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

Part-A

Summary of IS 456 : 2000

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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.

Part-B

Summary of IS 800 : 2007

CONTENTS

SECTION 1 : GENERAL

1.1 SCOPE

1.1.1 This standard applies to general construction using hot rolled steel sections joined using riveting, bolting and welding. Specific provisions for bridges, chimneys, cranes, tanks, transmission line towers, bulk storage structures, tubular structures, cold formed light gauge steel sections, etc, are covered in separate standards.

1.3 TERMINOLOGY

1.3.3 **Action Effect or Load Effect:** The internal force, axial, shear, bending or twisting moment, due to external actions and temperature loads.

1.3.4 **Action:** The primary cause for stress or deformations in a structure such as dead, live, wind, seismic or temperature loads.

1.3.6 **Beam:** A member subjected predominately to bending.

1.3.13 **Camber:** Intentionally introduced pre-curving (usually upwards) in a system, member or any portion of a member with respect to its chord. Frequently, camber is introduced to compensate for deflections at a specific level of loads.

1.3.14 **Characteristic Load (Action):** The value of specified load (action), above which not more than a specified percentage (usually 5 percent) of samples of corresponding load are expected to be encountered.

1.3.15 **Characteristic Yield/Ultimate Stress:** The minimum value of stress, below which not more than a specified percentage (usually 5 percent) of corresponding stresses of samples tested are expected to occur.

1.3.16 **Column:** A member in upright (vertical) position which supports a roof of floor system and predominantly subjected to compression.

1.3.25 **Design Life:** Time period for which a structure or a structural element is required to perform its function without damage.

1.3.30 **Ductility:** It is the property of the material or a structure indicating the extent to which it can deform beyond the limit of yield deformation before failure or fracture. The ratio of ultimate to yield deformation is usually termed as ductility.

1.3.31 **Durability:** It is the ability of a material to resist deterioration over long periods of time.

1.3.33 **Edge Distance:** Distance from the center of a fastener hole to the nearest edge of an element measured perpendicular to the direction of load transfer.

1.3.35 **Effective Length:** Actual length of a member between points of effective restraint or effective restraint and free end, multiplied by a factor to take account of the end conditions in buckling strength calculations.

1.3.40 **End Distance:** Distance from the center of a fastener hole to the edge of an element measured parallel to the direction of load transfer.

1.3.45 **Factor of Safety:** The factor by which the yield stress of the material of a member is divided to arrive at the permissible stress in the material.

1.3.46 **Fatigue:** Damage caused by repeated fluctuations of stress, leading to progressive cracking of a structural element.

1.3.51 **Fire Resistance:** The ability of an element, component or structure, to fulfil for a stated period of time, the required stability, integrity, thermal insulation and/or other expected performance specified in a standard fire test.

1.3.52 **Fire Resistive Level:** The fire resistance grading period for a structural element or system, in minutes, which is required to be attained in the standard fire test.

1.3.54 **Friction Type Connection:** Connection effected by using pre-tensioned high strength bolts where shear force transfer is due to mobilisation of friction between the connected plates due to clamping force developed at the interface of connected plates by the bolt pre-tension.

1.3.55 **Gauge:** The spacing between adjacent parallel lines of fasteners, transverse to the direction of load/stress.

1.3.57 **Gusset Plate:** The plate to which the members intersecting at a joint are connected.

1.3.63 **Limit State:** Any limiting condition beyond which the structure ceases to fulfil its intended function (see also **1.3.86**).

1.3.72 **Pitch:** The center-to-center distance between individual fasteners in a line, in the direction of load/stress.

1.3.73 **Plastic Collapse:** The failure stage at which sufficient number of plastic hinges have formed due to the loads (actions) in a structure leading to a failure mechanism.

1.3.86 **Serviceability Limit State:** A limit state of acceptable service condition exceedence of which causes serviceability failure.

1.3.88 **Shear Lag:** The in plane shear deformation effect by which concentrated forces tangential to the surface of plate gets distributed over the entire section perpendicular to the load over a finite length of the plate along the direction of the load.

1.3.91 **Slenderness Ratio:** The ratio of the effective length of a member to the radius of gyration of the cross-section about the axis under consideration.

1.3.93 **S-N Curve:** The curve defining the relationship between the number of stress cycles to failure (N_{SC}) at a constant stress range (S_c), during fatigue loading of a structure.

1.3.96 **Stability Limit State:** A limit state corresponding to the loss of static equilibrium of a structure by excessive deflection transverse to the direction of predominant loads.

1.3.102 **Strength Limit State:** A limit state of collapse or loss of structural integrity.

1.3.116 **Ultimate Limit State:** The state which, if exceeded can cause collapse of a part of the whole at the structure.

1.5 UNITS

For the purpose of design calculations the following units are recommended:

(a) Forces and loads, in kN, kN/m, kN/m^2
(b) Unit mass, in kg/m^3
(c) Unit weight, in kN/m^3
(d) Stresses and strengths in N/mm^2 (MN/m^2 or MPa)
(e) Moments (bending, etc) in kNm

1.8 CONVENTION FOR MEMBER AXES

Unless otherwise specified convention used for member axes is as follows.

(a) x-x along the member.
(b) y-y an axis of the cross-section.
  (i) perpendicular to the flanges, and
  (ii) perpendicular to the smaller leg in an angle section.
(c) z-z an axis of the cross-section.
  (i) axis parallel to flanges, and
  (ii) axis parallel to smaller leg in angle section.
(d) u-u major axis (when it does not coincide with z-z axis).
(e) v-v major axis (when it does not coincide with y-y aixs).

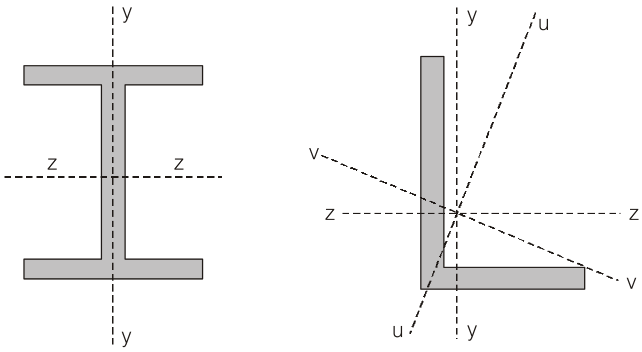


Fig. 1 Axes of Members

SECTION 2 : MATERIALS

2.1 GENERAL

The material properties given in this section are nominal values, to be accepted as characteristic values in design calculations.

2.2 STRUCTURAL STEEL

2.2.1 The provisions in this section are applicable to the steels commonly used in steel construction, namely, structural mild steel and high tensile structural steel.

2.4.1 Physical properties of structural steel irrespective of its grade may be taken as:

(a) Unit mass of steel, $\rho = 7850$ kg/m^3
(b) Modulus of elasticity, $E = 2.0 \times 10^5$ N/mm^2 (MPa)
(c) Poission ratio, $\mu = 0.3$
(d) Modulus of rigidity, $G = 0.769 \times 10^5$ N/mm^2 (MPa)
(d) Coefficient of thermal expansion, $\alpha = 2 \times 10^{-6}$/°C

Part-C

Elastic Curve

CONTENTS

Why Elastic Curve?

- To get better understanding about the behavior of structures subjected to loading.
- To solve the questions directly related to elastic curve.
- To determine degree of freedom and kinematic indeterminacy.
- To calculate the deflections at different points without any mathematical calculation.
- To draw the influence line diagram using Muller Breslau's principle.
- To check the correctness of directions of support reaction, which is calculated using mathematical analysis.
- To check the correctness of bending moment diagram.

How to draw Elastic curve?

There are only three simple steps to draw the elastic curve correctly.

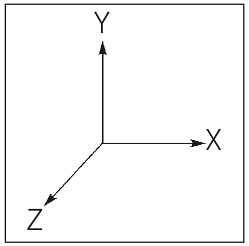
Step 1: By visual inspection

Step 2: By satisfying compatibility conditions

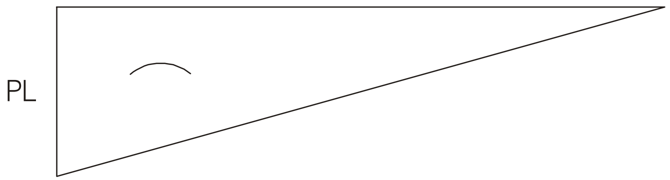
Step 3: By making elastic curve and bending moment diagram consistent

Assumptions

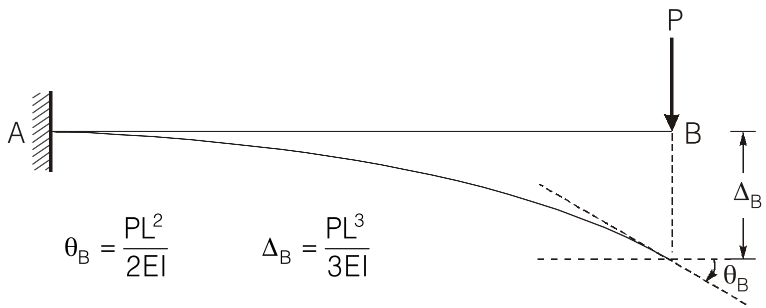
- Members of structure are linearly elastic.
- Structure is subjected to small displacement (deflection or rotation) under given loading.
- All members are axially inextensible unless mentioned.



EXAMPLE : 1



Bending Moment Diagram



Elastic Curve

DISCUSSION

Step 1: By visual inspection

Definitely, you can draw the elastic curve of the given structure by visual inspection only and that is correct. Then also, other steps are being discussed here to check the correctness of elastic curve. By visual inspection, it is evident that deflected shape will be hogging and beam is going downward.

Step 2: By satisfying compatibility conditions.

Compatibility conditions at A:

$$\Delta_x = 0 \quad \Delta_y = 0 \quad \theta_A = 0$$

Compatibility condition at B:

$$\Delta_x = 0 \text{ (axially inextensible)} \quad \Delta_y \neq 0 \quad \theta_B \neq 0$$

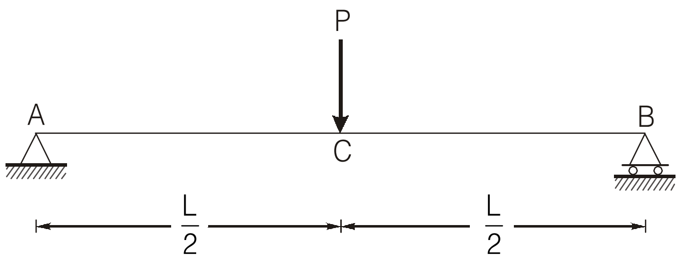
Point B will be just perpendicularly below to the member AB because structure is subjected to small displacement only.

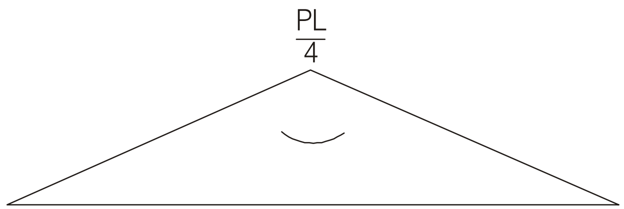
Note: Members always deflect in the perpendicular direction to its longitudinal axis.

Step 3: By making elastic curve and bending moment diagram consistent.

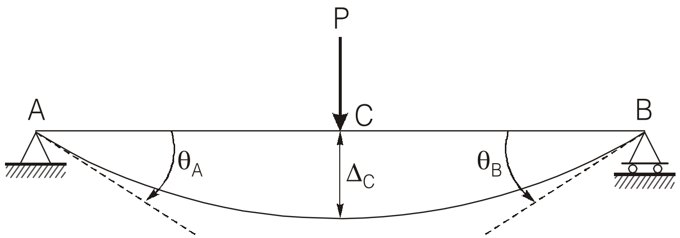
From bending moment diagram, it is clear that the entire span is under hogging shape which is clear from the deflected shape also. It means bending moment diagram and elastic curve is consistent.

EXAMPLE : 2





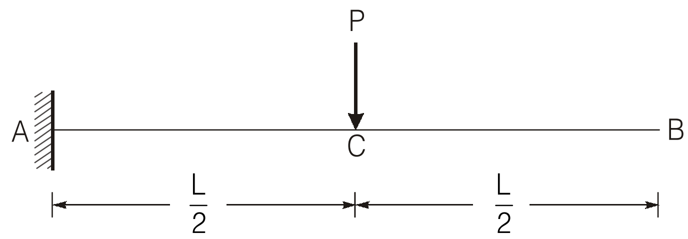
Bending Moment Diagram

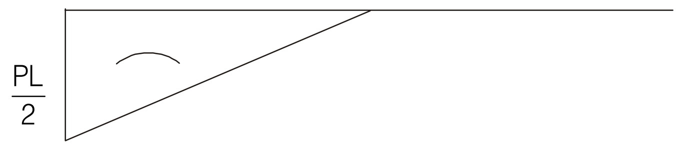


$$\theta_A = \theta_B = \frac{PL^2}{16EI} \qquad \Delta_C = \frac{PL^3}{48EI}$$

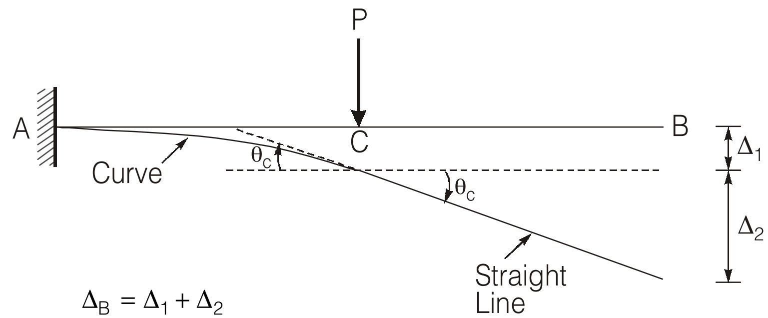
Elastic Curve

EXAMPLE : 3





Bending Moment Diagram



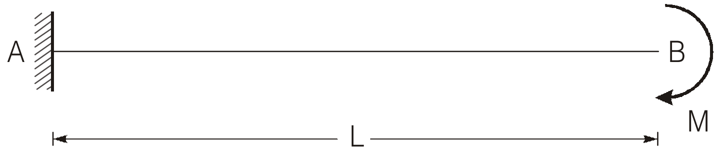
$$\Delta_B = \Delta_1 + \Delta_2$$

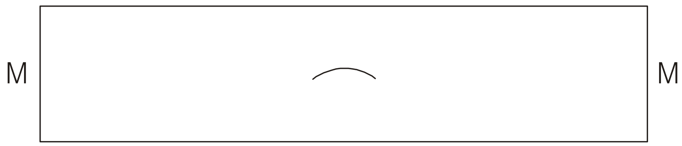
$$= \frac{P(L/2)^3}{3EI} + \theta_C \times \frac{L}{2} \qquad \left[\theta_C = \frac{P(L/2)^2}{2EI}\right]$$

$$= \frac{5PL^3}{48EI}$$

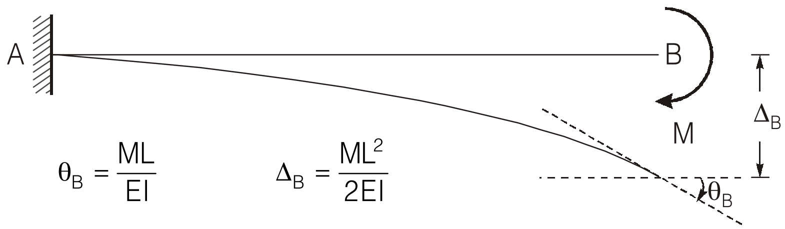
Elastic Curve

EXAMPLE : 4





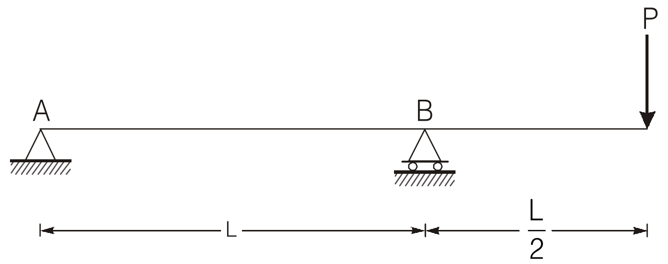
Bending Moment Diagram

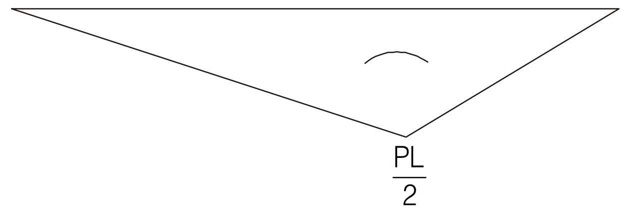


$$\theta_B = \frac{ML}{EI} \qquad \Delta_B = \frac{ML^2}{2EI}$$

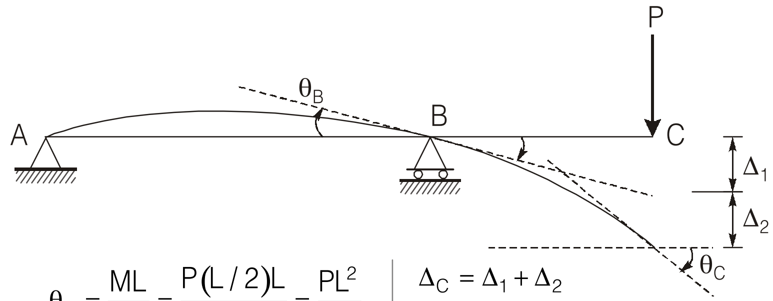
Elastic Curve

EXAMPLE : 5





Bending Moment Diagram



$$\theta_B = \frac{ML}{3EI} = \frac{P(L/2)L}{3EI} = \frac{PL^2}{6EI}$$

$$\theta_C = \theta_B + \frac{P(L/2)^2}{2EI} = \frac{7}{24}\frac{PL^3}{EI}$$

$$\Delta_C = \Delta_1 + \Delta_2$$

$$= \theta_B \times \frac{L}{2} + \frac{P(L/2)^3}{3EI}$$

$$= \frac{PL^3}{8EI}$$

Elastic Curve

ANSWER

1. (a)	2. (a)	3. (a)	4. (d)
5. (b)	6. (d)	7. (a)	8. (c)
9. (a)	10. (a)	11. (a)	12. (b)
13. (d)	14. (d)	15. (a)	16. (a)