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Civil Engineering : Volume-I
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Director's Message

B. Singh (Ex. IES)

Engineering is one of the most chosen graduating field. Taking engineering is usually a matter of interest but this eventually develops into "purpose of being an engineer" when you choose engineering services as a career option.

Train goes in tunnel we don't panic but sit still and trust the engineer, even we don't doubt on signalling system, we don't think twice crossing over a bridge reducing our travel time; every engineer has a purpose in his department which when coupled with his unique talent provides service to mankind.

I believe *"the educator must realize in the potential power of his pupil and he must employ all his art, in seeking to bring his pupil to experience this power"*. To support dreams of every engineer and to make efficient use of capabilities of aspirant, MADE EASY team has put sincere efforts in compiling all the previous years' ESE-Pre questions with accurate and detailed explanation. The objective of this book is to facilitate every aspirant in ESE preparation and so, questions are segregated chapterwise and topicwise to enable the student to do topicwise preparation and strengthen the concept as and when they are read.

I would like to acknowledge efforts of entire MADE EASY team who worked hard to solve previous years' papers with accuracy and I hope this book will stand up to the expectations of aspirants and my desire to serve student fraternity by providing best study material and quality guidance will get accomplished.

B. Singh (Ex. IES)
CMD, MADE EASY Group

Volume-I

CIVIL ENGINEERING

Objective Solved Questions

of UPSC Engineering Services Examination

Contents

■■■■

UNIT

I

Building Materials

Syllabus

Stone, Lime, Glass, Plastics, Steel, FRP, Ceramics, Aluminum, Fly Ash, Basic Admixtures, Timber, Bricks and Aggregates: Classification, properties and selection criteria;

Cement: Types, Composition, Properties, Uses, Specifications and various Tests; Lime & Cement Mortars and Concrete: Properties and various Tests; Design of Concrete Mixes: Proportioning of aggregates and methods of mix design.

Contents

■■■■

1 Cement

1.1 Consider the following statements:
1. Tests on cement paste to determine initial and final setting times are done at normal consistency condition.
2. Low heat cement has a high percentage of tricalcium aluminate.
3. High early strength portland cement contains a larger percentage of tricalcium silicate and a lower percentage of dicalcium silicate.

Which of these statements are correct?
(a) 1 and 2 (b) 1 and 3
(c) 2 and 3 (d) 1, 2 and 3
[ESE : 1999]

1.2 Match **List-I** (Property of cement) with **List-II** (Testing apparatus) and select the correct answer using the codes given below the lists:

List-I
A. Specific gravity
B. Setting time
C. Soundness
D. Fineness

List-II
1. Blain's apparatus
2. Le Chatelier's flask
3. Compressometer
4. Autoclave
5. Vicat's apparatus

Codes:

	A	B	C	D
(a)	3	5	1	2
(b)	2	5	1	4
(c)	2	5	4	1
(d)	5	3	4	1

[ESE : 1999]

1.3 Consider the following oxides:
1. Al_2O_3 2. CaO 3. SiO_2

The correct sequence in increasing order of their percentage in an ordinary portland cement is
(a) 2, 1, 3 (b) 1, 3, 2
(c) 3, 1, 2 (d) 1, 2, 3
[ESE : 1999]

1.4 Increase in fineness of cement
(a) reduces the rate of strength development and leads to higher shrinkage
(b) increases the rate of strength development and reduces the rate of deterioration
(c) decreases the rate of strength development and increases the bleeding of cement
(d) increases the rate of strength development and leads to higher shrinkage
[ESE : 1999]

1.5 Match **List-I** (Cement) with **List-II** (Characteristic) and select the correct answer using the codes given below the lists:

List-I
A. High alumina cement
B. Blast furnace cement
C. Quick setting cement
D. Rapid hardening cement

List-II
1. High early strength
2. Gypsum free cement
3. Selenetic cement
4. Used in mass concrete work
5. Used in chemical factories and mines

Codes:

	A	B	C	D
(a)	5	4	2	1
(b)	4	3	2	1
(c)	5	4	3	2
(d)	4	5	1	2

[ESE : 2000]

1.6 The fineness of cement is tested by
(a) air-content method
(b) air-permeability method
(c) Le-Chatelier apparatus
(d) Vicat's apparatus
[ESE : 2000]

1.7 The test on cement designed to accelerate the slaking process of the ingredient of cement and to determine the resulting expansion in a short time is

(a) setting time test
(b) soundness test
(c) normal consistency test
(d) accelerated test [ESE : 2000]

1.8 **Assertion (A):** Calcium chloride addition in concrete proves more effective in slow-hardening portland cement than in rapid-hardening cement.
Reason (R): Calcium chloride acts as an effective accelerator thereby increasing rate of reaction.
(a) both A and R are true and R is the correct explanation of A
(b) both A and R are true but R is not a correct explanation of A
(c) A is true but R is false
(d) A is false but R is true [ESE : 2001]

1.9 Consider the following statements:
High Alumina Cement (HAC)
1. has high early compressive strength and high heat of hydration than OPC-43 grade
2. is not suitable to be used in cold regions
Which of these statements is/are correct?
(a) 1 alone (b) 2 alone
(c) Both 1 and 2 (d) Neither 1 nor 2
[ESE : 2001]

1.10 Consider the following statements:
When cement is tested for setting time; on gauging it shows quick setting. This phenomenon known as "Flash set" of cement is due to the presence of high
1. tricalcium aluminate (C_3A) in cement
2. alkalies in cement
3. tricalcium silicate (C_3S) in cement
Which of these statements are correct?
(a) 1, 2 and 3 (b) 2 and 3
(c) 1 and 2 (d) 1 and 3
[ESE : 2001]

1.11 Which one of the following statements regarding the cement fineness is NOT correct?
(a) Fine cement is more liable to suffer from shrinkage cracking than a coarse cement.
(b) Fine cement will show faster rate of hardening than coarse cement.
(c) Fine cement shows faster rate of heat evolution and total quantity of heat evolved is much large than coarse cement.
(d) Fine cement shows the same setting time as coarse cement.
[ESE : 2001]

1.12 For marine works, the best suited cement is
(a) low heat portland cement
(b) rapid hardening cement
(c) ordinary portland cement
(d) blast furnace slag cement [ESE : 2001]

Directions: The following items consists of two statements; one labelled as **'Assertion (A)'** and the other as **'Reason (R)'**. You are to examine these two statements carefully and select the answers to these items using the codes given below:
Codes:
(a) both A and R are true and R is the correct explanation of A
(b) both A and R are true but R is not a correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

1.13 **Assertion (A):** Flash set is the stiffening of the cement paste within a few minutes after mixing.
Reason (R): Flash set occurs due to insufficient gypsum to control the rapid reaction of C_3A with water.
[ESE : 2002]

1.14 **Assertion (A):** The amount of cement paste should be sufficient to cover the surface of all particles for proper workability and bond.
Reason (R): The water-cement ratio is fixed accordingly.
[ESE : 2002]

1.15 **Assertion (A):** The higher percentage of tricalcium silicate in cement results in rapid hardening with an early gain in strength at a higher heat of hydration.
Reason (R): A higher percentage of dicalcium silicate in cement results in slow hardening and less heat of hydration and greater resistance to chemical attack.
[ESE : 2002]

1.16 **Assertion (A):** For a given composition, a finer cement will develop strength and generate heat more quickly than a coarse cement.
Reason (R): The reaction between water and cement starts on the surface of the cement

particles and in consequence the greater the surface area of a given volume of cement, the greater the hydration.

[ESE : 2002]

1.17 Match **List-I** (Type of cement) with **List-II** (Characteristics) and select the correct answer using the codes given below the lists:

List-I

A. Ordinary portland cement
B. Rapid hardening cement
C. Low heat cement
D. Sulphate resistant cement

List-II

1. The percentage of C_3S is maximum and is of the order of 50%
2. The percentages of C_2S and C_3S are the same and of the order of 40%
3. Reacts with silica during burning and causes particles to unite together and development of strength
4. Preserves the form of brick at high temperature and prevents shrinkage

Codes:

	A	B	C	D
(a)	2	4	1	3
(b)	3	1	4	2
(c)	2	1	4	3
(d)	3	4	1	2

[ESE : 2002]

1.18 Match **List-I** (Type of cement) with **List-II** (Property/Characteristic) and select the correct answer using the codes given below the lists:

List-I

A. High strength portland cement
B. Super sulphated cement
C. High alumina cement
D. Rapid hardening portland cement

List-II

1. Should not be used with any admixture
2. Is extremely resistant to chemical attack
3. Gives a higher rate of heat development during hydration of cement
4. Has a higher content of tricalcium silicate

Codes:

	A	B	C	D
(a)	3	2	1	4
(b)	4	1	2	3
(c)	3	1	2	4
(d)	4	2	1	3

[ESE : 2002]

1.19 Four main oxides present in ordinary portland cement are: CaO, Al_2O_3, SiO_2 and Fe_2O_3. Identify the correct ascending order of their proportions in a typical composition of OPC.

(a) Al_2O_3, Fe_2O_3, CaO, SiO_2
(b) Al_2O_3, CaO, Fe_2O_3, SiO_2
(c) Fe_2O_3, Al_2O_3, SiO_2, CaO
(d) Fe_2O_3, SiO_2, Al_2O_3, CaO

[ESE : 2002]

Directions: The following items consists of two statements; one labelled as **'Assertion (A)'** and the other as **'Reason (R)'**. You are to examine these two statements carefully and select the answers to these items using the codes given below:

Codes:

(a) both A and R are true and R is the correct explanation of A
(b) both A and R are true but R is not a correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

1.20 **Assertion (A):** The greater the surface area of a given volume of cement the greater the hydration.

Reason (R): The reaction between the water and cement starts from the surface of the cement particles.

[ESE : 2003]

1.21 **Assertion (A):** A low C_3A cement generates less heat and develops higher ultimate strength.

Reason (R): During setting and hardening, the amount of lime liberated appears to be about 15 to 20 per cent by weight of cement.

[ESE : 2003]

1.22 The proper size of mould for testing compressive strength of cement is

(a) 7.05 cm cube (b) 10.05 cm cube
(c) 15 cm cube (d) 12.05 cm cube

[ESE : 2003]

1.23 The specific gravity of commonly available ordinary portland cement is

(a) 4.92 (b) 3.15
(c) 2.05 (d) 1.83

[ESE : 2003]

1.24 A quick-setting cement has an initial setting time of about

(a) 50 minutes (b) 40 minutes
(c) 15 minutes (d) 5 minutes

[ESE : 2003]

1.25 Consider the following statements:

Low percentage of C_3S and high percentage of C_2S in cement will result in

1. higher ultimate strength with less heat generation
2. rapid-hardening
3. better resistance to chemical attack

Which of these statements are correct?

(a) 1 and 2 (b) 2 and 3
(c) 1 and 3 (d) 1, 2 and 3

[ESE : 2004]

1.26 Match **List-I** (Type of cement) with **List-II** (Property) and select the correct answer using the codes given below the lists:

List-I

A. Blast furnace slag cement
B. High alumina cement
C. Low heat cement
D. White cement

List-II

1. High percentage of tricalcium silicate
2. Initial setting time is approximately three and a half hours
3. Low percentage of iron oxide
4. Rate of hardening is low

Codes:

	A	B	C	D
(a)	4	3	1	2
(b)	1	3	4	2
(c)	1	2	4	3
(d)	4	2	1	3

[ESE : 2004]

1.27 Match **List-I** (Type of cement) with **List-II** (Characteristics) and select the correct answer using the codes given below the lists:

List-I

A. Rapidly hardening cement
B. Low heat portland cement
C. Portland pozzolana cement
D. Sulphate resisting cement

List-II

1. Lower C_3A content than that in OPC
2. Contains pulverised fly ash
3. Higher C_3S content than that in OPC
4. Lower C_3S and C_3A contents than that in OPC

Codes:

	A	B	C	D
(a)	1	2	4	3
(b)	3	4	2	1
(c)	1	4	2	3
(d)	3	2	4	1

[ESE : 2005]

1.28 Match **List-I** (Apparatus) with **List-II** (Purpose) and select the correct answer using the codes given below the lists:

List-I

A. Le-chatelier
B. Vicat needle with annular collar
C. Vee-Bee
D. Briquettes test machine

List-II

1. Workability of concrete
2. Soundness of cement
3. Tensile strength of cement
4. Final setting time of cement

Codes:

	A	B	C	D
(a)	1	3	2	4
(b)	2	4	1	3
(c)	1	4	2	3
(d)	2	3	1	4

[ESE : 2005]

1.29 **Assertion (A):** Low heat portland cement is used in dam construction.

Reason (R): Low heat portland cement attains higher 28 days strength than ordinary portland cements.

(a) both A and R are true and R is the correct explanation of A
(b) both A and R are true but R is not a correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

[ESE : 2006]

1.30 Match **List-I** (Job requirement) with **List-II** (Type of cement binder) and select the correct answer using the codes given below the lists:

List-I

A. High early strength
B. Lining for canals

C. Frost and acid resistance
D. Marine structure

List-II

1. Pozzolanic cement
2. Rapid hardening cement
3. Sulphate resisting cement
4. High alumina cement

Codes:

	A	B	C	D
(a)	1	4	3	2
(b)	2	3	4	1
(c)	1	3	4	2
(d)	2	4	3	1

[ESE : 2006]

1.31 As per specifications, the initial setting time of ordinary portland cement should not be less than
(a) 10 minutes (b) 20 minutes
(c) 30 minutes (d) 60 minutes
[ESE : 2006]

1.32 In cements, generally the increase in strength during a period of 14 days to 28 days is primarily due to
(a) C_3A (b) C_2S
(c) C_3S (d) C_4AF [ESE : 2006]

1.33 Consider the following types of cements :
1. Portland pulverized fuel ash cement
2. High alumina cement
3. Ordinary portland cement
4. Rapid hardening cement

Which one of the following is the correct sequence of the above cements in terms of their increasing rate of strength gain ?
(a) 2-3-4-1 (b) 1-3-4-2
(c) 2-1-3-4 (d) 3-1-2-4 [ESE : 2007]

1.34 Ultimate strength of cement is influenced by which one of the following?
(a) Tricalcium silicate
(b) Dicalcium silicate
(c) Tricalcium aluminate
(d) Tetracalcium alumino-ferrite [ESE : 2007]

1.35 Consider the following statements:
1. Setting and hardening of cement takes place after the addition of water.
2. Water causes hydration and hydrolysis of the constituent compounds of cement which act as binders.

Which of these statements is/are correct?
(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2
[ESE : 2007]

1.36 Match **List-I** (Composition of raw material used in manufacture of cement) with **List-II** (Component of raw material) and select the correct answer using the codes given below the lists:

	List-I		List-II
A.	25%	1.	Silica
B.	65%	2.	Calcium oxide
C.	5%	3.	Aluminium oxide
D.	5%	4.	Ferrous and magnesium oxides

Codes:

	A	B	C	D
(a)	1	2	3	4
(b)	4	3	2	1
(c)	1	3	2	4
(d)	4	2	3	1

[ESE : 2008]

1.37 Match **List-I** (Compound) with **List-II** (Proportion) in respect of ordinary Portland cement and select the correct answer using the codes given below the lists:

List-I

A. Tricalcium silicate
B. Dicalcium silicate
C. Tricalcium aluminate
D. Tetra calcium alumino ferrite

List-II

1. 25 to 30%
2. 50 to 60%
3. 6 to 8%
4. 8 to 12%

Codes:

	A	B	C	D
(a)	2	3	4	1
(b)	4	1	2	3
(c)	2	1	4	3
(d)	4	3	2	1

[ESE : 2008]

1.38 Match **List-I** (Equipment) with **List-II** (Property) and select the correct answer using the codes given below the lists:

List-I

A. Briquette testing machine

B. Le Chatelier apparatus
C. Vicat apparatus

List-II
1. Compressive strength
2. Consistency
3. Soundness
4. Tensile strength

Codes:

	A	B	C
(a)	1	3	2
(b)	1	2	3
(c)	4	2	3
(d)	4	3	2

[ESE : 2008]

1.39 Assertion (A): The rate of hydration is faster in finer cements.

Reason (R) : The surface area of fine cement is more in case of finer cement.

(a) both A and R are true and R is the correct explanation of A
(b) both A and R are true but R is not a correct explanation of A
(c) A is true but R is false
(d) A is false but R is true [ESE : 2009]

1.40 What is the requirement of water (expressed as % of cement w/w) for the completion of chemical reactions in the process of hydration of OPC ?

(a) 10 to 15% (b) 15 to 20%
(c) 20 to 25% (d) 25 to 30%

[ESE : 2009]

1.41 If P is the percentage of water required for determination of normal consistency of cement, then percentage of water to be added for determination of initial setting time is

(a) 0.70 P (b) 0.75 P
(c) 0.80 P (d) 0.85 P [ESE : 2010]

1.42 A cement bag contains 0.035 cubic meter of cement by volume. How many bags will one tonne of cement comprise?

(a) 16 (b) 17
(c) 18 (d) 20 [ESE : 2010]

1.43 Assertion (A): Low heat cement is used in the construction of large dams.

Reason (R): Very high compressive strength is achieved by low heat cement in 28 days.

(a) both A and R are true and R is the correct explanation of A
(b) both A and R are true but R is not a correct explanation of A
(c) A is true but R is false
(d) A is false but R is true [ESE : 2010]

1.44 If 'W' is the percentage of water required for normal consistency of cement, water to be added for determination of initial setting time is

(a) 0.50 W (b) 0.62 W
(c) 0.75 W (d) 0.85 W

[ESE : 2011]

1.45 Match **List-I** (Grade of cement and Age) with **List-II** (Compressive strength in N/mm^2) and select the correct answer using the code given below the lists:

List-I	List-II
A. Grade 33 (7 days)	**1.** 27
B. Grade 43 (28 days)	**2.** 43
C. Grade 53 (3 days)	**3.** 22
D. Grade 43 (7 days)	**4.** 33

Codes:

	A	B	C	D
(a)	4	2	1	3
(b)	3	2	1	4
(c)	4	1	2	3
(d)	3	1	2	4

[ESE : 2011]

1.46 Consider the following statements:
More than 6% magnesium oxide by weight in cement results in

1. high early strength and high heat generation.
2. less tendency towards volume change and formation of cracks

Which of these statements is/are correct?

(a) 1 only (b) 2 only
(c) Neither 1 nor 2 (d) Both 1 and 2

[ESE : 2012]

1.47 Fineness of cement is measured in the units of

(a) volume/mass (b) mass/volume
(c) area/mass (d) mass/area

[ESE : 2012]

1.48 The initial setting time of cement depends most on

(a) tri-calcium aluminate
(b) tri-calcium silicate
(c) tri-calcium alumino-ferrite
(d) di-calcium silicate [ESE : 2012]

1.77 For better chemical resistance, proportion of which one of the following compounds in cement clinker shall be increased?
(a) Tricalcium Silicate
(b) Dicalcium Silicate
(c) Tetracalcium Aluminate
(d) Tetracalcium Aluminoferrite [ESE : 2021]

1.78 The most suitable type of cement for mass concreting works is
(a) Rapid Hardening Cement
(b) High Alumina Cement
(c) Low Heat Portland Cement
(d) Quick Setting Cement [ESE : 2021]

1.79 Which one of the following statements is NOT correct in respect of wet process of manufacturing of cement?
(a) It requires longer kilns
(b) It produces more homogenous mix
(c) It is less responsive to a variable clinker demand
(d) It is high cost of excavating and grinding raw materials

[ESE : 2022]

1.80 As per IS 8112 : 1989, the minimum required compressive strength of 43 grade ordinary portland cement for 72 hours is
(a) 23 MPa (b) 33 MPa
(c) 43 MPa (d) 53 MPa

[ESE : 2023]

1.81 Consider the following oxides:
1. Al_2O_3
2. CaO
3. SiO_2

Which one of the following is the correct sequence in increasing order of their percentage analysis for an ordinary portland cement?
(a) 2, 1, 3 (b) 2, 3, 1
(c) 3, 2, 1 (d) 1, 3, 2

[ESE : 2023]

1.82 Match the following lists:

List-I (Property of Cement)
P. Specific gravity
Q. Setting time
R. Soundness
S. Fineness

List-II (Apparatus)
1. Blain's apparatus
2. Le-Chatelier's flask
3. Autoclave
4. Vicat's apparatus

Select the correct answer using the code given below:

	P	Q	R	S
(a)	1	2	3	4
(b)	2	1	4	3
(c)	2	4	3	1
(d)	4	2	1	3

[ESE : 2023]

■■■■

Answers Cement

1.1 (b)	1.2 (c)	1.3 (b)	1.4 (d)	1.5 (a)	1.6 (b)	1.7 (b)	1.8 (a)	1.9 (a)
1.10 (*)	1.11 (c, d)	1.12 (d)	1.13 (a)	1.14 (b)	1.15 (b)	1.16 (a)	1.17 (b)	1.18 (c)
1.19 (c)	1.20 (a)	1.21 (c)	1.22 (a)	1.23 (b)	1.24 (d)	1.25 (c)	1.26 (c)	1.27 (b)
1.28 (b)	1.29 (c)	1.30 (b)	1.31 (c)	1.32 (c)	1.33 (b)	1.34 (b)	1.35 (c)	1.36 (a)
1.37 (c)	1.38 (d)	1.39 (a)	1.40 (c)	1.41 (d)	1.42 (d)	1.43 (c)	1.44 (d)	1.45 (b)
1.46 (c)	1.47 (c)	1.48 (a)	1.49 (a)	1.50 (a)	1.51 (c)	1.52 (b)	1.53 (b)	1.54 (c)
1.55 (c)	1.56 (c)	1.57 (c)	1.58 (b)	1.59 (d)	1.60 (*)	1.61 (c)	1.62 (a)	1.63 (d)
1.64 (c)	1.65 (a)	1.66 (b, c)	1.67 (a)	1.68 (d)	1.69 (c)	1.70 (a)	1.71 (a)	1.72 (c)
1.73 (c)	1.74 (a)	1.75 (d)	1.76 (d)	1.77 (b)	1.78 (c)	1.79 (d)	1.80 (a)	1.81 (d)
1.82 (c)								

Explanations Cement

1.1 (b)
Test conditions like temperature and relative humidity are similar for normal consistency test, initial setting time test and final setting test i.e. 27°2 ± 2°C and 90% at moist closet.

1.2 (c)
Autoclave test measures soundness due to both magnesia and free lime.
Fineness is measured by:
(i) Sieve test
(ii) Air permeability method using Blaine's apparatus

1.3 (b)

Oxide	Percentage	Average
Lime, CaO	60-65	63
Silica, SiO_2	17-25	20
Alumina, Al_2O_3	3.5-9	6.3
Iron oxide, Fe_2O_3	0.5-6	3.3
Magnesia, MgO	0.5-4	2.4
Sulfur trioxide, SO_3	1.2	1.5
Alkalis, i.e., soda and /or potash, Na_2O+K_2O	0.5-1.3	1.0

1.4 (d)
Increase in fineness of cement increases rate of strength development by expediting the hydration reactions and increases shrinkage by leading to stronger reaction with alkali reactive aggregate making it more prone to cracking.

1.5 (a)
Blast furnace cement due to its low rate of heat evolution is used in mass concrete work. Quick setting cement is gypsum free cement (gypsum is added to slow down the process of setting). Rapid hardening cement has high early strength than normal OPC. High alumina cement is used in chemical factories and mines due to its resistance to chemical attack.

1.6 (b)
Blaine's air permeability method is used to test fineness of cement.

1.7 (b)
The expansion of cement due to presence of free lime and magnesia. It is determined by the soundness test.

1.8 (a)
Calcium chloride accelerates the setting and hardening process. It is used in extra rapid hardening cement.

1.9 (a)
High Alumina Cement (HAC) is very reactive and produces very high early strength. Therefore it can be used in cold regions.

1.10 (*)
- Only C_3A responsible for flash set.
- Alkali max accelerate setting time of cement paste.
- C_3S is responsible for early strength.

1.11 (c, d)
Total quantity of heat evolved is same far both fine as well as coarse cement. However find cement has lower setting time than, coarse cement.

1.12 (d)
Slag cements is manufactured by intimately inter grinding of a mixture of portland cement clinker, granulated slag with addition of gypsum in which slag content should not be less than 25% and not more than 70%.
Hence, it has low heat of hydration and is relatively better resistance to soils and water containing excess amount of sulphate and hence can be used for marine work, retaining wall, foundation and mass concrete.

1.13 (a)
Gypsum is added to prevent fast reaction. Insufficient gypsum lets rapid reaction of C_3A with water leading to stiffening of cement paste (i.e Flash set)

1.14 (b)
Only strength of cement depends on water cement ratio provided the mix is workable.
Though due consideration is given to workability and bond when fixing water cement ratio but the primary factor which drives water cement ratio is strength of cement as per Abrahm's Law.

1.15 (b)

The two silicates, namely C_3S and C_2S upon hydration, gives the same product called calcium silicate hydrate $C_3S_2H_3$ and calcium hydroxide. Tricalcium silicate (C_3S) having a faster rate of reaction accompanied by greater heat evolution develops early strength. On the other hand, dicalcium silicate (C_2S) hydrates and hardens slowly and provides much of the ultimate strength. C_3S liberates nearly three times as much calcium hydroxide on hydration as C_2S. However, C_2S provides more resistance to chemical attack. Thus, a higher percentage of C_3S results in rapid hardening with an early gain in strength at a higher heat of hydration. On the other hand, a higher percentage of C_2S results in slow hardening, less heat of hydration and greater resistance to chemical attack.

1.16 (a)

Fine cement has more surface area than coarse cement. Since more surface area is available for chemical reaction, finer cement has higher rate of hydration. This results in quick development of strength and generation of heat.

1.17 (b)

- Low heat cement results in minimum shrinkage due to its low heat generating property.

Rapid hardening Portland Cement (IS 8041:1990)	C_3S-57%, C_2S-19%, C_3A-10%, C_4AF-7%
Low heat Portland Cement (IS 12600:1989)	C_3S-28%, C_2S-49%, C_3A-4%, C_4AF-12%, [C_3A<7% & C_3S<35%]
Sulphate resisting Portland Cement (SRC) (IS 12330:1988)	C_3S-38%, C_2S-43%, C_3A-4%, C_4AF-9%, [C_3A<5% & C_4AF+2C_3A<25%]

1.18 (c)

- RHC require heigher amount of C_3S.
- Super sulphated cement itself prepared by good amount of slag which is a pozzolonic mineral additive.
- HAC has highest rate of gain in strength and it is a non-OPC cement hence does not required any admixture.

1.20 (a)

The finer the cement, the more the surface area and greater the hydration as more surface area is available for water and cement reaction. Hydration starts from the surface of cement particles.

1.21 (c)

C_3A (tricalcium aluminate) reacts with water in the start of hydration and generates heat of hydration at fast rate. So lower C_3A will generate less heat.
The ultimate strength depends upon C_3S and C_2S. Lower C_3A means higher C_3S and C_2S and higher ultimate strength.
The product of hydration are calcium hydroxide $Ca(OH)_2$ and calcium silicate hydrate ($C_3S_2H_3$), a gel structure.
The $Ca(OH)_2$ librated during hydration known as portlandite consist of 20-25% volume of the solid in the hydrated paste.

1.22 (a)

The mould size should be 7.06 cm cube as per IS 4031(Part-6) 1988.

1.23 (b)

Specific gravity of OPC is 3.15 and is measured using Le-chatelier's flask.

1.24 (d)

Quick setting cement is produced by adding a small percentage of aluminium sulphate and by finely grinding the cement. The percentage of gypsum or retarder for setting action is also greatly reduced. The addition of aluminium sulphate and fineness of grinding are responsible for accelerating the setting action of cement. The setting of cement starts within 5 minutes after addition of water and it becomes hard like stone in less than 30 minutes or so.

1.25 (c)

C_3S and C_2S together constitute about 70%-80% of the cement and control most of the strength giving properties. Upon hydration both give the same product called calcium silicate hydrate ($C_3S_2H_3$) and calcium hydroxide. Tricalcium silicate (C_3S) having a faster rate of reaction is accompanied by greater heat evolution develops early strength. On the other hand, dicalcium silicate (C_2S) hydrates and hardens slowly and provides much of ultimate strength. C_2S provide more resistance to chemical attack. Thus a higher C_3S percentage results in rapid hardening with early gain in strength at a higher heat of hydration. On the other hand, higher C_2S percentage results in slow hardening, less heat of hydration, higher ultimate strength and greater resistance to chemical attack.

1.26 (c)

- HAC has initial setting time of 3.5 hr but not less than 20 min.
- White cement has < 1% of Fe_2O_3 hence it does not have greyish colour like OPC.
- Due to higher amout of C_2S in LHC, it has low rate of gain in strength i.e. hardening.

1.29 (c)

The lower heat evolution is suitable for mass concreting in dam construction. However, the low heat cement attains same strength as that of OPC.

1.30 (b)

Pozzolanic cement evolves less heat during setting, therefore it is used for mass concreting like marine structures.

Rapid hardening cement attains high strength in early days.

In sulphate resisting cement the percentage of C_3A is kept below 5% and it results in the increase in resisting power against sulphate. This cement is used for structures which are likely to be damaged by severe alkaline conditions such as canal linings, culverts, syphons, etc.

High alumina cement evolves great heat during setting. It is therefore not affected by frost and resists the action of acids in a better way.

1.31 (c)

Initial setting time should not be less than 30 minutes and final setting time should not be greater than 600 minutes as per IS 12269.

1.32 (c)

The increase in strength of cement with time depends on the C_2S content of cement. C_2S is responsible for the ultimate strength of cement. Whereas C_3S is responsible for initial strength in the concrete.

1.34 (b)

Dicalcium silicate is responsible for ultimate strength while Tricalcium silicate is responsible for early strength of cement.

1.35 (c)

After water is added, setting and hardening of cement takes place due to hydration and hydrolysis of constituent compounds of cement.

1.36 (a)

Approximate oxide composition of raw materials used in manufacture of cement

Oxide	Percent content	Average
CaO	60-67	62
SiO_2	17-25	22
Al_2O_3	3.0-8.0	5
Fe_2O_3	0.5-6.0	3
MgO	0.1-3.0	2
Alkalies (K_2O_3, Na_2O)	0.4-1.3	1
SO_3	1.0-3.0	1.5

1.37 (c)

Compound	Proportion (wt%)	Average
Tricalcium Silicate	30-50	40%
Dicalcium Silicate	20-45	32%
Tricalcium aluminate	8-12	10.57%
Tetracalcium alumino ferrite	6-10	9%

1.39 (a)

Surface area is more for fine cement than coarse cement for a given weight of cement. As more surface area is available for chemical reaction, the rate of hydration in finer cement is more.

1.40 (c)

It may be noted that C_3S requires 23% of water by weight of cement and C_2S requires 21%. It means that on an average 23% of water by weight of cement is required for chemical reaction with portland cement compounds. This 23% of water chemically combines with cement and therefore, it is called bound water. A certain quantity of water (about 15% by weight of cement) is imbedded within the gel pores. This water is known as gel-water. Therefore, a total 38% of water by weight of cement is required for the complete chemical reactions and to occupy the space within gel pores.

1.41 (d)

As per IS: 4031 Part-5, 1988, initial setting time test on cement is conducted by gauging the cement with 0.85 times the water required to give a paste of standard consistency.

1.42 (d)

A bag of cement weighing 50 kg contains about 35 litres of cement.

∴ Number of bags for 1 tonne cement

$$= \frac{1 \times 1000}{50} = 20$$

1.43 (c)

The feature of low heat cement is a slow rate of gain of strength. But the ultimate strength of low heat cement is the same as that of ordinary portland cement.

1.44 (d)

Water to be added for determination of initial setting time is 0.85 W.

1.45 (b)

The compressive srength in N/mm^2 for ordinary 33 grade, 43 grade and 53 grade cement is shown below:

Grade	3 days	7 days	28 days
33	16	22	33
43	22	33	43
53	27	37	53

1.46 (c)

More than 6% magnesium oxide by weight in cement results in large change in volume accompanying expansion resulting in disintegration and cracking.

- OPC (all grade) PPC RHC LHC PSC

  Magnesia $\not>$ 6% $\not>$ 6% $\not>$ 6% > 6% $\not>$ 10%
- Magnesia and iron oxide are not responsible to impart strength directly like lime and silica.

1.47 (c)

Fineness of cement is measure of size of particles and is expressed in terms of (cm^2/kg) specific surface of cement i.e., area/mass.

1.48 (a)

The compound C_3A is characteristically fast reacting with water and may lead to an immediate stiffening of paste, and this process is termed flash set. Hence, initial setting time of cement depends most on C_3A.

1.49 (a)

The compound C_3A is fast reacting with water and leads to an immediate stiffening of paste and this process is called flash set. The role of gypsum added in the manufacture of cement is to prevent such a fast reaction.

1.50 (a)

The finer the cement, the higher is the rate of hydration, as more surface area is available for chemical reaction. This results in the early development of strength.

1.51 (c)

Free lime and magnesia content in cement is determined by the soundness test. Free lime and Magnesia are responsible for volume change in cement and thus making it unsound.

1.52 (b)

Fly ash, an industrial waste of thermal power plants is used in cement manufacturing. Free lime in cement is always tried to kept low.

Fineness of cement aids in hydration of cement.

Energy saving methods are invariably tried to keep cost of production as low as possible.

Increased free lime makes the surface porous and harms durability.

1.53 (b)

Simica is responsible for strength of cement, alumina imparts quick setting property, Calcium Sulphate delays setting of cement, Magnesium Oxide in large quantity- causes delayed expansion

1.54 (c)

Since, low heat cement has very low heat of hydration which is suitable for mass concreting such as dams, so, option (c) is correct.

1.55 (c)

Low heat cement sets slower than OPC. Setting time has no relation with strength of cement. So, option (c) is correct.