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Civil Engineering : Indian Forest Service Main Examination (Paper-II)

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Preface

B. Singh (Ex. IES)

Our country has a vast forest cover of near about 25% of geographical area and if man doesn't learn to treat trees with respect, man will become extinct; Death of forest is end of our life. Scientific management and judicial exploitation of forest becomes first task for sustainable development.

Engineer is one such profession which has an inbuilt word "Engineer – skillful arrangement" and hence IFS is one of the most talked about jobs among engineers to contribute their knowledge and skills for the arrangement and management for sustainable development

In order to reach to the estimable position of Divisional Forest Officer (DFO), one needs to take an arduous journey of Indian Forest Service Examination. Focused approach and strong determination are the pre-requisites for this journey. Besides this, a good book also comes in the list of essential commodity of this odyssey.

I feel extremely glad to launch the revised edition of such a book which will not only make Indian Forest Service Examination plain sailing, but also with 100% clarity in concepts.

MADE EASY team has prepared this book with utmost care and thorough study of all previous years' papers of Indian Forest Service Examination. The book aims to provide complete solution to all previous years' questions with accuracy.

On doing a detailed analysis of previous years' Indian Forest Service Examination question papers, it came to light that a good percentage of questions have been asked in Engineering Services, Indian Forest Services and State Services exams. Hence, this book is a one stop shop for all Indian Forest Service Examination, CSE, ESE and other competitive exam aspirants.

I would like to acknowledge efforts of entire MADE EASY team who worked day and night to solve previous years' papers in a limited time frame and I hope this book will prove to be an essential tool to succeed in competitive exams and my desire to serve student fraternity by providing best study material and quality guidance will get accomplished.

With Best Wishes

B. Singh

CMD, MADE EASY Group

Previous Years Solved Papers

Indian Forest Service Main Examination

Civil Engineering

Paper-II

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SYLLABUS

Part-A

CONSTRUCTION TECHNOLOGY, EQUIPMENT, PLANNING AND MANAGEMENT

1. **Construction Technology :**

   Engineering Materials:

   Physical properties of construction materials : Stones, Bricks and Tiles; Lime, Cement and Surkhi Mortars; Lime Concrete and Cement Concrete, Properties of freshly mixed and hardened concrete, Flooring Tiles, use of ferrocement, fibre-reinforced and polymer concrete, high strength concrete and light weight concrete. Timber : Properties and uses; defects in timber; seasoning and preservation of timber. Plastics, rubber and damp-proofing materials, termite proofing, Materials, for Low cost housing.

   Construction : Building components and their functions; Brick masonry : Bonds, jointing. Stone masonry. Design of Brick masonry walls as per I.S. codes, factors of safety, serviceability and strength requirements; plastering, pointing. Types of Floors & Roofs. Ventilators, Repairs in buildings. Functional planning of building : Building orientation, circulation, grouping of areas, privacy concept and design of energy efficient building; provisions of National Building Code. Building estimates and specifications; Cost of works; valuation.

2. **Construction Equipment :** Standard and special types of equipment, Preventive maintenance and repair, factors affecting the selection of equipment, economical life, time and motion study, capital and maintenance cost. Concreting equipments : Weigh batcher, mixer, vibration, batching plant, Concrete pump. Earth-work equipment : Power shovel hoe, bulldozer, dumper, trailors, and tractors, rollers, sheep foot roller.

3. **Construction Planning and Management :** Construction activity, schedules, job layout, bar charts, organization of contracting firms, project control and supervision. Cost reduction measures.

   New-work analysis : CPM and PERT analysis, Float Times, cashing of activities, contraction of network for cost optimization, updating, Cost analysis and resource allocation. Elements of Engineering Economics, methods of appraisal, present worth, annual cost, benefit-cost, incremental analysis. Economy of scale and size. Choosing between alternatives including levels of investments. Project profitability.

Part-B

SURVEY AND TRANSPORTATION ENGINEERING

Survey : Common methods of distance and angle measurements, plane table survey, leveling traverse survey, triangulation survey, corrections, and adjustments, contouring, topographical map. Surveying instruments for above purposes. Tacheometry. Circular and transition curves. Principles of photo-grammetry. Railways: Permanent way, sleepers, rail fastenings, ballast, points and crossings, design of turn outs, stations and yards, turntables, signals, and interlocking, level-crossing. Construction and maintenance of permanent ways : Super-elevation, creep of rail, ruling gradient, track resistance, tractive effort, relaying of track.

Highway Engineering : Principles of highway planning, Highway alignments. Geometrical design : Cross section, camber, super-elevation, horizontal and vertical curves. Classification of roads : low cost roads, flexible pavements, rigid pavements. Design of pavements and their construction, evaluation of pavement failure and strengthening.

Drainage of roads : Surface and sub-surface drainage.

Traffic Engineering : Forecasting techniques origin and destination survey, highway capacity. Channelised and unchannelised intersections, rotary design elements, markings, sign, signals, street lighting; Traffic surveys. Principle of highway financing.

Part-C

HYDROLOGY, WATER RESOURCES AND ENGINEERING

Hydrology : Hydrological cycle, precipitation, evaporation, transpiration, depression storage, infiltration, overland flow, hydrograph, flood frequency analysis, flood estimation, flood routing through a reservoir, channel flow routing-Muskingam method. Ground water flow : Specific yield, storage coefficient, coefficient of permeability, confined and unconfined aquifers, aquitards, radial flow into a well under confined and unconfined conditions, tube wells, pumping and recuperation tests, ground water potential.

WATER RESOURCES ENGINEERING : Ground and surface water resource, single and multipurpose projects, storage capacity of reservoirs, reservoir losses, reservoir sedimentation, economics of water resources projects.

IRRIGATION ENGINEERING : Water requirements of crops : consumptive use, quality of water for irrigation, duty and delta, irrigation methods and their efficiencies.

Canals : Distribution systems for canal irrigation, canal capacity, canal losses, alignment of main and distributory canals, most efficient section, lined canals, their design, regime theory, critical shear stress, bed load, local and suspended load transport, cost analysis of lined and unlined canals, drainage behind lining.

Water logging : causes and control, drainage system design, salinity.

Canal structures : Design of cross regulators, head regulators, canal falls, aqueducts, metering flumes and canal outlets.

Diversion head work : Principles and design of weirs of permeable and impermeable foundation, Khosla's theory, energy dissipation, stilling basin, sediment excluders.

Storage works : Types of dams, design, principles of rigid gravity and earth dams, stability analysis, foundation treatment, joints and galleries, control of seepage.

Spillways : Spillway types, crest gates, energy dissipation.

River training : Objectives of river training, methods of river training.

Part-D

ENVIRONMENTAL ENGINEERING

Water Supply : Estimation of surface and subsurface water resources, predicting demand for water, impurities, of water and their significance, physical, chemical and bacteriological analysis, waterborne diseases, standards for potable water.

Intake of water : pumping and gravity schemes. Water treatment : principles of coagulation, flocculation and sedimentation; slow-; rapid-, pressure-, filters; chlorination, softening, removal of taste, odour and salinity.

Water storage and distribution : storage and balancing reservoirs : types, location and capacity.

Distribution system : layout, hydraulics of pipe lines, pipe fittings, valves including check and pressure reducing valves, meters, analysis of distribution systems, leak detection, maintenance of distribution systems, pumping stations and their operations.

Sewage systems : Domestic and industrial wastes, storm sewage-separate and combined systems, flow through sewers, design of sewers, sewer appurtenances, manholes, inlets, junctions, siphon. Plumbing in public buildings.

Sewage characterization : BOD, COD, solids, dissolved oxygen, nitrogen and TOC. Standards of disposal in normal water course and on land.

Sewage treatment : Working principles, units, chambers, sedimentation tanks, trickling filters, oxidation ponds, activated sludge process, septic tank, disposal of sludge, recycling of waste water.

Solid waste : collection and disposal in rural and urban contexts, management of long-term ill-effects.

Environmental pollution : Sustainable development. Radioactive wastes and disposal. Environmental impact assessment for thermal power plants, mines, river valley projects. Air pollution. Pollution control acts.

■■■■

1 Construction Technology and Equipment

1. Cement

Q.1 Describe the components, properties and uses of
(i) Air Entraining cement
(ii) Water repellent cement

[5 × 2 = 10 marks : 2000]

Solution:

(i) **Air entraining cement:** Vinsol resin or vegetable fat and oils and fatty acids are ground with ordinary cement. These materials have the property to entrain the air in the form of fine tiny air bubbles in concrete.

Properties Minute voids are formed while setting of cement which increase resistance against freezing and scaling action of salts. Air entrainments improves the workability and w/c ratio can be reduced which in turn reduces shrinkage.

Uses: Air entraining cements are used in cold areas and improving the workability.

(ii) **Water repellent cement:** The water repellent cement is also called **hydrophobic cement**. A small amount of hydrophobic surfactants such as stearic acid, boric acid or oleic acid is mixed with the ordinary portland cement during grinding of clinker. These substances are added in amount of 0.1% to 0.5% of cement in terms of dry mixtures.

When concrete is being prepared, hydrophobic admixtures plasticize the mix and contribute to the formation of uniformly distributed fines pores in the concrete as it hardness and thus enhance its frost resistance. Hydrophobic cement also features greater water resistance and water impermeability.

The specific surface of cement should not be less than 350 m^2/g.

The average compressive strength should not be less than.

72 ± 1 hour $\not<$ 15.69 N/mm^2
168 ± 2 hour $\not<$ 21.57 N/mm^2
672 ± 4 hour $\not<$ 30.40 N/mm^2

Uses: It is most suitable for using in basements to make watertight concrete.

Q.2 Describe the function properties and uses of:
(i) Rapid Hardening Cement
(ii) Quick Setting Cement

[10 marks : 2001]

Solution:

Rapid Hardening Cement : Rapid Hardening Cement has a high lime content and can be obtained by increasing C_3S content but is normally obtained from OPC clinker by fine grinding of 450 m^2/kg. The basis of application of rapid hardening cement (RHC) is hardening properties and heat emission rather than setting rate. This permits addition of little more gypsum during manufacture to control the rate of setting. RHC attains same strength in one day which normal OPC achieve in 3 day. Due to low time availability for placing requirement for workability is more. The cost of rapid hardening cement is about 10% more than the ordinary cement. Concrete made with RHC can be safely exposed to frost since it matures more quickly.

Properties:

Initial setting time	30 minutes (minimum)
Final setting time	10 hours (maximum)
Compressive strength	
1 day	16.0 N/mm^2
3 day	27.5 N/mm^2

Uses:

(i) It is suitable for repair of roads and bridges and when load is applied in a short period of time.

(ii) Where formwork is required to removed early.

Quick Setting Portland Cement: The quantity of gypsum is reduced and small percentage of **aluminium sulphate** is added. It is ground much finer than OPC.

Properties:

Initial setting time = 5 minutes (minimum)

Final setting time = 30 minutes (maximum)

Use : It is used when concrete is to be laid under water or in running water.

Q.3 What are various physical properties of a building material? Explain briefly each.

[15 marks : 2001]

Solution:

These are the properties required to estimate the quality and condition of the material without any external force. The physical properties of engineering materials are as follows:

(i) Bulk density	(ii) Porosity	(iii) Durability
(iv) Density	(v) Density Index	(vi) Specific gravity
(vi) Fire resistance	(vii) Frost resistance	(viii) Weathering resistance
(ix) Spalling resistance	(x) Water absorption	(xi) Water permeability
(xii) Hygroscopicity	(xiii) Coefficient of softening	(xiv) Refractoriness

- **Weathering Resistance:** The property of a material to withstand against all atmospheric actions without losing its strength and shape. Weathering effects the durability of material.
- **Water Absorption :** The capacity of a material to absorb and retain water in it is known as water absorption.
- **Hygroscopicity :** Hygroscopicity is the property of material to absorb water vapour from the air. It depends on the relative humidity, porosity, air temperature etc.
- **Refractoriness :** The property of a material which cannot melt or lose its shape at prolonged exposure to high temperature (1580°C or more).
- **Durability :** The property of material to withstand against the combined action of atmospheric and other factors is known as durability of materials.

Q.4 Name different types of cement and write their special uses.

[10 marks : 2002]

Solution:

(i) Rapid Hardening Cement : It is suitable for repair of roads and bridges and when load is applied in a short period of time.

(ii) High Alumina Cement : It is resistant to action of fire, sea water, acidic water and sulphates and is applied in a short period of time.

(iii) **Super Sulphated Portland Cement :** It is preferred in hydraulic engineering installations and also in constructions intended for service in moist media. This cement is sulphatic resistant.

(iv) **Sulphate Resisting Portland Cement :** It is used as an alternative to order portland cement or PPC or Portland slag cement under normal conditions, and under conditions where there are chances of chemical attack due to sulphates.

(v) **Portland Slag Cement :** Because of its low heat of hydration it can be used for mass concreting e.g. dams, foundations.

(vi) **Low Heat Portland Cement :** It is most suitable for large mass concrete works such as dams, large raft foundations etc.

(vii) **Portland Pozzolana Cement :** It has low heat of evolution and is used in places of mass concrete such as dams and in places of high temperature.

(viii) **Quick Setting cement :** It is used when concrete is to be laid under water or in running water.

(ix) **Masonry Cement :** These cements are used for making terrazoflooring, face plaster of walls (stucco), ornamental works and casting stones.

(x) **Water Repellent Cement :** Water retaining structures like tanks, reservoir, retaining wall, swimming pools, bridge piers etc.

(xi) **Water Proof Cement :** It is used in water retaining structures like tanks, reservoirs retaining walls, swimming pools, bridge piers, etc.

Q.5 Discuss the effect of calcium lignosulphonate and sodium hydroxide admixtures on cement?

[5 marks : 2010]

Solution:

(a) Effect of Calcium lignosulphonate:

(i) Calcium lignosulphonate is commonly used dispersing agents which acts as surface active chemicals imparting electrostatic charges on cement particles. This causes cement particles to repel each other and thus prevents coagulation.

(ii) A small amount of air is also entrained in the concrete and workability is increased.

(iii) Decrease the w/c ratio requirement thus increases the strength.

(iv) Reduces the heat of hydration.

(b) Effect of Sodium hydroxide:

- Sodium hydroxide is a accelerator used which normally reduces the setting time.
- It accelerates the rate of hydration of cement and consequently the rate of gain of strength.
- It also increase the ability of the concrete to resist frost by speeding up rate of gain of strength.

Q.6 Differentiate flash set and false set?

[2 marks : 2015]

Solution:

Flash Set : When portland Clinker is ground alone and mixed with water, the aluminate (C_3A) phase initially reacts rapidly and if C_3A level is appreciable, then a so-called flash set or quick set is likely to ensure.

- Since plasticity of mix is not restored after flash setting, it is deleterious to concrete production.
- In order to prevent flash set, gypsum is ground to cement to ensure smooth set regulation prior to normal setting.

False Set : False set is sometimes also known as early stiffening or premature stiffening or gum set. It refers to cement which when gauged with water and mixed for short while, stiffens up and appears to set. Remixing breaks up this stiffening and cement proceeds to the normal sets.

Q.7 What are main compounds of cement? Mention their relative behaviour on hydration and rate of strength gain.

[5 marks : 2015]

Solution:

Main compounds of Cement:

(a) **Tricalcium Silicate :** It is supposed to be the best cementing material and is well burnt cement. It renders the clinker easier to grind. It increases the resistance to freezing and thawing, hydrates rapidly generating high beat and develops an early hardness and strength. The hydrolysis of C_3S is mainly responsible for 7 days strength and hardness.

The heat of hydration is 500 J/gram.

(b) **Dicalcium Silicate :** It is about 25-40% of cement. It hydrates and hardens slowly and takes long time to add the strength (after a year or more). It imparts resistance to chemical attack. Raising of C_2S content renders clinker harder to grind, reduces early strength, decreases resistance to freezing and thawing at early stages.

The heat of hydration is 260 J/g.

(c) **Tricalcium Aluminate :** It is a about 5-11% (normally about 10.5%) of cement. It rapidly reacts with water and is responsible for flash set of finely grounded clinker. Tricalcium aluminate is responsible for the initial set, high heat of hydration and has greater tendency to volume changes causing cracking.

The heat of hydration is 865 J/gram.

(d) **Tetracalcium Alumino Ferrite :** It is about 8-14% of cement. It is responsible for flash set but generates less heat. It has poorest cementing value raising the C_4AF content reduces the strength slightly.

The heat of hydration is 420 J/g.

Q.8 What are the approximate oxide composition limits found in ordinary portland cement? Briefly explain the functions of following oxides:
(i) Lime (ii) Silica (iii) Alumina (iv) Iron oxide

[10 marks : 2017]

Solution:

Chemical composition of Portland Cement.

Oxide	Composition (%)
Lime (CaO)	60 – 65
Silica (SiO_2)	17 – 25
Alumina (Al_2O_3)	3 – 8
Iron Oxide (Fe_2O_3)	0.5 – 6
Magnesia (MgO)	0.5 – 4
Sulphur Dioxide	1 – 2
Alkalies (Soda and Potash)	0.1 – 0.4
Calcium sulphate ($CaSO_4$)	3%

Functions:

(i) **Lime (CaO):** It control strength and soundness. It is a major ingredient of cement and constitutes about two-third of cement. Its quantity should be maintained very carefully, as excess quantity and low quantity of lime are both harmful to cement. If it is used in excess quantity, some of lime remains present unused or uncombined or as free lime. Its deficiency reduces strength and setting time.

(ii) **Silica (SiO_2):** Its presence in proper quantity forms calcium silicates which gives strength to cement. If silica is used in excess, the setting time of cement is increased and the strength is increased.

(iii) **Alumina (Al_2O_3):** It reacts with water very quickly and makes the cement to set quickly. If it is used in excess quantity it will weaken the cement as it acts as flux which lower the clining temperature. But since high temperature is essential for proper cement, it should not be used in excess.

(iv) **Iron Oxide (Fe_2O_3):** Iron-oxide imparts colour an hardness to cement. It reacts with lime and silica during manufacture which reduces the calcination temperature. Its presence also imparts strength to the cement.

Q.9 Answer the following in brief:

(i) What is the basic advantage of using ferro-cement in ferro-cement concrete?

(ii) Why is carbon fiber reinforced polymer used for seismic retrofitting and repair of damaged structures?

[8 marks : 2018]

Solution:

(i) Advantages of ferro cement in ferro cement concrete.

- High ductility
- Good fire resistance
- High resistance to cracking
- favourable tensile property
- low maintenance cost
- Ability to undergo large deflection
- Improved impact resistance and toughness
- environmental friendly

(ii) Carbon Fiber Reinforced Polymer (CFRP) or Carbon fibre refers to materials consisting of more than 92% by mass of carbon filaments, yarns, roving etc. usually in non graphitic state. It has characteristic like low density, high specific strength and stiffness, excellent chemical stability, biocompatability, low coefficient of thermal expansion and excellent fatigue and creep behaviour. CFRP application in civil engineering includes increasing the load capacity of old structures (such as bridges) which were designed to tolerate lower service loads than they are experiencing today, seismic retrofitting and repair of damaged structures. Seismic retrofitting and repairing of damaged structures using CFRP can be cost effective than replacing the defective structure. CFRP wrapping around sections (columns, beams etc.) can enhance the ductility of the section and greatly increasing the resistance to collapse under seismic loading.

Q.10 Briefly explain how fineness modulus of an aggregate is obtained. The actual masses of various materials required at the site to prepare a concrete mix are:

1. Cement = 350 kg/m^3
2. Coarse aggregate = 1526 kg/m^3

(Fineness modulus = 7.6)

Determine the mass of fine aggregate (having fineness modulus as 2.8) required to make a mix of fine and coarse aggregate having designed fineness modulus as 6.4.

[10 marks : 2020]

Solution:

Finances modulus: It is a numerical index of fineness, giving some idea about the mean size of the particles in the aggregate. The fineness modulus (F.M.) varies between 2.0 and 3.5 for fine aggregate, between 5.5 and 8.0 for coarse aggregate and from 3.5 to 15.5 for all in aggregate.

- Aggregate, whose F.M is required, is placed on a standard set of sieves (80, 63, 40, 20, 12.5, 10, 4.75, 2.36, 1.18 mm and 600, 300, 150 μm) and the set vibrated. The material retained on each sieve after sieving represent the fraction of aggregate coarser than the sieve in question but finer than the sieve above. The sum of the cumulative percentage retained on the sieves divided by 100 gives the F.M.

- The object of finding F.M is to grade the given aggregate for the required strength and workability of concrete mix with minimum cement. Higher F.M. aggregate results in harsh concrete mixes and the lower F.M result in uneconomical concrete mixes.

Given, coarse aggregate = 1526 kg/m^3; F.M = 7.6

Cement = 350 kg/m^3

Fine aggregate = ?; F.M = 2.8,

Desired F.M of mix of fine and coarse aggregate = 6.4

Let quantity of fine aggregate be 'x' kg/m^3.

$$\Rightarrow \quad 6.4 = \frac{\dot{x}\times 2.8+1526\times 7.6}{x+1526}$$

$$6.4x - 2.8x = 1526(7.6-6.4)$$

$$3.6x = 1831.2$$

$$x = 508.67 \text{ kg/m}^3 \simeq 509 \text{ kg/m}^3$$

Q.11 What are the oxide compositions of Ordinary Portland Cement? Mention the typical percentage ranges for each one of them.

[8 marks : 2021]

Solution:

Chemical ingredients of ordinary portland cement are:

(i) Lime (CaO) : 62-67%

- This is an important ingredient of cement and its proportion is to be carefully maintained.
- Lime in excess makes the cement unsound and causes the cement to expand and disintegrate.
- Lime in deficiency reduces the strength of cement and causes it to set quickly.

(ii) Silica (SiO_2) : 17-25%

- Imparts strength to the cement due to formation of dicalcium and tricalcium silicates.
- If it is present in excess, strength of cement increases but setting time gets prolonged.

(iii) Alumina (Al_2O_3) : 3-8%

- Imparts quick setting property.
- Acts as a flux and lowers clinkering temperature. So, suitable cement type is not formed.
- In excess amount, its presence weakens the cement.

(iv) Calcium sulphate ($CaSO_4$) : 3-4%

- Added in the form of gypsum.
- Increases initial setting time of cement.

(v) Iron Oxide (Fe_2O_3) : 3-4%

- Imparts colour, hardness and strength to cement.

(vi) Magnesia (MgO) : 0.1-3%

- Imparts hardness and colour if present in small amount.
- High content causes unsoundness.

(vii) Alkalies (Soda and Potash; $Na_2O + K_2O$) – (0.5-1.3%)

- Causes alkali-aggregate reaction, efflorescence and staining.

2. Mortar

Q.12 What are requirements of good mortar? How the consistency of mortar is determined?

[10 marks : 2001]

State the properties of good mortar.

[5 marks : 2005]

Solution:

Requirement of good mortar:

1. The strength of mortar must be sufficient for development of good bond with building units.
2. ***Mobility and place ability:*** It should be enough workable.
3. It should set quickly to ensure speed of construction.
4. The mortar should be cheap and durable and should not affect the durability of building units in contact.
5. ***Water Retention :*** The mortar should not stratify during transportation and able to retain humidity in thin layer spread over a porous bed.
6. ***Resistance to penetration of rain:*** It should protect the masonry joints and units by forming an impermeable sheet. A satisfactory bond between the building units, mortar and plaster should be ensured.

Consistency of mortar: The quantity of water to be added to the mortar should be such that working consistency is obtained. Excess water should be avoided. In case of cement, lime, mortars the following formula may be used to get the approximate quantity of water:

$$V_W = 0.65\,(W_c + W_l) \text{ where}$$

V_W = Volume of water (in litres per m^3 of sand)

W_C = added amount of cement kg/m^3 of sand

W_l = added amount of lime kg/m^3 of sand

In general, the quantity of water depends upon the following factors:

(i) Nature and condition of aggregate

(ii) Temperature and humidity at time of working

(iii) Richness of the mix

The working consistency of the mortal is usually judged by the mason during application to maintain required fluidity.

Q.13 What are different types of lime? Give their composition, source of manufacture, characteristic and use.

[10 marks : 2011]

Solution:

According to percentage of calcium oxide and clayey impurities in it, lime can be classified as lean, hydraulic and fatlime.

1. **Lean or Poor lime :** It consists of CaO + MgO <70% with Mgo less than 5% and clayey impurities of more than 30% in form of silica, alumina and iron-oxide. It set on absorbing CO_2 from atmosphere.

   Characteristics:

   1. Slaking requires more time and so it hydrates slowly. Its expansion is less than that of fatlime.
   2. It makes thin paste with water.
   3. Setting and hardening is very slow.
   4. The colour varies from yellow to grey.

   Uses: It gives poor and inferior mortar and is recommended for less important structure.

2. **Hydraulic lime :** It is a product obtained by moderate burning (900°-1100°c) of raw limestone which contains small proportions of clay (silica and alumina) 5-30% and iron oxide in chemical combination with calcium oxide content (CaO + MgO 70-80%) with MgO less than 5%). Depending upon percentage of clay classified as:

Feebly Hydraulic Lime	Moderately Hydraulic Lime	Eminently Hydraulic Lime
• (< 5-10% of silica and alumina • slaking time 5-15 min.) • setting time 21 days • Used in damp places	• (<10-20% impurities, • slaking time 1-2 hours) • setting time 7 days • Used in damp places	• (20-30% impurities, • Initial setting time – 2 hours • slakes difficulty • Used in damp places and oil structural purposes

3. **Pure, Rich or Fat lime :** It is a soft lime (CaO + MgO more than 85% with MgO less than 4%) obtained by calcination of nearly pure limestone, marble, chalk powder, oolitic limestone and calcareous beta. Also known as while washing lime should not have impurities of clay and stone more than 5%. Fat lime is nearly pure calcium oxide and when it is hydrated with the required amount of water the solid lumps fall to a soft fine powder of $Ca(OH)_2$ and high heat of hydration produces a cloud of steam.

   Characteristics:

   1. Slaking is vigorous and the volume becomes 2-3 times.
   2. It sets slowly in contact with air and hence not suitable for thick walls or in wet climate.
   3. Sp. gravity of pure lime is about 3.4.
   4. If kept under water a fat lime waste does not lose its plasticity and consequently does not set and hard.

   Uses: Fat lime finds extensive use in making mortar, matrix for concrete, base for distemper and in whitewash, manufacturing of cement and metallurgical industry.

Q.14 Explain characteristics and uses of lime mortar and cement mortar.

[5 marks : 2015]

Solution:

Lime mortar :

- In this type of mortar lime is used as a binding material.
- It has high plasticity and more workability.
- Good cohesiveness with other building material.
- Shrinkage is less.
- Durability is good but hardens slowly i.e. does not set quickly and hence the progress of work is slow.

Uses: It is suitable for masonry and plastering in cheap and light load bearing wall construction above ground level. It is also used in thin joints in brickwork.

Cement mortar : Cement mortar is prepared by mixing cement sand and water in desired proportions. It is strongest type of mortar and is therefore preferred for use in construction of structures subjected to heavy loading. Depending upon the strength required, the proportion of cement to sand by volume varies from 1 : 2 to 1 : 6 or more. This mortar can be used where a high strength and water resisting properties is required.

Uses : It is used in underground constructions, water saturated soils, and also used in masonry, pointing, plastering, reinforced brickwork and foundation etc.