounts for overlapping signals (e.g., Si affected by Mg/Al); correction factors may be applied.
h) Applicable to cement, clinker, raw materials, and raw mix analysis.

i) Not a referee method in disputes; IS 4032:1985 is to be used for final reference.

18. IS 12813 : 1989 - Method of Analysis of Hydraulic Cement by Atomic Absorption Spectrophotometer

Scope:

Describes a method for rapid and sensitive chemical analysis of hydraulic cement and clinker using atomic absorption spectrophotometry (AAS), aimed at quality control in cement production.

Applicable for determining SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, Na_2O, K_2O, Mn_2O_3, TiO_2, and Cr_2O_3.

Key Provisions:

a) Faster than conventional volumetric/gravimetric methods (e.g., IS 4032:1985).
b) High sensitivity and selectivity, capable of detecting over 60 elements with minimal interferences.
c) Analytical Principle — The sample is aspirated into a flame where atoms absorb light from a specific source (e.g., hollow cathode lamp).
d) Absorbance is directly related to elemental concentration via a calibration curve.
e) Sample Preparation — Sample fused with lithium metaborate, dissolved in dilute nitric acid, and diluted to the required concentration for AAS.
f) Instrumentation — Requires an AAS with burner, atomizer, spectrometer, hollow cathode lamps, and appropriate gas supplies (acetylene, nitrous oxide).
g) Calibration— Calibration curves are prepared using standard reference cement samples or pure element salts, matched with sample matrix and acidity.