Civil Engineering

Part-A

Summary of IS 456 : 2000

Part-B

Summary of IS 800 : 2007

Part-C

Elastic Curve

Comprehensive Theory

with Solved Examples and **Practice Questions**

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Summary of IS 456 : 2000, Summary of IS 800 : 2007 and Elastic Curve

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Contents

IS 456 : 2000, IS 800 : 2007 and Elastic Curve

Part-A

Part-B

Part-C

❍❍❍❍

Part-A

Summary of IS 456 : 2000

CONTENTS

LIST OF IMPORTANT CODES

IS Code No.	Title
456 : 2000	Code of practice for plain and reinforced concrete
800 : 2007	Code of practice for general construction in steel
875 : 1987	Code of practice for design loads (other than earthquake) for building and structures
875 (Part-1) : 1987	Dead load
875 (Part-2) : 1987	Imposed load
875 (Part-3) : 1987	Wind load
875 (Part-4) : 1987	Snow loads
875 (Part-5) : 1987	Special loads and load combinations
1343 : 1980	Code of practice for prestressed concrete
1893 : 2002	Criteria for earthquake resistance design of structures
3370 : 1965	Code of practice for concrete structures for the storage of liquids
10262 : 2009	Guideline for concrete mix proportioning
13920 : 1993	Code of practice for ductile detailing of reinforced Concrete structure subjected to seismic forces
SP 6 (1) : 1964	Handbook for structural engineers (Structural Steel Section)
SP 16 : 1980	Design aid for reinforced concrete to IS 456 : 1978
SP 23 : 1982	Handbook on concrete mixes
SP 24 : 1983	Explanatory handbook on IS 456 : 1978
SP 34 : 1987	Handbook on concrete reinforcement and detailing

Example:

Q.1 Match **List-I** with **List-II** and select the correct answer using the codes given below the lists:

List-I	List-II
A. IS-875	1. Earthquake resistant design
B. IS-1343	2. Loads
C. IS-1893	3. Liquid storage structure
D. IS-3370	4. Prestressed concrete

Codes:

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

[IES-2009]

Ans. (d)

SALIENT FEATURES

- Targeted readers are B.Tech students and students preparing for IES, GATE and PSUs.
- No doubt, each word of IS codes are very important but for students, all are not of same importance. So, effort has been made to consolidated the important clauses (for students only) with explanations and pictorial representation.
- Objective questions that have been asked previously in IES and GATE, placed just after the relevant clause.
- On extreme left, clause numbers are given which is same as clause number of original code.
- Figure number and Table number has been kept same as original code.

INTRODUCTION

This code is used for design and analysis of plain and reinforced concrete structures. It comprises five sections and eight annexures. Out of which 3 sections and 3 annexures only are important for competitive examinations.

Example:

Q.1 Do we use PCC in structural elements?

Ans. We seldom use PCC in structural element. Here we should not confuse PCC means no reinforcement. A minimum amount of reinforcement is definitely provided in concrete to prevent cracks due to shrinkage but that reinforcement is not taken into account while calculating strength of that member, that is why it is called PCC.

[Interview]

Q.2 Is there any difference between steel and reinforcement?

Ans. Yes, steel is a metal which is widely used as reinforcement. It is used because coefficient of thermal expansion of steel and concrete is approximately same otherwise we can go for other reinforcing material aluminium, brass, bamboo etc. Currently rigorous research is being conducted to replace steel by some other material like bamboo, because it is environmental friendly and economical.

[Interview]

SECTION 1 : GENERAL

Description of symbols are given which is used in case of any confusion between two symbols.

SECTION 2 : MATERIAL, WORKMANSHIP, INSPECTION & TESTING

5.0 MATERIALS

5.1 Cement

Types of recommended cement:

(i) 33 grade ordinary portland cement (OPC)
(ii) 43 grade ordinary portland cement (OPC)
(iii) 53 grade ordinary portland cement (OPC)
(iv) Rapid hardening portland cement

(v) Portland slag cement
(vi) Portland pozzolana cement (fly ash based) (PPC)
(vii) Portland pozzolana cement (calcined clay based) (PPC)
(viii) Hydrophobic cement
(ix) Low heat portland cement
(x) Sulphate resisting portland cement

Example:

Q.1 What is the meaning of 33, 43 and 53 grade of ordinary portland cement?

Ans. Digits 33, 43 and 53 represents 28 days compressive strength (N/mm^2) of standard cube of face area 50 cm^2 made up of cement mortar 1 : 3.

[Interview]

Q.2 **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.
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

[IES-2010]

Ans. (c)
The feature of low heat cement is a slow rate of gain of strength and slow rate of release of heat. But the ultimate strength of low heat cement is the same as that of ordinary portland cement.

Q.3 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

[IES-2003]

Ans. (a)

5.3 Aggregates

Coarse aggregates of light weight with comparable strength is preferable as it reduces dead load of structure. Aggregates should not be more porous (should not absorb more than 10% of their own mass of water) and free from excessive sulphate in the form of SO_3. Size of coarse aggregate is governed by following:

(i) Size of structural member – aggregates should go to each corner of member and cover reinforcement completely.
(ii) Distance between two main bars – aggregates should be small enough so that it can pass through the distance between two main bars. Due to this reason, it is kept 5 mm less than distance between two main bars.
(iii) Minimum cover – If aggregate size is more than the minimum cover provided for member, then there is possibility of exposure of reinforcement to environment so it is kept 5 mm less to minimum nominal cover.

In general, 20 mm nominal size coarse aggregate is used for most of the work but in the case of massive concreting, like dam construction, 40 mm and even higher nominal size can be used. For extremely thin slabs, like shelf, 10 mm nominal size aggregate is used for better finish.

Example:

Q.1 Which one of the following aggregates gives maximum strength in concrete?
(a) Rounded aggregate (b) Elongated aggregate
(c) Flaky aggregate (d) Cubical aggregate

[IES-2001]

Ans. (d)

The rounded aggregate has minimum voids and minimum ratio of surface area to volume, thus requiring minimum cement paste to make good concrete. However due to absence of interlocking, these aggregates are not suitable for high strength concrete and pavements.

5.4 Water

Water used for mixing and curing shall be clean and free from injurious amounts of oils, acids, alkalies, salts, sugar, organic materials etc. Potable water is preferable. The pH value of water shall be not less than 6. Sea water is not recommended because of presence of harmful salts in sea water. Water found satisfactory for mixing is also suitable for curing of concrete.

5.5 Admixture

Admixture should not impair durability of concrete nor combine with the constituent to form harmful compounds nor increase the risk of corrosion of reinforcement. Chloride content of admixtures shall be independently tested as it is harmful to concrete.

Broadly, admixtures are divided into two parts:

(i) Mineral admixture
- Fly ash
- Silica fume
- Rice husk ash

(ii) Chemical admixture
- Accelerating admixture – Calcium chloride, Fluosilicate, Tri ethanolamine
- Retarding admixture – Sodium tartrate, Tartaric acid
- Water reducing or plasticiser – Calcium lignosulphonate
- Air entraining admixture – Aluminium powder, Neutralised vinsol resin

Example:

Q.1 Consider the following statements:
Entrainment of air in concrete is done so as to
1. increase the workability.
2. increase the strength.
3. increase the resistance to freezing and thawing.

Which of these statements is/are correct?
(a) 1, 2 and 3 (b) 1 only
(c) 1 and 3 only (d) 3 only

[IES-2010]

Ans. (c)

Air-entrainment improves durability, workability and plasticity but it have an adverse effect on the strength of concrete. The decrease in strength is usually proportional to the amount of entrained air. For each per cent increase in air content, the compressive strength reduces approximately by 1.4 MPa.

Q.2 Consider the following statements:
Admixtures are added to concrete to
1. increase its strength. 2. reduce heat of hydration.
3. delay the setting of cement. 4. reduce water-cement ratio.

Which of these statements is/are correct?

(a) 1 only (b) 1 and 2

(c) 2 and 3 (d) 3 and 4

[IES-2010]

Ans. (d)

Admixtures are essentially classified as water-reducers (plasticizers), set-retarders and accelerators. The purpose of water-reducers is to achieve a higher strength by decreasing the water/cement ratio. Set-retarders are admixtures which delay the setting of concrete. Accelerators accelerate the hardening or the development of early strength of concrete. However, reducing the heat of hydration is not the main purpose of admixtures.

Q.3 Consider the following statements:

The use of superplasticizers as admixture

1. increases compressive strength of concrete
2. permits lower water-cement ratio, thereby strength is increased
3. reduces the setting time of concrete
4. permits lower cement content, thereby strength is increased?

Which of these statements is/are correct?

(a) 1 and 3 only (b) 3 and 4 only

(c) 1, 3 and 4 only (d) 2 only

[IES-2007]

Ans. (d)

Superplasticizers permit the reduction of water to the extent upto 30% without affecting workability for the same amount of cement.

Q.4 Match **List-I** (Admixture) with **List-II** (Action in concrete) and select the correct answer using the codes given below the lists:

	List-I		List-II
A.	Calcium lignosulphonate	**1.**	Anti-bleeder
B.	Aluminium powders	**2.**	Retarder
C.	Tartaric Acid	**3.**	Air entrainer
D.	Aluminium sulphate	**4.**	Water reducer

Codes:

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

[IES-2003]

Ans. (b)

1. Retarders delay setting time of cement either by forming a thin coating on the cement particles and thus slowing down their dissolution in and reaction with water, or by increasing the intra-molecular distance of reacting silicates and aluminates from water molecules by forming certain transient compounds in the system. These belong to following two groups:

(i) Soluble carbohydrate derivatives like sugar, starch, dextrin etc.
(ii) Inorganic retarders based on hydroxides of zinc and lead, alkali-bi-carbonates, calcium borate, calcium sulphate (gypsum), skimmed milk powder (casein) etc.
Other admixtures used as retarders are Ligno sulphonic acids and their salts, hydroxylated carboxylic acids and their salts, calcium acetate.

2. Air entrainers-natural wood resins containing abietic and pimeric acid salts, various sulphonated compounds, some animal and vegetable fats and oils such as fallow, olive oil and their fatty acids such as stearic and oleic acid.
Various wetting agents like alkali salts or sulphated and sulphonated compounds. Sodium salts of petroleum sulphonic acids, hydrogen peroxide, and aluminium powder etc. are also used.
3. Water reducers-anionic surfactants such as lignosulphonates and their modifications and derivatives, salts of sulphonates hydrocarbons. Among these calcium, sodium and ammonium lignosulphonates are most used.

Q.5 Match **List-I** (Admixtures) with **List-II** (Chemicals) and select the correct answer using the codes given below the lists:

	List-I		List-II
A.	Water-reducing admixture	1.	Sulphonated melanin formaldehyde
B.	Air-entraining agent	2.	Calcium chloride
C.	Superplasticiser	3.	Lignosulphonate
D.	Accelerator	4.	Neutralised vinsol resin

Codes:

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

[IES-1998]

Ans. (c)

5.6 Reinforcement

5.6.3 Modulus of Elasticity of steel shall be taken as 2×10^5 MPa.
Three grades of steel is covered in this code
(i) Fe 250
(ii) Fe 415
(iii) Fe 500
Recent development: Fe 550 and TMT (Thermo Mechanically Treated) bars is also available in market.

6.0 CONCRETE

6.1.1 The characteristic strength is defined as the strength of material below which not more than 5 percent of the test results are expected to fall. It is denoted by f_{ck}.

6.2.1 There is normally a gain of strength beyond 28 days also but the design should be based on 28 days characteristic strength of concrete.

Table 2 : Grades of Concrete

Group	Grade designation	Specified characteristic compressive strength of 150 mm cube at 28 days in N/mm^2
Ordinary Concrete	M 10 M 15 M 20	10 15 20
Standard Concrete	M 25 M 30 M 35 M 40 M 45 M 50 M 55	25 30 35 40 45 50 55
High strength Concrete	M 60 M 65 M 70 M 75 M 80	60 65 70 75 80
Note: For design of high strength concrete mix (M 60 or above), specialized literatures is used.		

Example:

Q.1 What is the meaning of grade designation in Table 2 as M 20?

Ans. In M 20, M refers to concrete mix and 20 is the compressive strength of 150 mm cube at 28 days in N/mm^2.

[Interview]

Q.2 What is the approximate ratio of the strength of cement concrete at 7 days to that at 28 days curing?

(a) 0.40 (b) 0.65

(c) 0.90 (d) 1.15

[IES-2006]

Ans. (b)

6.2.2 Tensile strength of concrete is calculated using compressive strength by following formula.

Flexural strength,

$$f_{cr} = 0.7\sqrt{f_{ck}}\ N/mm^2$$

Example:

Q.1 At what stress does the first flexural crack appear in RCC beams made of M 25 grade concrete ?

(a) 3.0 MPa (b) 3.5 MPa

(c) 4.0 MPa (d) 4.5 MPa

[IES-2009]

Ans. (b)

Q.2 What is the value of flexural strength of M25 concrete?

(a) 4.0 MPa (b) 3.5 MPa

(c) 3.0 MPa (d) 1.75 MPa

[IES-2005]

Ans. (b)

6.2.3.1 The modulus of elasticity of concrete can be assumed as follows:

$$E_c = 5000\sqrt{f_{ck}}\ \text{N/mm}^2$$

E_c is short term static modulus of elasticity. Actual measured values may differ by ±20 percent from the values obtained from the above expression.

Example:

Q.1 As per IS 456-2000, which one of the following correctly expresses the modulus of elasticity of concrete? (read with the relevant units)

(a) $E_c = 0.7\sqrt{f_{ck}}$
(b) $E_c = 500\sqrt{f_{ck}}$
(c) $E_c = 5000\sqrt{f_{ck}}$
(d) $E_c = 5700\sqrt{f_{ck}}$

[IES-2006]

Ans. (c)

6.2.4 The total shrinkage of concrete is significantly influenced by the total amount of water present while mixing and to a lesser extent, by the cement content. The approximate value to total shrinkage strain for design may be taken as 0.0003.

6.2.5.1 Creep coefficient, which is used for the calculation of total creep depends upon age of concrete at the time of loading applied on it.

$$\text{Creep coefficient} = \phi = \frac{\text{Ultimate creep strain}}{\text{Elastic strain at the age of loading}}$$

Age at loading	Creep coefficient (ϕ)
7 days	2.2
28 days	1.6
1 year	1.1

Effective modulus of elasticity using creep coefficient is $E_{ce} = \dfrac{E_c}{1+\phi}$.

Example:

Q.1 Which one of the following predicts the effective modulus of elasticity of concrete?

(a) $\dfrac{E_c}{1+\theta}$
(b) $\dfrac{E_c}{1+2\theta}$
(c) $\dfrac{E_c}{1+3\theta}$
(d) $\dfrac{E_c}{1+5\theta}$

where E_c is short-term elastic modulus and θ is the ultimate creep coefficient

[IES-2007]

Ans. (a)

Q.2 Long term elastic modulus in terms of creep coefficient (θ) and 28-day characteristic strength (f_{ck}) is given by

(a) $\dfrac{5000\sqrt{f_{ck}}}{1+\theta}$ MPa
(b) $\dfrac{50000\sqrt{f_{ck}}}{1+\theta}$ MPa
(c) $\dfrac{5000 f_{ck}}{1+\sqrt{\theta}}$ MPa
(d) $\dfrac{5000\sqrt{f_{ck}}}{\sqrt{1+\theta}}$ MPa

[IES-2004]

Ans. (a)