SCHEME :K

Name :___________________________

Roll No.:_________ Year : 20 ___ 20 __

Exam Seat No. :____________________

LABORATORY MANUAL FOR
DESIGN OF RCC AND STEEL STRUCTURES
(316308)

CIVIL ENGINEERING GROUP

MAHARASHTRA STATE BOARD OF
TECHNICAL EDUCATION, MUMBAI
(Autonomous)(ISO21001:2018)(ISO/IEC27001:2013)

VISION:

To ensure that the Diploma Level Technical Education constantly matches the latest requirements of Technology and industry and includes the all-round personal development of students including social concerns and to become globally competitive, technology led organization.

MISSION:

To provide high quality technical and managerial manpower, information and consultancy services to the industry and community to enable the industry and community to face the challenging technological & environmental challenges.

QUALITY POLICY:

We, at MSBTE are committed to offer the best-in-class academic services to the students and institutes to enhance the delight of industry and society. This will be achieved through continual improvement in management practices adopted in the process of curriculum design, development, implementation, evaluation and monitoring system along with adequate faculty development programs.

CORE VALUES:

MSBTE believes in the following:

- Skill development in line with industry requirements
- Industry readiness and improved employability of Diploma holders
- Synergistic relationship with industry
- Collective and Cooperative development of all stake holders
- Technological interventions in societal development
- Access to uniform quality technical education.

A Laboratory Manual

For

DESIGN OF RCC AND STEEL STRUCTURES

(316308)

SEMESER-VI

“K-scheme”

(CE/ CR/ CS/ LE)

Maharashtra State

Board of Technical Education, Mumbai

(Autonomous) (ISO: 21001:2018) (ISO/IEC 27001:2013)

Maharashtra State Board of Technical Education, Mumbai
(Autonomous) (ISO: 21001:2018) (ISO/IEC 27001:2013)
4th Floor, Government Polytechnic Building, 49, Kherwadi,
Bandra (East), Mumbai – 400051,

Maharashtra State
Board of Technical Education, Mumbai

Certificate

This is to certify that Mr. Ms.……………………………………………………

Roll No………………………of Sixth semester of Diploma in ……………………………………………………………………..............of Institute,………………………………………………………………..……… …………………………………………(Code:…………) has completed the term work satisfactorily in course **DESIGN OF RCC AND STEEL STRUCTURES (316308)** for the academic year 20…… to 20…… as prescribed in the curriculum**.**

Place: …………… Enrollment No: ………………..

Date: ……………. Exam. Seat No: …………………

Subject teacher **Head of the Department** **Principal**

Seal of Institution

PREFACE

The primary focus of any engineering laboratory/field work in the technical education system is to develop the much-needed industry relevant competencies and skills. With this in view, MSBTE embarked on this innovative 'I' Scheme curricula for engineering diploma programs with outcome-based education as the focus and accordingly, relatively large amount of time is allotted for the practical work. This displays the great importance of laboratory work making each teacher; instructor and student to realize that every minute of the laboratory time need to be effectively utilized to develop these outcomes, rather than doing other mundane activities. Therefore, for the successful implementation of this outcome-based curriculum, every practical has been designed to serve as a 'vehicle' to develop this industry identified competency in every student. The practical skills are difficult to develop through 'chalk and duster' activity in the classroom situation. Accordingly, the 'K' scheme laboratory manual development team designed the practical's to focus on the outcomes, rather than the traditional age-old practice of conducting practical's to 'verify the theory' (which may become a byproduct along the way).

This laboratory manual is designed to help all stakeholders, especially the students, teachers and instructors to develop in the student the pre-determined outcomes. It is expected from each student that at least a day in advance, they have to thoroughly read through the concerned practical procedure that they will do the next day and understand the minimum theoretical background associated with the practical. Every practical in this manual begins by identifying the practical significance; Industry/Employer expected outcome(s), course outcomes and laboratory learning outcomes which serve as a key focal point for doing the practical. The students will then become aware about the skills they will achieve through procedure shown there and necessary precautions to be taken, which will help them to apply in solving real-world problems in their professional life.

This manual also provides guidelines to teachers and instructors to effectively facilitate student-centered lab activities through each practical exercise by arranging and managing necessary resources in order that the students follow the procedures and precautions systematically ensuring the achievement of outcomes in the students.

In day-to-day working we come across different types of structures created for different purposes and functions. While designing the structures, analysis of forces and stresses is an important and prerequisite step. Correct analysis is possible only when one knows the types and effects of forces acting on the structures. This course provides the scope to understand Fundamental concepts of laws of mechanics and their applications to different engineering problems. This course is designed to provide basic understanding about the different types of forces, moments and their effects on structural elements, which will analyze different structural systems.

Although best possible care has been taken to check for errors (if any) in this laboratory manual, perfection may elude us as this is the first edition of this manual. Any errors and suggestions for improvement are solicited and highly welcome.

Program outcome (POs)

PO 1. Basic & Discipline specific knowledge: Apply knowledge of basic mathematics, sciences and engineering fundamentals and engineering specialization to solve the engineering problems.

PO 2. Problem Analysis: Identify and analyze well defined engineering problems using codified standard methods.

PO 3. Design /Development Solutions: Design solutions for well-defined technical problems and assist with the design of systems components or processes to meet specified needs.

PO 4. Engineering tools experimentation and testing: Apply modern engineering tools and appropriate technique to conduct standard tests and measurements.

PO 5. Engineering practices for society sustainability and environment: Apply appropriate technology in context of society, sustainability, environment and ethical practices.

PO 6. Project Management: Use engineering management principles individually, as a team member or a leader to manage projects and effectively communicate about well-defined engineering activities.

PO 7. Lifelong learning: Ability to analyze individual needs and engage in updating in context of technological changes.

List of Relevant Skills

The following industry identified competency through various teaching learning experiences. Repair and maintain different types of structures using appropriate materials and methods. To develop this competency, students should gain both practical experiences and relevant soft skills through teaching–learning activities. The outcome is that students will be able to demonstrate the following industry-relevant skills:

1. Identify the causes of structural damages and evaluate their extent.
2. Operate minor and major tools/equipment efficiently and safely to complete repair works.
3. Evaluate the strength and performance of different structural components in existing buildings.
4. Interpret results obtained from various structural tests and inspections.
5. Recommend suitable materials for repairing different types of defects/damages under varied site conditions.
6. Select and apply feasible repair and retrofitting technologies appropriate to the type and severity of damage.

Guidelines to teachers

Teachers shall discuss the following points with students before start of practical of the subjects.

1. Learning Overview: To develop better understanding of importance of the subject through intellectual skills and motor skills.
2. Know your laboratory work: To understand the layout of laboratory, specifications of equipment/instrument/materials, procedure, working in groups, planning time etc. also to know total amount of work to be done in laboratory.
3. For difficult practical's if required, teacher should provide the demonstration of the practical emphasizing of the skills which the student should achieve.
4. Teachers should give opportunity to students for hands-on after the demonstration.
5. Assess the skill achievement of the students and COs of each unit.
6. Teachers should give relevant information (including safety measures) to students prior to visit arranged for effective utilization of time and understanding.
7. Teachers shall ensure that required equipment are in working condition before start each experiment, also keep operating instruction manual available.
8. One or two questions ought to be added in each practical for different batches. For this teacher can maintain various practical related question banks for each course.
9. If some repetitive information like data sheet, use of software tools etc. has to be provided for effective attainment of practical outcomes, they can be incorporated in Appendix.
10. For effective implementation and attainment of practical outcomes, teacher ought to ensure that in the beginning itself of each practical, students must read through the complete write-up of that practical sheet.
11. During practical, ensure that each student gets chance and takes active part in taking observations/ readings and performing practical.

Note: Kindly do add specific guidelines for effective implementation of practical's depending upon your course, if needed.

Instructions to Students

1. For effective implementation and attainment of practical outcomes, in the beginning it self of each practical, student need to read through the complete write-up including the practical related questions and assessment scheme of that practical sheet.
2. Student must refer the data books, IS codes, safety norms, etc.
3. Student should not hesitate to ask any difficulties they face during the conduct of practical's.
4. Student should develop the habit of pear discussions/group discussion related to the experiment/exercise so that exchanges of knowledge /skills could take place.
5. Student shall attempt to develop related hands-on skills and gain confidence.
6. Students shall visit the nearby construction site, technical exhibitions, trade fair etc. even not included in the lab manual.
7. Students should develop the habit of not to depend totally on teachers but to develop self-learning techniques.
8. Student should develop habit to submit the practical exercise continuously and progressively on the scheduled dates and should get the assessment done.
9. It is necessary to take all types of precautionary measures by students during the visit.
10. Each student must follow the instructions given by the site engineer during the visit.
11. Special precautions must be taken for special type of work.
12. As far as possible, go through NPTEL, MOOC'S, SWAYAM website and register for the certificate courses.
13. Attach minimum four photographs of work done during site visit on separate blank page.

Note: Kindly do add specific instructions for students for effective implementation of practical depending upon your course, if needed.

Practical Course outcome matrix:

CO1 - Explain the given criteria in relation to RCC and steel structures.
CO2 - Design the reinforced concrete beams for given condition as per IS codes
CO3 - Design the given type of slab for the given edge condition.
CO4 - Design of axially loaded short columns and footings.
CO5 - Design the connections for the given steel joints.

Pr. No.	Title of the Practical	Mapped Course Outcome				
		CO 01	CO 02	CO 03	CO 04	CO 05
01	Write IS clauses related to partial safety factors for loads and materials from IS 456:2000.	√	----	----	----	----
02	Write five IS clauses related to shear reinforcement in beams and slabs from IS 456:2000.	----	√	----	----	----
03	Write five IS clauses related to each for slab and column from IS 456:2000.	----	√	----	----	----
04	*Write the stepwise procedure for design of Doubly reinforced beam section.	----	√	----	----	----
05	*Interpret the given working drawing and write reinforcement details along with sizes provided for minimum two structural members.	√	√	√	√	----
06	*Design a cantilever slab for the given data and draw reinforcement details..	----	----	√	----	----
07	*Design a one-way simply supported slab for the given data and draw reinforcement details.	----	----	√	----	----
08	*Design a two-way simply supported slab for the given data and draw reinforcement details.	----	----	√	----	----
09	*Design the beam for the given data and draw reinforcement details.	----	√	----	----	----
10	*Design an axially loaded Square column for the given data and draw reinforcement details.	----	----	----	√	----
11	*Design an axially loaded Rectangular column for the given data and draw reinforcement details.	----	----	----	√	----
12	*Design the footing for the axially loaded Square column designed in Sr. no. 10 and draw reinforcement details..	----	----	----	√	----
13	Design the footing for the axially loaded rectangular column designed in Sr. no. 11 and draw reinforcement details..	----	----	----	√	----
14	*Draw the reinforcement details for cantilever slab, one way simply supported slab and two way simply supported slab designed in Sr. no. 06 to 08 using Auto-CAD software.(A2 Size Sheet)	----	----	√	----	----
15	*Draw the reinforcement details for the beam, column and footing designed in Sr. no. 09 to 13 using Auto-CAD software.(A2 Size Sheet)	----	√	----	√	----
16	*Prepare a report of site visit to a RCC work under construction for slab and beam reinforcement with neat sketches.	----	√	√	----	----

17	Prepare a report of site visit to a RCC work under construction for column and footing reinforcement with neat sketches.	----	----	----	√	----
18	Write five IS clauses related to load from IS 875:1987.	√	√	√	√	----
19	Write five IS clauses related to joints in steel structure from IS 800:2007.	----	----	----	----	√
20	*Design a bolted connection for the given data.	----	----	----	----	√
21	*Design a welded connection for the given data.	----	----	----	----	√
22	Write three IS clauses related to tension member and compression member in steel structure from IS 800:2007.	----	----	----	----	√
23	*Write the stepwise procedure for Design of tension member.	----	----	----	----	√
24	*Write the stepwise procedure for Design of compression member.	----	----	----	----	√
25	*Prepare a report on a site visit for joints in steel structures.	----	----	----	----	√

CONTENT PAGE

List of Practical's and Formative Assessment sheet

13	Design the footing for the axially loaded rectangular column designed in Sr. no. 11 and draw reinforcement details..	110					
14	*Draw the reinforcement details for cantilever slab, one way simply supported slab and two way simply supported slab designed in Sr. no. 06 to 08 using Auto-CAD software.(A2 Size Sheet)	121					
15	*Draw the reinforcement details for the beam, column and footing designed in Sr. no. 09 to 13 using Auto-CAD software.(A2 Size Sheet)	130					
16	*Prepare a report of site visit to a RCC work under construction for slab and beam reinforcement with neat sketches.	137					
17	Prepare a report of site visit to a RCC work under construction for column and footing reinforcement with neat sketches.	147					
18	Write five IS clauses related to load from IS 875:1987.	157					
19	Write five IS clauses related to joints in steel structure from IS 800:2007.	165					
20	*Design a bolted connection for the given data.	173					
21	*Design a welded connection for the given data.	181					
22	Write three IS clauses related to tension member and compression member in steel structure from IS 800:2007.	189					
23	*Write the stepwise procedure for Design of tension member.	198					
24	*Write the stepwise procedure for Design of compression member.	207					
25	*Prepare a report on a site visit for joints in steel structures.	216					
Total marks :							

These marks are to be transferred in pro-forma published by MSBTE.

- '*' Marked Practical (LLOs) are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs is to be performed to achieve desired outcomes.

Practical No. 1: Write IS clauses related to partial safety factors for loads and materials from IS 456:2000.

I. Practical Significance:

IS 456-2000 is the Indian Standard Code that provides specifications for design of RCC structures. Design requirements for special structures and systems are specified in this code. This practical will help the students to understand salient provisions of IS 456:2000. These provisions include general, material, workmanship, inspection, testing, general and special design requirement for buildings and structures.

II. Industry/Employer expected outcome(s):

This practical is expected to develop the following skills for the industry identified competency, ***"Apply knowledge of specifications for buildings and structures."***

a. Know IS clauses related to partial safety factors for loads and materials as specified in IS 456:2000.
b. Follow design steps as per IS 456: 2000.

III. Course Level Learning Outcome (COs):

CO1 - Explain the given criteria in relation to RCC and steel structures.
CO2 - Design the reinforced concrete beams for given condition as per IS codes
CO3 - Design the given type of slab for the given edge condition.
CO4 - Design of axially loaded short columns and footings.
CO5 - Design the connections for the given steel joints.

IV. Laboratory Learning Outcome (LLO):

Identify the relevant IS clauses related to partial safety factors from IS 456:2000.

V. Relevant Affective Domain related Outcome(s):

a. Demonstrate working as a leader/ team member.
b. Follow ethical practices.

VI. Relevant Theoretical Background:

- In reinforced concrete design, partial safety factors are applied to account for possible variations in material strengths, workmanship, and loading conditions. These factors ensure that structures are safe, serviceable, and economical throughout their design life. The IS 456:2000 specifies separate partial safety factors for loads and materials under Clause 36.4.1 and Clause 36.4.2, respectively.
- This code contains total five sections.
  Section 1 - General
  Section 2 - Materials, Workmanship, Inspection and Testing
  Section 3 - General Design Consideration
  Section 4 - Special Design Requirements for Structural Members and Systems
  Section 5 - Structural Design (Limit State Method)
- In this code it has been assumed that the design of plain and reinforced cement concrete work

is entrusted to a qualified engineer and that the execution of work is carried out under the direction of a qualified and experienced supervisor.

VII. Required resources/equipment:

S.N.	Resource required	Particulars	Quantity
1	IS 456:2000	Plain and Reinforced Concrete Code of Practice	1 No.

VIII. Precautions to be followed:

1. Careful reading for the extract of information is must.
2. Students should write precisely the clauses.

IX. Procedure:

1. Take a general browse through the IS code, understand it and enter the information.
2. Study each section with reference to the information asked and enter the information extract accordingly.
3. Write Clause 36.4.1 of IS 456: -2000 related to partial safety factors for loads.
4. Write Table 18 Page No. 68 of IS 456: -2000 related to values of partial safety factors for loads.
5. Write Clause 36.4.2.1 of IS 456: - 2000 related to partial safety factors for material strength.

Space to write Clauses

XI. Conclusions:

XII. Practical Related Questions:

(Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO. Write answers of minimum three questions.)

1. Explain how the partial safety factors for loads differ in the Limit State Method and the Working Stress Method as per IS 456:2000.
2. Why does IS 456:2000 recommend a higher partial safety factor for concrete ($\gamma m = 1.5$) compared to steel ($\gamma m = 1.15$)?
3. A reinforced concrete beam is subjected to a dead load of 20 $\frac{kN}{m}$ and a live load of 10 $\frac{kN}{m}$. Calculate the design load for the beam as per Clause 36.4.1 of IS 456:2000.
4. How do partial safety factors contribute to ensuring both safety and serviceability in limit state design?
5. If the characteristic strength of M25 concrete is 25 $\frac{N}{mm^2}$, determine the design strength of concrete used in design as per Clause 36.4.2 of IS 456:2000.
6. Write full forms of i) HYSD ii) TMT.

<u>Space for Answer</u>

XIII. References / Suggestions for further Reading:

- IS 456:2000 – Plain and Reinforced Concrete Code of Practice

XIV. Assessment Scheme:

Sr. No.	Performance Indicators	Weightage
A.	**Process Related (15 marks)**	**60%**
1.	Use of IS: 456- 2000	40%
2.	Precision in sketchbook, neatness, cleanliness.	20%
B.	**Product Related (10 marks)**	**40%**
3.	Interpretation of given clauses	10%
4.	Answers to practical related questions.	10%
5.	Submission of report in time.	20%
C.	**Total marks (25 marks)**	**100%**

Marks Obtained			**Dated sign of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 2: Write five IS clauses related to shear reinforcement in beams and slabs from IS 456:2000

I. Practical Significance:

Shear failure, which in reality occurs under the combined action of shearing force and bending moment, is characterized by very small deflection and lack of ductility. This failure is many times sudden and without any warning. For this reason, shear failure is considered very undesirable and is usually avoided. The IS code provisions for shear are therefore more conservative. This practical will help the students to understand necessity of shear reinforcement, its various forms and provisions regarding area of reinforcement and its spacing by referring various clauses given in IS 456:2000.

II. Industry/Employer expected outcome(s):

a. This practical is expected to develop the following skills for the industry identified competency, ***"Apply knowledge of shear reinforcement in beam and slabs."***

b. Ability to understand necessity of shear reinforcement.

c. Ability to understand various forms of shear reinforcement.

d. Ability to refer IS code clauses related to shear reinforcement.

III. Course Level Learning Outcome (COs):

CO2 - Design the reinforced concrete beams for given condition as per IS codes

CO3 - Design the given type of slab for the given edge condition.

IV. Laboratory Learning Outcome (LLO):

LL 2.1: Identify the relevant IS clauses related to shear reinforcement in beams and slabs from IS 456:2000.

V. Relevant Affective Domain related Outcome(s):

Demonstrate working as a leader / a team member.
Follow ethical practices.

VI. Relevant Theoretical Background:

Shear Reinforcement: Shear in beams is caused due to variation in bending moment along the span. The bending stress and shear stress combine into principal tensile and compressive stresses. When the principal tensile stress exceeds tensile strength of concrete, very low cracks due to tension develop along the diagonal. These cracks are called 'Diagonal tension cracks'. The tension cracks developed due to shear is required to be taken care of by providing reinforcement. The reinforcement provided is known as "Shear reinforcement".

Various forms of shear reinforcement: It can be provided in various forms as mentioned below-

1) Vertical stirrups
2) Inclined stirrups
3) Bent-up bars

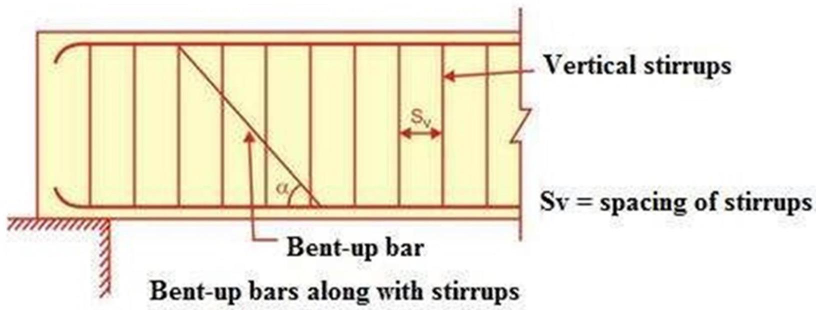
VII. Required resources/equipment:

S.N.	Resource required	Particulars	Quantity
1	IS 456:2000	Plain and Reinforced Concrete Code of Practice	1 No.

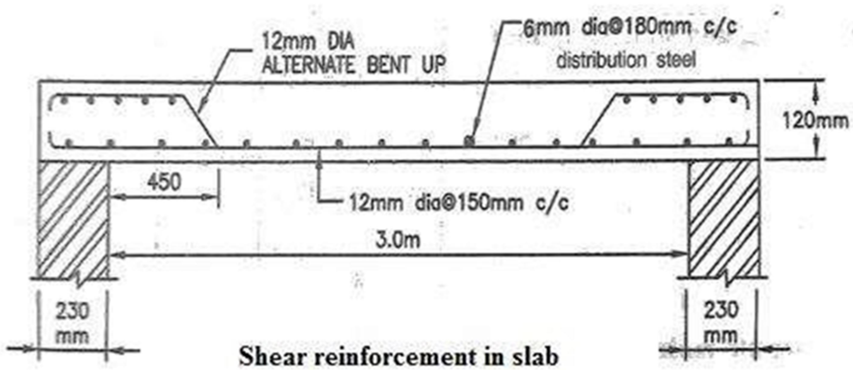
VIII. Precautions to be followed:

1. Read carefully the IS code to extract the information related to shear reinforcement detailing.

IX. Experimental Set-up:



Shear reinforcement in beam



Shear reinforcement in slab

X. Procedure:

1. Teacher should discuss with the student's importance of shear reinforcement, its various forms and IS code provisions.
2. Student should read clauses related to shear reinforcement detailing from IS 456:2000 and

should write it.

3. Write clause 26.5.1.5 from IS 456: 2000 (Page no. 47) related to maximum spacing of shear reinforcement.
4. Write clause 26.5.1.6 from IS 456: 2000 (Page no. 48) related to minimum shear reinforcement.
5. Write clause 40.1 from IS 456: 2000 (Page no. 72) related to Nominal shear stress.
6. Write clause 40.2.3 from IS 456: 2000 (Page no. 72) related to Maximum shear stress.
7. Write clause 40.4 from IS 456: 2000 (Page no. 72) related to design of shear reinforcement.

Space to write Clauses

XI. Conclusions:

Practical Related Questions:

(Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO. Write answers of minimum three questions.)

1. Why is shear reinforcement necessary in reinforced concrete beams, even when nominal shear stress is within limits?
2. What is the effect of diagonal tension cracks on the performance of a reinforced concrete beam?
3. Differentiate between vertical stirrups and bent-up bars as forms of shear reinforcement.
4. State the IS 456:2000 clause related to the maximum spacing of shear reinforcement and explain its importance.
5. How does the provision of minimum shear reinforcement improve the structural behaviour of beams and slabs?

Space to Write Answers

XIII. References / Suggestions for further Reading:

- IS 456:2000 – Plain and Reinforced Concrete - Code of Practice

XIV. Assessment Scheme:

Sr. No.	Performance Indicators	Weightage
A.	**Process Related (15 marks)**	**60%**
1.	Use of IS: 456- 2000	40%
2.	Precision in sketchbook, neatness, cleanliness.	20%
B.	**Product Related (10 marks)**	**40%**
3.	Interpretation of given clauses	10%
4.	Answers to practical related questions.	10%
5.	Submission of report in time.	20%
C.	**Total marks (25 marks)**	**100%**

Marks Obtained			**Dated sign of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No: 3 **Write five IS clauses related to each for slab and column from IS 456:2000.**

I. Practical Significance:

A Framed structure is a structure consisting of framework of different members such as beam, column and slab to resist the lateral and gravity loads. These structures are usually used to overcome the large moments developed due to the applied loads. In framed structures the load from the slab is transferred to columns through beams. The columns in tum transfer the load to the foundation system. This practical will help the students to understand the elements of framed structure with provisions of various causes related to it using IS 456:2000.

II. Industry/Employer expected outcome(s):

This practical is expected to develop the following skills for the industry identified competency, ***"Safe and economical design of beam, slab and column."***

Ability to understand IS code provisions for beam, slab and column.

III. Course Level Learning Outcome (COs):

CO3 - Design the given type of slab for the given edge condition.

CO4 - Design of axially loaded short columns and footings.

IV. Laboratory Learning Outcome (LLO):

LLO 3.1 Identify the relevant IS clauses for slabs and columns from IS 456:2000.

V. Relevant Affective Domain related Outcome(s):

a. Demonstrate working as a leader / a team member.
b. Follow ethical practices.

VI. Relevant Theoretical Background:

- Slab: It is a two-dimensional member supporting a transverse load and providing working floor or a covering shelter. The loads are transferred to the supporting beams by bending in one or both directions.
- Column: It is one dimensional vertical member providing a support to the beam. They receive load from beam and it is transferred by axial compression accompanied by bending and shear.

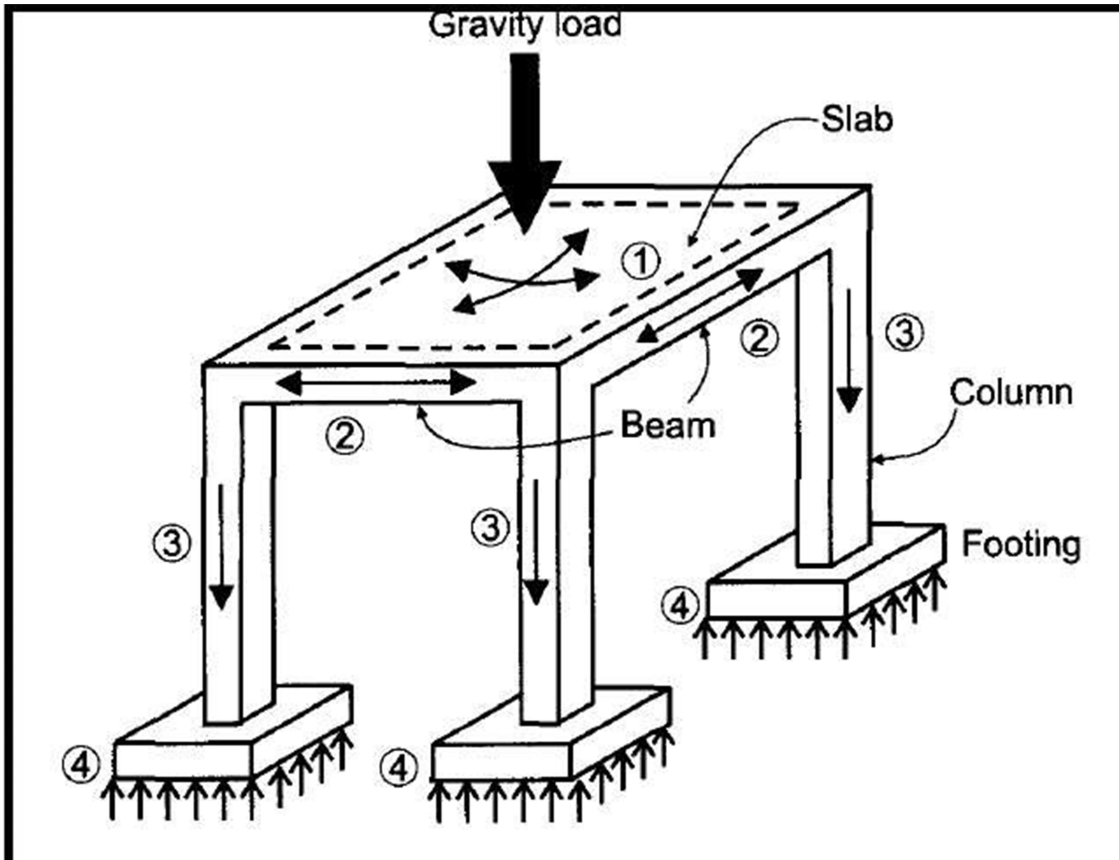
VII. Required resources/equipment:

S.N.	Resource required	Particulars	Quantity
1	IS 456:2000	Plain and Reinforced Concrete Code of Practice	1 No.

VIII. Precautions to be followed:

1. Read carefully the IS code to extract the information related to beam, slab and column.

IX. Experimental Set-up:



Load transfer mechanism in Framed Structure

X. Procedure:

1. Teacher should discuss with the students regarding structural elements of a RCC structure.
2. He I She should discuss the various IS code provisions related to beam, slab and column.
3. Student should read clauses related to it from IS 456:2000 and should write it.

- IS clauses related to slab:
  1. Write clause 22.2 (a) from IS 456: 2000 (Page no. 34) related to effective span of simply supported beam or slab.
  2. Write clause 22.2 (c) from IS 456: 2000 (Page no. 35) related to effective span of cantilever beam or slab.
  3. Write clause 26.3.3.(b) (1) from IS 456: 2000 (Page no. 46) related to horizontal distance between parallel bars of slab.
  4. Write clause 26.5.2.1 from IS 456: 2000 (Page no. 48) related to minimum reinforcement to be provided in slab.

- IS clauses related to column:

1. Write clause 25.1.1 from IS 456: 2000 (Page no. 41) related to definition of column.
2. Write clause 25.1.2 from IS 456: 2000 (Page no. 41) related to short and slender compression member.
3. Write clause 25.4 from IS 456: 2000 (Page no. 42) related to minimum eccentricity of column
4. Write clause 26.5.3.1 from IS 456: 2000 (Page no. 48) related to longitudinal reinforcement of column.
5. Write clause 26.5.3.2 (c) from IS 456: 2000 (Page no. 49) related to pitch and diameter of lateral ties of column.
6. Write clause E-3 from IS 456:2000 (Page no.94) Table 28 related to effective length of column

Space for Clauses

XI. Conclusions:

XII. Practical Related Questions:

(Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO. Write answers of minimum three questions.)

1. What is the significance of considering effective span while designing slabs and beams as per IS 456:2000?
2. Why is minimum reinforcement specified in slabs and beams according to IS 456:2000?
3. Define short and slender columns as per IS 456:2000.
4. What is the purpose of providing lateral ties in reinforced concrete columns?
5. Why is minimum eccentricity considered in column design as per IS 456:2000?
6. Calculate the minimum area of steel reinforcement for a slab having an overall depth = 120 mm.
7. Calculate the minimum and maximum longitudinal steel area for a column having size = 300 mm × 450 mm as per IS 456:2000 Clause 26.5.3.1.

Space to Write Answers

XIII. References / Suggestions for further Reading:

IS 456:2000 – Plain and Reinforced Concrete - Code of Practice

XIV. Assessment Scheme:

Sr. No.	Performance Indicators	Weightage
A.	**Process Related (15 marks)**	**60%**
1.	Use of IS: 456- 2000	40%
2.	Precision in sketchbook, neatness, cleanliness.	20%
B.	**Product Related (10 marks)**	**40%**
3.	Interpretation of given clauses	10%
4.	Answers to practical related questions.	10%
5.	Submission of report in time.	20%
C.	**Total marks (25 marks)**	**100%**

Marks Obtained			**Dated sign of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

<u>Practical No: 4</u> Write the Stepwise Procedure for Design of Doubly Reinforced Beam Section

I. Practical Significance:

A doubly reinforced beam is used when the beam depth is restricted due to architectural or functional requirements, and the moment of resistance of a singly reinforced section is insufficient. Additional reinforcement is provided in the compression zone to increase the moment-carrying capacity. This practical helps students understand the need, concept, and systematic design steps for a doubly reinforced beam as per IS 456:2000 under the Limit State Method.

II. Industry/Employer expected outcome(s):

After completing this practical, students should be able to:

1. Apply the limit state design principles for reinforced concrete beams.
2. Design and detail doubly reinforced beams used in multi-stored and high-load structures.
3. Interpret and apply relevant IS 456:2000 clauses in structural design documentation.
4. Prepare bar bending schedules and drawings using AutoCAD or manual drafting.

III. Course Level Learning Outcome (COs):

CO2 - Design the reinforced concrete beams for given condition as per IS codes

IV. Laboratory Learning Outcome (LLO):

LLO 4.1: Write the stepwise procedure for the design of a doubly reinforced beam section.

V. Relevant Affective Domain related Outcome(s):

1. Demonstrate the ability to work as a team member during design work and drafting.
2. Follow ethical practices in calculation accuracy and documentation.
3. Show discipline and responsibility while using software and preparing design reports.

VI. Relevant Theoretical Background:

- A doubly reinforced beam contains steel reinforcement in both the tension and compression zones. It is adopted when:
- The section's depth is restricted.
- The applied moment exceeds the moment of resistance of a singly reinforced section.
- Reversal of bending occurs. Basic Principles:
  The additional moment is resisted by compression steel and additional tension steel.
  The section satisfies force equilibrium and strain compatibility conditions.

  Key Formulas:
  1. $Cc = 0.36 \cdot fck \cdot b \cdot xu$
  2. $Cs = 0.87 \cdot fy \cdot As'$
  3. $T = 0.87 \cdot fy \cdot As$
  4. $Cc + Cs = T$
  5. $Mu = Cc (d - xu/2) + Cs (d - d')$

VII. Required resources/equipment:

S.N.	Resource required	Particulars	Quantity
1.	Limit State Theory and Design of Reinforced Concrete Structures	Dr. V. L. Shah & Dr. S. R. Karve	1 no. per 5 students
2	IS 456:2000	Plain and Reinforced Concrete Code of Practice	1 No. per 5 students

XIII. Precautions to be followed:

1. Maintain consistency in units throughout the calculation.
2. Refer correctly to IS 456:2000 clauses for stress block parameters.
3. Avoid excessive rounding errors in steel area calculations.
4. Ensure that final detailing satisfies minimum cover, spacing, and bar limits.
5. Draft drawings neatly to scale with correct bar symbols.

X. Procedure:

Step 1. Given Data

Parameter	Symbol
Factored Moment	Mu
Beam Width	b
Total Depth	D
Effective Depth	d
Cover to Compression Steel	d′
Concrete Grade	fck
Steel Grade	fy

Step 2. Maximum Depth of Neutral Axis (Xu_{max})

This depends on the steel grade: f_y

$$\text{Fe 250}: \ Xu_{max} = 0.53 * d$$
$$\text{Fe 415}: \ Xu_{max} = 0.48 * d$$
$$\text{Fe 500}: \ Xu_{max} = 0.46 * d$$

Limiting Moment Calculations ($\boldsymbol{Mu_{lim}}$)

$$(Mu_{lim}) = 0.36\,.\,fck\,.\,b\,.\,Xu_{max}.\,(d - .42.\,Xu_{max})$$

Checks

If $\boldsymbol{Mu} \leq \boldsymbol{Mu_{lim}}$ Design as a Singly Reinforced Beam.

If $\boldsymbol{Mu} \geq \boldsymbol{Mu_{lim}}$ Design as a Doubly Reinforced Beam

The excess moment, $\mathbf{Mu_2}$ must be resisted by the compression steel (A_{sc}) and the additional tensile steel (A_{st}).

$$M_{u2} = M_u - M_{u.lim}$$

Step 3. Calculate Area of Tensile Steel (A_{st})

Ast_1 : his is the steel required to develop $M_{u.lim}$. It corresponds to the area of steel in a balanced singly reinforced section.

$$A_{st1} = \frac{0.36 . fck. b. xu, lim}{0.87. fy}$$

Ast $_2$: This is the steel required to resist the excess moment M_{u2}

$$A_{st2} = \frac{M_{u2}}{0.87. fy. (d - d')}$$

Total Tensile Steel:

$$A_{st} = A_{st1} + A_{st2}$$

Step 4. Calculate Area of Compression Steel (A_{sc})

The compression steel area (**A_{sc}**) is required to resist the moment Mu_2 The required force in the compression steel is equated to the compressive force of the additional tension steel A_{st2}

Find the **stress in compression steel (F_{sc})**. This stress depends on the strain at the level of compression steel, ε_{sc} , which is a function of $x_{u,lim}$ and d'. Code tables (e.g., Table G in IS 456:2000) or formulas based on the stress-strain curve for steel are used.

The required compression steel area is:

$$A_{sc} = \frac{M_{u2}}{(f_{sc} - 0.446\, f_{ck}). (d - d')}$$

Step 5. Check Minimum and Maximum Steel Reinforcement

Ensure the calculated steel areas comply with code requirements:

Minimum Tensile Steel ($A_{st,min}$)

$$A_{st,min} = \frac{0.85 . b . d}{fy}$$

Maximum Steel $A_{st,} max$:

$$A_{st,max} \leq 0.04. b\ D$$

XI. Conclusions:

XII. Practical Related Questions:

(Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO. Write answers of minimum three questions.)

1. Why is it necessary to provide additional steel in compression when the depth of beam is restricted?
2. Why is the compression reinforcement provided near the top fiber of the beam?
3. In what practical situations (real structures) would you recommend using a doubly reinforced beam?
4. How would you check if the beam tested is under-reinforced, balanced, or over-reinforced?
5. When designing a beam with limited depth (like in a multi-storey frame), why is a doubly reinforced section preferred?

Space to Write Answers

XIII. References / Suggestions for further Reading:

- IS 456:2000 – Plain and Reinforced Concrete - Code of Practice
- IS 875:1987 (Part 1 and 4) – Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures.

XIV. Assessment Scheme:

Sr. No.	Performance Indicators	Weightage
A.	**Process Related (15 marks)**	**60%**
1.	Use of IS 456:2000	20%
2.	Understand design steps	20%
3.	Teamwork and collaboration	20%
B.	**Product Related (10 marks)**	**40%**
4.	Interpretation of given data.	10%
5.	Answers to practical related questions.	10%
6.	Timely submission and addressing identified COs (Completeness, accuracy of suggestions)	20%
C.	**Total marks (25 marks)**	**100%**

Marks Obtained			**Dated sign of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No: 5 Interpret the given working drawing and write reinforcement details along with sizes provided for minimum two structural members.

I. Practical Significance:

Understanding how to read and interpret structural working drawings is crucial for ensuring that steel reinforcement is placed accurately as per design intent. These practical bridges the gap between design documentation and on-site execution by developing the ability to extract bar details, reinforcement sizes, spacing, and placement methods from actual construction drawings. Accurate interpretation prevents construction errors, ensures safety, and maintains the structural integrity of RCC components.

II. Industry/Employer expected outcome(s):

After this practical, Students should be able to:

1. Read and interpret civil/structural working drawings used on construction sites.
2. Identify different types of reinforcement (main bars, distribution bars, stirrups, ties, hooks, laps, etc.).
3. Prepare reinforcement schedules/bar bending schedules (BBS) from drawings.
4. Communicate effectively with site engineers, bar benders, and supervisors using correct technical terminology.
5. Ensure that reinforcement detailing follows IS codes (IS 456:2000, SP-34, IS 2502).

III. Course Level Learning Outcome (COs):

CO1 - Explain the given criteria in relation to RCC and steel structures.

CO2 - Design the reinforced concrete beams for given condition as per IS codes

CO3 - Design the given type of slab for the given edge condition.

CO4 - Design of axially loaded short columns and footings.

IV. Laboratory Learning Outcome (LLO):

LLO 6.1 Use the given data to Design the given cantilever slab and draw reinforcement details.

V. Relevant Affective Domain related Outcome(s):

- Develop discipline and accuracy in reading engineering drawings.
- Demonstrate teamwork and communication skills when discussing details with peers or site staff.
- Show professional responsibility in ensuring correctness of reinforcement information.

VI. Relevant Theoretical Background:

1. Working Drawing:

   A structural working drawing provides detailed dimensions, section details, reinforcement arrangements, and bar schedules necessary for construction.

2. Reinforcement Detailing:

   Detailing specifies:

   - Bar diameters (Ø8, Ø10, Ø12, Ø16, Ø20 mm, etc.)
   - Spacing and arrangement (tension steel, compression steel, stirrups, ties)

- Cover to reinforcement (20–40 mm as per IS 456)
- Lap, anchorage, and bend details (as per IS 2502)

3. Structural Members Commonly Detailed:
   - Beams: Top & bottom longitudinal bars, stirrups for shear.
   - Columns: Longitudinal bars and lateral ties.
   - Slabs: Main reinforcement and distribution bars.
   - Footings: Mesh reinforcement, dowel connections.
4. IS Codes Used:
   - IS 456:2000 — Plain and Reinforced Concrete Code of Practice
   - IS 2502:1963 — Code of Practice for Bending and Fixing of Bars
   - SP 34:1987 — Handbook on Concrete Reinforcement and Detailing

VII. Required resources/equipment:

S.N.	Resource required	Particulars	Quantity
1.	IS 456:2000	Plain and Reinforced Concrete Code of Practice	1 no. per 5 students
2.	IS 2502:1963	Code of Practice for Bending and Fixing of Bars	1 no. each student
3	SP 34:1987	Handbook on Concrete Reinforcement and Detailing	1 no. each student
4	Working Drawing for RCC Structures	Detailed working drawing for RCC work	1 no. each student

VIII. Precautions to be followed:

- Ensure all dimensions and bar diameters are read carefully from the drawing.
- Maintain correct scale and proportion in sketches.
- Verify clear cover and spacing with IS 456 provisions.
- Avoid mixing bars of different diameters without proper laps.
- Check lap and anchorage lengths before finalizing schedule.
- Always use correct symbols and notation for reinforcement.
- Handle bar samples carefully during physical demonstration.

IX. Procedure:

1. Collect suitable working drawing/ Blue print from the site for RCC framed structures
2. Teacher should guide the students regarding of structural drawing and IS 456:2000 provisions of reinforcement details
3. Students should discuss with batch mates to correlate the obtained structural drawing with IS 456:2000 specifications

X. Conclusions:

XI. Practical Related Questions:

(Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO. Write answers of minimum three questions.)

1. What is the purpose of providing reinforcement in concrete members?
2. Define main and distribution reinforcement.
3. What information is generally included in a working drawing?
4. What is a bar bending schedule (BBS) and why is it important?
5. What are the standard covers for beams, slabs, and columns?

<u>Space to Write Answers</u>

XIII. References / Suggestions for further Reading:

- IS 456:2000 – Plain and Reinforced Concrete - Code of Practice

XIV. Assessment Scheme:

Sr. No.	Performance Indicators	Weightage
A.	**Process Related (15 marks)**	**60%**
1.	Identify type of structures	20%
2.	Reading of working drawings	20%
3.	Teamwork and collaboration	20%
B.	**Product Related (10 marks)**	**40%**
4.	Interpretation of given data.	10%
5.	Answers to practical related questions.	10%
6.	Timely submission and addressing identified COs (Completeness, accuracy of suggestions)	20%
C.	**Total marks (25 marks)**	**100%**

Marks Obtained			**Dated sign of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

<u>Practical No. 06</u>: Design a cantilever slab for the given data and draw reinforcement details.

I. Practical Significance:

A **cantilever slab** projects beyond its support and is fixed at the other end (no vertical support under the projection). Cantilever slabs are used for balconies, chajjas (sunshades), canopies, and projecting steps. This practical helps students identify cantilever action, understand the bending & shear demands (negative moment at the fixed end, shear at the support), design the slab using Limit State Method (IS 456:2000), and prepare reinforcement drawings suitable for site placing.

II. Industry/Employer expected outcome(s):

This practical is expected to develop the following skills for the industry identified competency, ***"Identify, design, laying and placing the reinforcement of cantilever slab on the site."***

a. Follow design steps as per IS 456: 2000
b. Know IS specifications for depth and placement of steel reinforcement.

III. Course Level Learning Outcome (COs):

CO3 - Design the given type of slab for the given edge condition.

IV. Laboratory Learning Outcome (LLO):

LLO 6.1: Use the given data to Design the given cantilever slab and draw reinforcement details.

V. Relevant Affective Domain related Outcome(s):

- Maintain precision, clarity, and cleanliness in technical drawings.
- Exhibit effective teamwork and leadership skills in collaborative tasks.

VI. Relevant Theoretical Background:

- Cantilever slab: slab with one end fixed and the other free — bending about the fixed support produces tension at the top face (unlike simply supported slabs where bottom is in tension at midspan).
- For a uniformly distributed load (w per unit width) over a cantilever length L, the maximum bending moment at the fixed support is:

$$M = \frac{w\,l^2}{2}$$

(for service loads for design apply load factors (IS 456: 2000)

$$Mu = 1.5\ x\ M$$

- Main reinforcement is provided at the **top** of the slab (because top face is in tension). Distribution steel runs at right angles (parallel to the support wall) and is normally placed at the bottom.
- Minimum thickness, clear cover, bar spacing, bar diameters and anchorage/hooks must follow IS 456:2000 and IS 13920/IS 1786 (as applicable). Check deflection limits and minimum reinforcement requirements from IS 456.
- Alternate bar-cutting/bending practice (cut/bar bents) and anchorage with hooks/bends are typically used at the fixed end to develop tension.

VII. Required resources/equipment:

Sr. No.	Particulars	Specification	Quantity
1	IS 456: 2000	Plain and Reinforced concrete code of practice	1 no. per 5 students
2	SP 34 - 1987	Handbook on concrete reinforcement and Detailing	1 no. per 5 students

Abbreviations Used:

Ast	- Area of steel	D	- Overall depth	d	- Effective depth
D.L.	-Dead Load	F.F.	- Floor Finish	L	- Span of beam
l	- Effective span	L.L.	-Live Load	M.F.	- Modification Factor
Mu	- Ultimate moment of resistance	t	- Thickness of support	Wu	- Factored Load

VIII. Precautions to be followed:

1. Identify the type of slab from the given working drawing or blue print.
2. Design the identified slab considering IS requirement.
3. Use appropriate cover for reinforcement according to available environmental exposure conditions at site.
4. List of one-way slabs from given working drawing/ blue print is as

IX. Procedure:

1. Collect suitable working drawing/ blue print from the site for a RCC framed building
2. Study the plan and identify the type of slab.
3. Teacher shall prepare four groups for a batch of 20 students.
4. Each group shall design at least one slab.
5. Students should identify the slab type from aspect ratio and design the same as per IS 456: 2000.
6. Use following steps for design:
   a. Take span of slab as shorter side of panel i.e. L = Lx
   b. Determine effective depth required from deflection control [Clause 23.2.1.a]

$$\left(\frac{L}{d}\right) \leq (M.F.x\ basic\ value\ of\ span - depth\ ratio)$$

$$i.e. \qquad d_{req} \geq \frac{L_x}{M.F.x\ 7}$$

$$D_{req} \geq d_{req} + effective\ cover$$

Suggest suitable, practicable overall depth in multiples of 10 mm; say
D Hence provided effective depth

$$d = D - effective\ cover$$

c. Calculate effective span min. of-
Cantilever length in m (Projections)

d. Determine intensity of ultimate u.d. load per m run of slab of strip of width 1m, as

$$W = DL + LL + FF$$

$$Wu = \gamma_f[(density\ of\ RCC\ x\ D) + LLi + FFi]\ x\ 1\ x\ 1, \quad \gamma_f = 1.5$$

$$Wu = 1.5\ [(25\ x\ D) + LLi + FFi]\ x\ 1\ x\ 1$$

e. Determine designed or factored bending moment

using $Mu = \frac{Wu\,(l^2)}{2}$

Determine and Check the required effective depth using,

$$Mu = Mur = Ru_{lim}(bd^2)$$

If provided 'd' is > required 'd' then **ok**

If 'd' is < required 'd', then repeat design step at Sr.No.6 a) to 6 e) as above

f) Determination of tensile steel area (for TOR steel) -

i) Min. steel area in any direction= 0.12% of Ag

ii) Ast_{reqd} to resist Mu with provided 'd' is given by

$$Ast_{reqd} = \frac{0.5\ fck}{fy}\left[1 - \sqrt{\frac{4.6\ x\ M_u}{fck\ bxd^2}}\right] x(b\ x\ d)$$

iii) Assuming suitable bar diameter calculate required spacing using,

$$S_{req} = \frac{1000\ x\ A1}{Ast_{req}}$$

iv) Apply check for maximum spacing [Clause no. 26.3.3.b.1]
i.e. It should be lesser of (3d) or (300 mm)
Hence suggest proper spacing of selected bar diameter.

g) Assume bar diameter for distribution steel as per clause Calculate area of Distribution steel -as per clause....

$$A_{DS} = 0.15\% \; of \; Ag$$

$$A_{DS} = 0.15\% \; x \; b \; x \; D$$

i) Calculate spacing of distribution steel

$$S = \frac{Area \; of \; one \; bar}{A_{DS}} x \; 1000$$

ii) Give check for spacing of distribution steel as per [Clause26.3.3.b.2]

It should not be more than minimum of the following two

1) 5d =

2) 450 mm

Spacing as calculated = -----mm < Minimum of above two = ---- mm

Hence O.K.

h) Check for development length L_d

$$Ld = \frac{0.87 \; x \; fy \; x \; \emptyset}{4. \tau \, . b. d}$$

As per [Clause 26.2.1.1], page no. 43,

$\tau bd =$ for ______ grade concrete

$$M_o = 0.87 \; fy. Ast \frac{(d - fy. Ast)}{fck. b}$$

Factored shear force,

$$V_u = Wu. L$$

Lo= d or 12 ϕ or can be considered as zero

Hence –

$$L_d \; calculated = 1.3 \left[\frac{1.3 \; Mo}{Vu} + L_0\right]$$

Thus provide development length = $\boldsymbol{Ld/3}$ from the face of wall.

Space for Design

X. Results (Summery of Design)

1. Overall depth (D) = ____________mm.
2. Effective depth (d) = ___________mm.
3. Main steel _____ mm Φ bars ____ mm c/c.
4. Dist. steel _____ mm Φ bars ____ mm c/c.

XI. Conclusions:

XII. Practical Related Questions:

(Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO. Write answers of minimum three questions.)

1. What is a cantilever slab and how does it differ from a simply supported one-way slab?
2. Which clause of IS 456 governs development length?
3. State the minimum clear cover required for mild exposure conditions in slabs.
4. Why is shear checked at the support in a cantilever slab?
5. Calculate the required effective depth for a cantilever slab carrying 7 kN/m service load on a 1.3 m projection.
6. Select appropriate bar diameter and spacing to satisfy a requirement of 260 mm^2/m tensile steel.
7. A balcony slab is showing cracks near the fixed end. List three possible structural causes.

Space to Write Answers

XIII. References / Suggestions for further Reading:

- IS 456:2000 – Plain and Reinforced Concrete - Code of Practice
- IS 875:1987 (Part 1 and 4) – Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures.

XIV. Assessment Scheme:

Sr. No.	Performance Indicators	Weightage
A.	**Process Related (15 marks)**	**60%**
1.	Design of slab details	20%
2.	AutoCAD Drawing skills	20%
3.	Teamwork and collaboration	20%
B.	**Product Related (10 marks)**	**40%**
4.	Interpretation of given data.	10%
5.	Answers to practical related questions.	10%
6.	Timely submission and addressing identified COs (Completeness, accuracy of suggestions)	20%
C.	**Total marks (25 marks)**	**100%**

Marks Obtained			Dated sign of Teacher
Process Related (15)	Product Related (10)	Total (25)	

Practical No. 07: Design a one-way simply supported slab for the given data and draw reinforcement details.

I. Practical Significance:

One Way Slab is a slab provided over rectangular panel. It bends in only one direction i.e. along shorter side of rectangular panel and it is supported on supports provided along longer side of rectangular panel. This practical will help the students to identify type of slab and the procedure of design of slabs using Limit State Method along with the knowledge of placing of reinforcement in actual practice.

II. Industry/Employer expected outcome(s):

This practical is expected to develop the following skills for the industry identified competency, ***"Identify, design, laying and placing the reinforcement of one-way slab on the site."***

a) Follow design steps as per IS 456: 2000
b) Know IS specifications for depth and placement of steel reinforcement.

III. Course Level Learning Outcome (COs):

CO3 - Design the given type of slab for the given edge condition.

IV. Laboratory Learning Outcome (LLO):

LLO 7.1: Use the given data to Design the given one way simply supported slab and draw reinforcement details.

V. Relevant Affective Domain related Outcome(s):

- Maintain precision, clarity, and cleanliness in technical drawings.
- Exhibit effective teamwork and leadership skills in collaborative tasks.

VI. Relevant Theoretical Background:

- When the aspect ratio i.e. ratio of longer span to shorter span is greater than two, the slab is designed as spanning one way.
- One way simply supported slab is designed for maximum bending moment at centre of span. The depth of slab is calculated from span to effective depth ratio as per IS: 456:2000. The area of main reinforcement is provided to resist maximum bending moment. The area of distribution steel is calculated to resist temperature and shrinkage stresses. The reinforcement of One way simply supported slab consists of mesh of main steel and distribution steel. In this mesh, main steel is laid parallel to shorter side of rectangular panel (shorter span) and at the bottom position in slab (Due to tension developed at bottom of one-way slab). The distribution steel is laid perpendicular to main reinforcement i.e. parallel to longer side of rectangular panel and above it. Alternate main bars are made bent upon cut bar system is followed. The load of One-Way slab is equally shared by supporting beams which are parallel to longer side of rectangular panel.

VII. Required resources/equipment:

Sr. No.	Particulars	Specification	Quantity
1	IS 456: 2000	Plain and Reinforced concrete code of practice	1 no. per 5 students
2	SP 34 - 1987	Handbook on concrete reinforcement and Detailing	1 no. per 5 students

Abbreviations Used:

Ast	- Area of steel	D	- Overall depth	d	- Effective depth
D.L.	-Dead Load	F.F.	- Floor Finish	L	- Span of beam
l	- Effective span	L.L.	-Live Load	M.F.	- Modification Factor
Mu	- Ultimate moment of resistance	t	- Thickness of support	Wu	- Factored Load

VIII. Precautions to be followed:

1. Identify the type of slab from the given working drawing or blue print.
2. Design the identified slab considering IS requirement.
3. Use appropriate cover for reinforcement according to available environmental exposure conditions at site.
4. List of one-way slabs from given working drawing/ blue print is as

IX. Procedure:

1. Collect suitable working drawing/ blue print from the site for a RCC framed building
2. Study the plan and identify the type of slab.
3. Teacher shall prepare four groups for a batch of 20 students.
4. Each group shall design at least one slab.
5. Students should identify the slab type from aspect ratio and design the same as per IS 456: 2000.
6. Use following steps for design:
   a. Take span of slab as shorter side of panel i.e. L = Lx
   b. Determine effective depth required from deflection control [Clause 23.2.1.a]

$$\left(\frac{L}{d}\right) \leq (M.F. x\ basic\ value\ of\ span - depth\ ratio)$$

$$i.e. \qquad d_{req} \geq \frac{L_x}{M.F. x\ 20}$$

$$D_{req} \geq d_{req} + effective\ cover$$

Suggest suitable, practicable overall depth in multiples of 10 mm; say
D Hence provided effective depth

$$d = D - effective\ cover$$

c. Calculate effective span min. of-

i. centre to centre distance between supports and

ii. $l = L + d$

d. Determine intensity of ultimate u.d. load per m run of slab of strip of width 1m, as

$$W = DL + LL + FF$$

$$Wu = \gamma_f [(density\ of\ RCC\ x\ D) + LLi + FFi]\ x\ 1\ x\ 1, \quad \gamma_f = 1.5$$

$$Wu = 1.5\ [(25\ x\ D) + LLi + FFi]\ x\ 1\ x\ 1$$

e. Determine designed or factored bending moment

using $Mu = \frac{Wu\ (l^2)}{8}$

Determine and Check the required effective depth using,

$$Mu = Mur = Ru_{lim}(bd^2)$$

If provided 'd' is > required 'd' then **ok**

If 'd' is < required 'd', then repeat design step at Sr.No.6 a) to 6 e) as above

i) Determination of tensile steel area (for TOR steel) -

i) Min. steel area in any direction= 0.12% of Ag

ii) Ast_{reqd} to resist Mu with provided 'd' is given by

$$Ast_{reqd} = \frac{0.5\ fck}{fy}\left[1 - \sqrt{\frac{4.6\ x\ M_u}{fck\ bxd^2}}\right] x(b\ x\ d)$$

iii) Assuming suitable bar diameter calculate required spacing using,

$$S_{req} = \frac{1000\ x\ A1}{Ast_{req}}$$

iv) Apply check for maximum spacing [Clause no. 26.3.3.b.1]
i.e. It should be lesser of (3d) or (300 mm)
Hence suggest proper spacing of selected bar diameter.

j) Assume bar diameter for distribution steel as per clause Calculate area of Distribution steel -as per clause....

$$A_{DS} = 0.15\%\ of\ Ag$$

$$A_{DS} = 0.15\% \; x \; b \; x \; D$$

i) Calculate spacing of distribution steel

$$S = \frac{Area\ of\ one\ bar}{A_{DS}} x\ 1000$$

ii) Give check for spacing of distribution steel as per [Clause26.3.3.b.2]

It should not be more than minimum of the following two

1) 5d =

2) 450 mm

Spacing as calculated = -----mm < Minimum of above two = ---- mm

Hence O.K.

k) Check for development length L_d

$$Ld = \frac{0.87\ x\ fy\ x\ \emptyset}{4.\tau\ .b.d}$$

As per [Clause 26.2.1.1], page no. 43,

$\boldsymbol{\tau bd} =$ for ______ grade concrete

$$M_o = 0.87\ fy.Ast \frac{(d - fy.Ast)}{fck.b}$$

Factored shear force,

$$V_u = \frac{Wu.L}{2}$$

Lo= d or 12 ɸ or can be considered as zero

Hence –

$$L_d\ calculated = 1.3 \left[\frac{1.3\ Mo}{Vu} + L_0\right]$$

Thus provide development length = $\boldsymbol{Ld/3}$ from the face of wall.

<u>Space for Design</u>

X. Results (Summery of Design)

1 Overall depth (D) = __________mm.
2 Effective depth (d) = _________mm.
3 Main steel ___ mm Φ bars ____ mm c/c.
4 Dist. steel ___ mm Φ bars ____ mm c/c.

XI. Conclusions:

XII. Practical Related Questions:

(Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO. Write answers of minimum three questions.)

1 Write the functions of main steel.
2 Write the available grades of reinforcing steel in the market.
3 Explain the terms overall depth, effective depth with sketch.
4 State the de-shuttering time for slab as per IS 456:2000 and compare with site practice.
5 Draw reinforcement details for sloping slab. Indicate main and distribution bars.

Space to Write Answers

XIII. References / Suggestions for further Reading:

- IS 456:2000 – Plain and Reinforced Concrete - Code of Practice
- IS 875:1987 (Part 1 and 4) – Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures.

XIV. Assessment Scheme:

Sr. No.	Performance Indicators	Weightage
A.	**Process Related (15 marks)**	**60%**
1.	Design of slab details	20%
2.	AutoCAD Drawing skills	20%
3.	Teamwork and collaboration	20%
B.	**Product Related (10 marks)**	**40%**
4.	Interpretation of given data.	10%
5.	Answers to practical related questions.	10%
6.	Timely submission and addressing identified COs (Completeness, accuracy of suggestions)	20%
C.	**Total marks (25 marks)**	**100%**

Marks Obtained			Dated sign of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No: 8 Design a two-way simply supported slab for the given data and draw reinforcement details.

I. Practical Significance:

Two-Way Slab is a slab panel which bends in both directions. For any type of structure, two-way slabs are designed depending upon identification of slab by adopting certain criteria. This practical will help the students to identify type of slab and understand the procedure of design of slabs using Limit State Method along with the knowledge of placing of reinforcement in actual practice.

II. Industry/Employer expected outcome(s):

This practical is expected to develop the following skills for the industry identified competency, ***"Identify, design, laying and placing the reinforcement of two-way slab on the site."***

a. Follow design steps as per IS 456: 2000
b. Know IS specifications for depth and placement of steel reinforcement.

III. Course Level Learning Outcome (COs):

- **CO3 -** Design the given type of slab for the given edge condition.

IV. Laboratory Learning Outcome (LLO):

- **LLO 8.1** Use the given data to Design the given two way simply supported slab and draw reinforcement details.

V. Relevant Affective Domain related Outcome(s):

1. Maintain precision, clarity, and cleanliness in technical drawings.
2. Exhibit effective teamwork and leadership skills in collaborative tasks.

VI. Relevant Theoretical Background:

Identify the slab to be designed as two-way slab. It depends upon aspect ratio i.e. ratio of longer span to shorter span is less than or equal to two, the slab is designed as spanning two way. Main reinforcement (mid span steel) is placed at bottom in both directions in the form of mesh such that reinforcement parallel to shorter direction is laid first and then over its reinforcement is laid parallel to longer direction is to be laid. Bent up bar or cut bar system is followed in detailing. The load of two slab is supported by all the four supports but not in equal proportion.

VII. Required resources/equipment:

S.N.	Resource required	Particulars	Quantity
1.	Limit State Theory and Design of Reinforced Concrete Structures	Dr. V. L. Shah & Dr. S. R. Karve	1 no. per 5 students
2.	Auto-CAD Software	A2 Size Sheet	1 no. each student

Abbreviations used

Ast	- Area of steel	d	- Effective depth	D	- Overall depth
D.L.	-Dead Load	F.F.	- Floor Finish	L	- Span of beam
l	- Effective span	L.L.	- Live Load	M.F.	- Modification Factor
Mu	- Ultimate moment of Resistance	t	- Thickness of support	Wu	- Factored Load

VIII. Precautions to be followed:

1. Identify the type of slab from the given working drawing or blue print.
2. Design the identified slab considering IS requirement.
3. Use appropriate cover for reinforcement according to available environmental conditions at site.

List of two-way slab from given working drawing/ blue print is as below

IX. Procedure:

1 Collect suitable working drawing/ blue print from the site for a RCC framed building
2 Study the plan and identify the type of slab.
3 Teacher shall prepare four groups for a batch of 20 students.
4 Each group shall design at least one slab.
5 Students should identify the slab type from aspect ratio and design the same as per IS 456: 2000.
6 Use following steps for design:

a. Write down both shorter span (Lx) and longer span (Ly).

b. Using short span, determine overall depth required for deflection control. [Clause 23.2.1.a]

(Lx/D) ≤ (M.F. x basic value of span-depth ratio)

For two-way slab of shorter span up to 3.5 m and loading class up to 3 kN/m^2

Mild steel, Basic value of span to overall depth ratio = 35

For Tor steel, Basic value of span to overall depth ratio = 28

$$\boldsymbol{D_{req} \geq \frac{L_x}{M.F.x\,35}}$$

or

$$\boldsymbol{D_{req} \geq \frac{L_x}{M.F.x\,28}}$$

$$d_{req} \geq D_{req} - effective\ cover$$

Select overall depth in multiples of 10 mm; say D

Hence provided effective depth

$$d = D - effective\ cover$$

c. Calculate effective span
Lx as lesser of
I) Centre to centre dist. between supports **and**
ii) Lx + dx
Ly as lesser of
i. Centre to centre dist. between supports **and**
ii. Ly + dy

d. Determine intensity of ultimate ud.load perm run of slab of strip of width 1m, as

$$W = DL + LL + FF$$

$$Wu = \gamma_f[(density\ of\ RCC\ x\ D)\ +\ LLi\ +\ FFi]\ x\ 1\ x\ 1, \quad \gamma_f\ =\ 1.5$$

$$Wu = 1.5\ [(25\ x\ \ D)\ +\ LLi\ +\ FFi]\ x\ 1\ x\ 1$$

Determine aspect ratio i.e. ratio of *ly* to *lx*

Referring IS 456-2000, Table 27, Appendix D, obtain values of B.M. coefficients

$$\propto_x = \_\ \_\ and\ \propto_y = \_\ \_$$

e. Determine design or factored moment using

$$M_{ux} = \propto_x (w_u {l_x}^2)$$

And

$$M_{ux} = \propto_x (w_u {l_x}^2)$$

Check the required effective depth using, Mu = Mur = $R_{u1im}(bd^2)$
If provided 'dx' is > required 'd' ,then ok
If 'd' is < required 'd', repeat design steps from Sr.No.2

f. Determination of tensile steel area (for TOR steel) -
i. Min. steel area in any direction= $0.12\%\ of\ Ag$

ii. Astx reqd to resist Mux with provided 'dx' is given by

$$Astx_{reqd} = \frac{0.5\ fck}{fy}\left[1 - \sqrt{\frac{4.6\ x\ M_u}{fck\ bxd^2}}\right] x(b\ x\ d_x)$$

Similarly calculate, Asty req to resist Muy with 'dy'

$$Asty_{reqd} = \frac{0.5\ fck}{fy}\left[1 - \sqrt{\frac{4.6\ x\ M_u}{fck\ bxd^2}}\right] x(b\ x\ d_y)$$

iii. Assuming suitable bar diameter calculate required spacing using,

$$S = \frac{1000\ x\ A1}{Ast\ req}$$

iv. Apply check for maximum spacing in both direction[Clause no. 26.3.3.b.1]
i.e. ≤ lesser of (3d) or (300 mm)
Hence suggest proper spacing of selected bar diameter
Spacing as calculated = -----mm < Minimum of above two = ---- mm
Hence O.K.

<u>Space for Design</u>

X. Results (Summery of Design)

1. Overall depth (D) = __________mm.
2. Effective depth (d) = _________mm.
3. Main steel ___ mm Φ bars ____ mm c/c.
4. Dist. steel ___ mm Φ bars ____ mm c/c.

XI. Conclusions:

XII. Practical Related Questions:

(Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO. Write answers of minimum three questions.)

1. Differentiate between One way slab and Two-way slab.
2. Stair slab is designed as __________________slab.
3. Mention the different grades of steel available in the market.
4. State the meaning of two-way restrained slab.
5. State the functions of reinforcement in RCC slab.
6. Draw reinforcement details for a loft slab. Indicate main and distribution bars.

Space to Write Answers

XIII. References / Suggestions for further Reading:

- IS 456:2000 – Plain and Reinforced Concrete - Code of Practice
- IS 875:1987 (Part 1 and 4) – Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures.

XIV. Assessment Scheme:

Sr. No.	Performance Indicators	Weightage
A.	**Process Related (15 marks)**	**60%**
1.	Design Two Way Slab	20%
2.	AutoCAD Drawing skills	20%
3.	Teamwork and collaboration	20%
B.	**Product Related (10 marks)**	**40%**
4.	Interpretation of given data.	10%
5.	Answers to practical related questions.	10%
6.	Timely submission and addressing identified COs (Completeness, accuracy of suggestions)	20%
C.	**Total marks (25 marks)**	**100%**

Marks Obtained			Dated sign of Teacher
Process Related (15)	Product Related (10)	Total (25)	

Practical No: 9 Design the beam for the given data and draw reinforcement details.

I. Practical Significance:

Reinforced concrete beams are horizontal structural elements those are designed to carry transverse loads. The load produces bending moment, shear force and torsion. Basically beam is a flexural member and due to bending, sagging and hogging moments are produced. This causes tension to develop in the beam material. The tension developed is carried by steel bars provided in the beam. The load from slab is transferred to supporting beam and then beam transfers the load to supporting column. This practical will help the students to understand the design procedure of different types of beams considering various IS 456:2000 specification.

II. Industry/Employer expected outcome(s):

This practical is expected to develop the following skills for the industry identified competency, ***"Identify, design and reinforcement detailing of beam on site."***

a. Observation skill.
b. Ability to understand IS 456:2000 specifications for design of beams.
c. Ability to understand design procedure of beam.
d. Ability to understand reinforcement detailing for beam.

III. Course Level Learning Outcome (COs):

CO2 - Design the reinforced concrete beams for given condition as per IS codes

IV. Laboratory Learning Outcome (LLO):

LLO 9.1 Use the given data to Design the beam and draw reinforcement details.

V. Relevant Affective Domain related Outcome(s):

1. Maintain precision, clarity, and cleanliness in technical drawings.
2. Exhibit effective teamwork and leadership skills in collaborative tasks.

VI. Relevant Theoretical Background:

Singly reinforced Beam: A reinforced concrete section having an area of steel on tension side only is known as 'Singly reinforced beam.

Design of beam: It is the procedure resulting in determination of cross-sectional dimensions and reinforcement for a beam for the given span, grade of concrete and steel. The main design criteria under limit state of collapse for design of beams are flexure and shear. The design is required to be checked for bond and deflection.

VII. Required resources/equipment:

S.N.	Resource required	Particulars	Quantity
1.	Limit State Theory and Design of Reinforced Concrete Structures	Dr. V. L. Shah & Dr. S. R. Karve	1 no. per 5 students
2.	Auto-CAD Software	A2 Size Sheet	1 no. each student

Abbreviations used:

Asb	= Area of one bent up bar	Ast	= Area of steel in tension
Asv	= Area of one stirrup	b	= Width of beam
C	= Cover	d	= Effective depth of beam
D	= Overall depth of beam	H	= Height of wall
l	= Span of beam	Ld	= Development length
Mu	= Ultimate moment of resistance	Vu	= Factored shear force
Vue	= Factored shear force resisted by concrete	Vus	= Factored shear force resisted by stirrups
Vus	= Factored shear force resisted by bent up bar		
Wu	= Factored udl	Xu	= Actual depth of Neutral axis

VIII. Precautions to be followed:

Identify the type of beam according to its position from the given working drawing or blue print.

Design the identified beam according to IS 456:2000 specifications.

Use appropriate cover for beam according to environmental conditions at site.

IX. Procedure:

1. Collect suitable working drawing/ blue print from the site for a RCC framed structure.
2. Study the plan and identify the types of beam.
3. Teacher shall prepare a group of four to five students for a batch of students.
4. Each group shall design at least one beam. Preferably teacher should assign the beam supporting the slab which students have designed in experiment no. 20, 21 and 22.For e,g, Students who have designed cantilever slab should design a beam supporting cantilever slab.
5. Use following design steps while designing the beam -

(A) Flexural design of beam:

- **Designation, type and support condition:** From the blue print / working drawing, write the designation of the beam as Bl, B2,.....Bn Also write support conditions as cantilever/ simply supported beam etc.
- **Effective span (le):** According to IS 456:2000- Clause 22.2, page 34

  For simply supported beam

  le = Minimum of (i) __________________ and (ii) ______________________

  For cantilever beam

  le= _______________________
- **Load Analysis:**

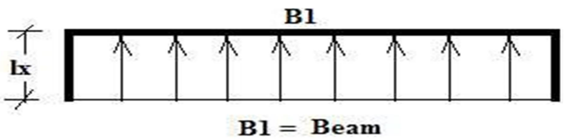
  (a) Ultimate self-weight of beam $W_{u.self} = 1.5 \ x \ \rho_{Rcc} x \ b \ x \ D$

  (Unit weight of RCC ($\boldsymbol{\rho_{Rcc}}$) = 25 kN/m^3, assume b and D.)

  (b) Ultimate slab load (Wu_{slab}): Depending upon whether the beam is supporting a cantilever slab or one way simply supported slab or two-way simply supported slab, load transfer can be calculated as shown below -

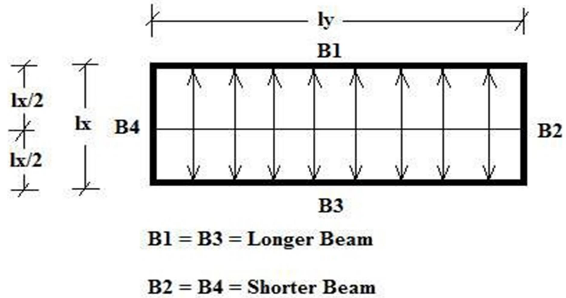
Let - qu = Total ultimate slab load in kN/m^2.

Load transfer from cantilever slab



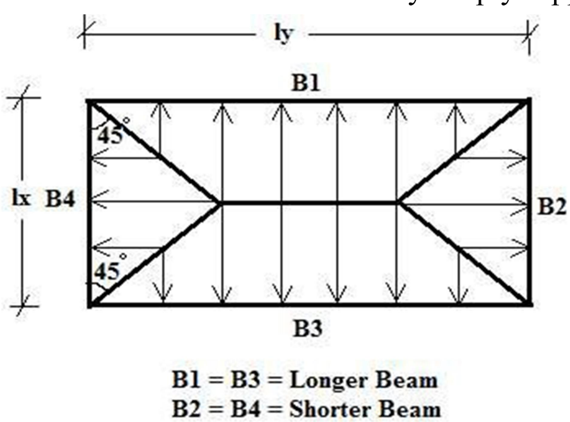
Transfer of load from Cantilever slab

Load transfer from one way simply supported slab



Transfer of load from one way simply supported slab

Load transfer from two way simply supported slab



Transfer of load from two way simply supported slab

(c) Ultimate wall load: Wuwall = 1.5 * masonry * b * **H**

(Pmasonry = Unit weight of masonry, b = Width of wall, H = Clear height of wall)

(d) Calculate total ultimate design load i.e **udl**

Wu = WU-selr + Wu_slab I + Wu_slab 2 + Wuwall

(e) Ultimate load from secondary beams: Calculate support reaction of the supported secondary beam on the beam and show it in the load diagram of the beam.

- **Calculation of bending moment:** Draw load diagram and bending moment diagram of the beam. Hence calculate maximum ultimate bending moment as **(Mu).** If the beam is not supporting a secondary beam, then ultimate bending moment of simply supported beam can be calculated using formula –

$$\mathbf{M} = \frac{W_u \times l_e^2}{8}$$

- Depth required for balanced beam:
  For rectangular beam effective depth for balanced section is calculated as -

$$\boldsymbol{d_{bal}} = \sqrt{\frac{\boldsymbol{m_u}}{\boldsymbol{q_{max} fck.\, b}}}$$

- **Trial depth for flexure:** Provide effective depth 'd' such that d > d_{bal}

- **Provision of overall depth (D):** Calculate effective cover required for the bars provided and hence calculate overall depth of beam. Round off it to next higher multiple of 10 or 25. Hence calculate final value of effective depth provided as'd' and use it in the further calculations.

- **Reinforcement:**

  If $Ast_{reqd} < Ast_{min}$, then $Ast = Ast_{min}$.

  Calculate area of main steel as –

$$\boldsymbol{A}st = \frac{0.5\, fck}{fy}\left[1 - \sqrt{\frac{4.6\, x\, M_u}{fck\ bxd^2}}\right] x(b\ x\ d)$$

Check

$$Ast_{min} = \frac{0.85 \text{ x b x d}}{fy}$$

If $Ast_{reqd} < Ast_{min}$, then $Ast = Ast_{min}$.

- **Provision of bars:** Assuming appropriate bar diameter (0) in mm, calculate number of bars.

$$No\ of\ Bars = \frac{\text{Ast}}{\frac{\pi}{4}\ x\ \emptyset^2}$$

Round off value of no. of bars to next higher integer. Bars to next higher integer.

(B) Concepts and terminology used in design of shear reinforcement in beam

- Ultimate design shear force (Vu)

$$V_u = \frac{W_u\ x\ l}{2}$$

- Nominal shear force (Tv)

$$\tau_v = \frac{V_u}{b\ x\ d} < \tau_{c\ max}$$

- Ultimate shear force resisted by concrete

Bent-up bars not used: Calculate percentage of tension steel as

$$\%\ pt = \frac{Ast}{b\ x\ d} x\ 100$$

Where, Ast= Area of bars available as tension reinforcement near the support.

From Table 19 of IS 456:2000, determine value of Tc. Determine ultimate shear force resisted by concrete as

$$V_{uc} = \tau_c x\ b\ x\ d$$

Bent-up bars used:

$$\%\ pt = \frac{Ast}{b\ x\ d} x\ 100$$

Where, Ast = Area of bars available as tension reinforcement near the support. Here, while calculating Ast, Number of bars = Total number of bars - Number of bent up bars. Hence from Table 19 of IS 456:2000, determine value of 'tc-

Determine ultimate shear force resisted by concrete.

$$V_{uc} = \tau_c x\ b\ x\ d$$

- Ultimate shear force for which shear reinforcement is required (V_{us}) :

$$V_{us} = V_u - V_{uc}$$

- Ultimate shear force resisted by one bent-up bar (V_{usb}):

$$V_{usb} = .87\ x\ fy\ xA_{sb}\ x\ sin \propto > \frac{V_{us}}{2}$$

Where, Asb = Area of one bent up bar.

- Ultimate shear to be resisted by vertical stirrups (Vusv):
- $\boldsymbol{V_{usb} = V_{us} - V_{usb}}$

- Steps for design of shear reinforcement in beam:

(a) If $\tau_v < \tau_c$
Minimum shear stirrups are sufficient. Hence provide minimum shear stirrups at spacing of-

$$S = \frac{0.87\ x\ fy\ xA_{sv}\ x\ d}{0.4\ x\ b}$$

Where,

$$A_{sv} = \frac{2\ x\ \pi\ x\ \emptyset^2}{4}$$

for two legged stirrups of diameter Ø mm.

(b) If $\tau_v > \tau_c$
Minimum shear stirrups are not sufficient. In this case, shear reinforcement is required to be designed. Calculate spacing of two legged stirrups as -

$$S = \frac{0.87\ x\ fy\ xA_{sv}\ x\ d}{V_{usv}}$$

Where,

$$A_{sv} = \frac{2\ x\ \pi\ x\ \emptyset^2}{4}$$

for two legged stirrups of diameter Ø mm.

- **Check for spacing of shear stirrups:** Distance between successive stirrups shall not be more than lesser of the two values (0.75 x d) or 300 mm. Where d = effective depth of beam.

(a) Check for development length: Calculate development length -

$$L_d = \frac{0.87\ x\ fy\ x\ \emptyset}{4\ x\ \tau\ _{bd}}$$

Take values of $\tau\ _{bd}$ from Clause 26.2.1.1, page 43 of IS 456:2000.

Check whether,

$$= \frac{1.3\ x\ M_u}{V\ _u} > L_d$$

Space for Design

X. Results (Summery of Design)

1. Size of beam -
   b = ________________mm and
   D= ________________mm
   d = ________________mm.
2. Main steel
   Dia. of bar (0) = _______mm and
   No. of bars= _______
3. Stirrups
   Dia. of stirrup= ___________mm and
   spacing of stirrup = ___________mm c/c.

XI. Conclusions:

XII. Practical Related Questions:

(Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO. Write answers of minimum three questions.)

1. Calculate ultimate self- weight per meter of a rectangular beam of overall size - b = ______________________ mm and D = ________________ mm.

(Teacher should provide values of b and D.)

2. Preferably width of beam is taken as wall thickness. Justify your answer.
3. Calculate effective span of beam having clear span (1) = ____________________mm, effective depth (d) = ____________________ mm and supporting wall thickness = ____mm.
   (Teacher should provide values of, d and wall thickness.)
4. Calculate ultimate wall load of a 230 mm thick masonry wall for a clear height of m. *(Teacher should provide height of wall.)*
5. Calculate ultimate shear force resisted by concrete if beam size is 230 mm x 450 mm effective. Take span of beam as 6 m and it is reinforced with 4 bars of 20 mm diameter. Use M20 concrete and Fe 415 steel.

<u>Space to Write Answers</u>

XIII. References / Suggestions for further Reading:

- IS 456:2000 – Plain and Reinforced Concrete - Code of Practice
- IS 875:1987 (Part 1 and 4) – Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures.

XIV. Assessment Scheme:

Sr. No.	Performance Indicators	Weightage
A.	**Process Related (15 marks)**	**60%**
1.	Design of Beam	20%
2.	AutoCAD Drawing skills	20%
3.	Teamwork and collaboration	20%
B.	**Product Related (10 marks)**	**40%**
4.	Interpretation of given data.	10%
5.	Answers to practical related questions.	10%
6.	Timely submission and addressing identified COs (Completeness, accuracy of suggestions)	20%
C.	**Total marks (25 marks)**	**100%**

Marks Obtained			**Dated sign of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 10 : Design an axially loaded Square column for the given data and draw reinforcement details.

I. Practical Significance:

A reinforced concrete column is a structural member designed to carry compressive loads. The column takes load from beams and transfers it safely to the foundation. For design purposes, the columns are classified into two categories depending upon the slenderness ratio as short column and long (slender) column. This practical will help the students to understand the design procedure of axially loaded short column by considering various clauses of IS 456:2000.

II. Industry/Employer expected outcome(s):

This practical is expected to develop the following skills for the industry identified competency, ***"Identify, design and reinforcement detailing of column on site."***

a. Observation skill.
b. Ability to understand IS 456:2000 specifications for design of column.
c. Ability to understand design procedure of column.
d. Ability to understand reinforcement detailing for column.

III. Course Level Learning Outcome (COs):

CO4 - Design of axially loaded short columns and footings.

IV. Laboratory Learning Outcome (LLO):

LLO 10.1 Use the given data to Design one axially loaded Square column and draw reinforcement details.

V. Relevant Affective Domain related Outcome(s):

- Maintain precision, clarity, and cleanliness in technical drawings.
- Exhibit effective teamwork and leadership skills in collaborative tasks.

VI. Relevant Theoretical Background:

Column: In reinforced concrete construction, a compression member having its effective length greater than three times its least lateral dimension is defined as column.

Slenderness Ratio: The ratio of effective length to the corresponding lateral dimension is called as slenderness ratio.

Classification of column on the basis of slenderness ratio: The columns are classified as short column or long column depending upon the slenderness ratio.

- **Short column:** A column is considered to be short when both of the slenderness ratio le/D and le/b are less than 12.
- **Long column:** A column is considered to be long if any one or both of the ratio le/D and le/bare greater than 12.

Reinforcement in column: Longitudinal and lateral reinforcement is provided in column.

- **Longitudinal / Main reinforcement:** These are the bars parallel to the longitudinal axis of column.
- **Transverse reinforcement / Links:** It is provided in the form of lateral ties i.e. links.

VII. Required resources/equipment:

Sr. No.	Particulars	Specification	Quantity
1	IS 456:2000	Plain and Reinforced concrete code of practice	1 No. per 5 Students
2	SP 34 - 1987	Handbook on concrete reinforcement and Detailing	1 No. per 5 Students

Abbreviations used:

Ag = Gross area of column   Ac = Area of concrete

Ase = Area of steel in compression

b = Shorter side of column   D = Longer side of column

e_{min} = Minimum eccentricity e_{max} = Maximum eccentricity

L = Unsupported length of column   Le = Effective length of column

VIII. Precautions to be followed:

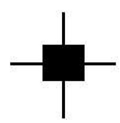
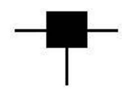
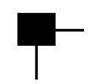
1. Identify the type of column according to its position from the given working drawing or blue print.
2. Design the identified column according to IS 456:2000 specifications.
3. Use specified cover for column according to environmental exposure conditions at site.

IX. Procedure:

1. Collect suitable working drawing/ blue print from the site for a RCC framed structure.
2. Study the plan and identify the type of short column based on their positions.
3. Teacher shall prepare a group of four to five students for a batch of students.
4. Each group shall design at least one column based on their positions.
   For e,g, column supporting two beams (comer column), three beams and four beams
5. Use following design steps while designing the column-
   (A) Estimation of equivalent axial load on column Column is subjected to loads that includes -

   • Ultimate shear transferred by beams that rest on the column i.e. Vu from experiment no. 23. (reaction of different beams supporting column).

- Self-weight of column *(teacher should provide suitable size).*
- Ultimate self-weight= 1.5(ρ*Volume) = 1.5 { ρ * (b * d * Height of column)}
- Calculate total load carried by specific column.
- Obtain equivalent axial load by adopting multiplication factor given below, which depends upon position of column within structure in plan.

Interior Column	Side Column	Comer Column
		
1.1 to 1.15	1.25 to 1.3	1.4 to 1.5
Increase load by 10 to 15 %	Increase load by 25 to 30 %	Increase load by 40 to 50 %

- Total load carried by specific column
  = (Factored shear force from beams+ Self weight of column)
  * Percentage by which load is to be increased according to position of column

(B) Design of axially loaded short column

- Column No. -
- Equivalent ultimate axial load
- Unsupported height/ length of column
- Assumed % of Asc
- Area of concrete Ag

(C) Calculation of Area, Ag and Asc

- Size of column
  (Pu) = ______kN
  (L) = ______m
  (Asc) = 1% of Ag = _Ag
  (Ac) = Ag-Asc = Ag - (_ Ag) =
  Assuming column is subjected to minimum eccentricity.
  Using,

Determine Ag required.

Let, one side of column = b = width of wall

Therefore, obtain other side required using, $d = \frac{\text{Ag required}}{b}$

Suggest suitable size = b * d of column.

- Longitudinal Steel

Based on required Ag and assumed % of Asc, calculate Asc required.
Check for minimum Asc = 0.8 % of Ag
Select combination of number and diameter of bars such that provided Asc provided >Asc required.
(Number of bars in a column is always even, minimum bar diameter = 12 mm, minimum number of bars for rectangular columns= 4 numbers.)

Accordingly, suggest diameter and number of longitudinal bars.

- Transverse steel i.e. Lateral ties

i) Diameter of bar used for lateral ties shall be more than greater of -

(1/4 of larger diameter of main bar) and 5 mm

ii) Pitch or spacing of ties shall not be more than - lesser of

Least lateral dimension of column 16 * smaller diameter of main bar 300mm

Hence, suggest pitch and diameter of lateral ties.

(D) Check for minimum eccentricity

Every column is designed for certain minimum eccentricity.

1) Actual emin is taken as

$$\boldsymbol{e\ min} = \frac{\boldsymbol{L}}{\boldsymbol{500}} + \frac{\boldsymbol{D}}{\boldsymbol{30}}$$

but subjected to minimum 20 mm

2) Permissible minimum eccentricity is 5 % of least lateral dimension of column
i.e. permissible e_{min} = 5 %
if actual emin ≤ Permissible e_{min}
Then ok.

Space for Design

X. Results (Summery of Design)

1. Size of column -
   b = ______________mm
   and D= __________mm.

2. Longitudinal / Main steel
   Dia. of bar (0) = _________mm
   and No. of bars _________

3. Transverse steel
   Dia. of links _________mm
   and Spacing of links = _____mm
   c/c.

XI. Conclusions:

XII. Practical Related Questions:

(Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO. Write answers of minimum three questions.)

1. Differentiate between short and long column.
2. Identify whether column is short or long for following data -
   b = __________mm, D = ___________mm and le =___________________ mm.
   (Teacher should provide values of b, D and le.)

3. Calculate self weight of column, if dimensions of column are b = ____________ mm, D = _mm and height of column = _____________mm.
   (Teacher should provide dimensions and height of column.)
4. Write function of longitudinal reinforcement in column.
5. Write function of transverse reinforcement in column.

Space to Write Answers

XIII. References / Suggestions for further Reading:

- IS 456:2000 – Plain and Reinforced Concrete - Code of Practice
- IS 875:1987 (Part 1 and 4) – Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures.

XIV. Assessment Scheme:

Sr. No.	Performance Indicators	Weightage
A.	**Process Related (15 marks)**	**60%**
1.	Identify and draw column details	20%
2.	AutoCAD Drawing skills	20%
3.	Teamwork and collaboration	20%
B.	**Product Related (10 marks)**	**40%**
4.	Interpretation of given data.	10%
5.	Answers to practical related questions.	10%
6.	Timely submission and addressing identified COs (Completeness, accuracy of suggestions)	20%
C.	**Total marks (25 marks)**	**100%**

Marks Obtained			**Dated sign of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 11 : Design an axially loaded Rectangular column for the given data and draw reinforcement details.

I. Practical Significance:

A reinforced concrete column is a structural member designed to carry compressive loads. The column takes load from beams and transfers it safely to the foundation. For design purposes, the columns are classified into two categories depending upon the slenderness ratio as short column and long (slender) column. This practical will help the students to understand the design procedure of axially loaded short column by considering various clauses of IS 456:2000.

II. Industry/Employer expected outcome(s):

This practical is expected to develop the following skills for the industry identified competency, ***"Identify, design and reinforcement detailing of column on site."***

e. Observation skill.
f. Ability to understand IS 456:2000 specifications for design of column.
g. Ability to understand design procedure of column.
h. Ability to understand reinforcement detailing for column.

III. Course Level Learning Outcome (COs):

CO4 - Design of axially loaded short columns and footings.

IV. Laboratory Learning Outcome (LLO):

LLO 11.1 Use the given data to Design one axially loaded Rectangular column and draw reinforcement details.

V. Relevant Affective Domain related Outcome(s):

- Maintain precision, clarity, and cleanliness in technical drawings.
- Exhibit effective teamwork and leadership skills in collaborative tasks.

VI. Relevant Theoretical Background:

Column: In reinforced concrete construction, a compression member having its effective length greater than three times its least lateral dimension is defined as column.

Slenderness Ratio: The ratio of effective length to the corresponding lateral dimension is called as slenderness ratio.

Classification of column on the basis of slenderness ratio: The columns are classified as short column or long column depending upon the slenderness ratio.

- **Short column:** A column is considered to be short when both of the slenderness ratio le/D and le/b are less than 12.
- **Long column:** A column is considered to be long if any one or both of the ratio le/D and le/bare greater than 12.

Reinforcement in column: Longitudinal and lateral reinforcement is provided in column.

- **Longitudinal / Main reinforcement:** These are the bars parallel to the longitudinal axis of column.
- **Transverse reinforcement / Links:** It is provided in the form of lateral ties i.e. links.

VII. Required resources/equipment:

Sr. No.	Particulars	Specification	Quantity
1	IS 456:2000	Plain and Reinforced concrete code of practice	1 No. per 5 Students
2	SP 34 - 1987	Handbook on concrete reinforcement and Detailing	1 No. per 5 Students

Abbreviations used:

Ag = Gross area of column Ac = Area of

concrete Ase = Area of steel in

compression

b = Shorter side of column D = Longer side of column

e_{min} = Minimum eccentricity e_{max} = Maximum eccentricity

L = Unsupported length of column Le = Effective length of column

VIII. Precautions to be followed:

1. Identify the type of column according to its position from the given working drawing or blue print.
2. Design the identified column according to IS 456:2000 specifications.
3. Use specified cover for column according to environmental exposure conditions at site.

IX. Procedure:

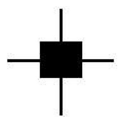
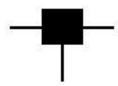
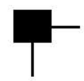
1. Collect suitable working drawing/ blue print from the site for a RCC framed structure.
2. Study the plan and identify the type of short column based on their positions.
3. Teacher shall prepare a group of four to five students for a batch of students.
4. Each group shall design at least one column based on their positions.
   For e,g, column supporting two beams (comer column), three beams and four beams
5. Use following design steps while designing the column-

(E) Estimation of equivalent axial load on column Column is subjected to loads that includes -

- Ultimate shear transferred by beams that rest on the column i.e. Vu from experiment no. 23. (reaction of different beams supporting column).
- Self-weight of column *(teacher should provide suitable size).*

$$Ultimate\ self - weight = 1.5\ (\rho\ x\ Volume\ )$$
$$= 1.5(\rho\ x\ (b\ x\ d\ x\ Height\ of\ column)$$

- Calculate total load carried by specific column.
- Obtain equivalent axial load by adopting multiplication factor given below, which depends upon position of column within structure in plan.

Interior Column	Side Column	Comer Column
		
1.1 to 1.15	1.25 to 1.3	1.4 to 1.5
Increase load by 10 to 15 %	Increase load by 25 to 30 %	Increase load by 40 to 50 %

- Total load carried by specific column
  = (Factored shear force from beams+ Self weight of column)
  * Percentage by which load is to be increased according to position of column

(F) Design of axially loaded short column

- Column No. -
- Equivalent ultimate axial load
- Unsupported height/ length of column
- Assumed % of Ase
- Area of concrete Ag

(G) Calculation of Area, Ag and Asc

- Size of column
  (Pu) = kN
  (L) ___m
  (Ase)= 1% of Ag= __Ag
  (Ac) =Ag-Asc = Ag- Ag) =
  Assuming column is subjected to minimum eccentricity.
  Using,

$$Pu = (0.4\ x\ fck\ x\ Ac) + (0.67x\ fy\ xAsc)$$

Determine Ag required.

Let, one side of column = b = width of wall

Therefore, obtain other side required using, $d = \frac{Ag\ required}{b}$

Suggest suitable size = b * d of column.

- Longitudinal Steel

Based on required Ag and assumed % of Ase, calculate Ase required.
Check for minimum Ase = 0.8 % of Ag
Select combination of number and diameter of bars such that provided Ase provided >Ase required.
(Number of bars in a column is always even, minimum bar diameter = 12 mm, minimum number of bars for rectangular columns= 4 numbers.)

Accordingly, suggest diameter and number of longitudinal bars.

Transverse steel i.e. Lateral ties)

- Diameter of bar used for lateral ties shall be more than greater of -

(1/4 of larger diameter of main bar) and 5 mm

Pitch or spacing of ties shall not be more than - lesser of

Least lateral dimension of column 16 * smaller diameter of main bar 300mm

Hence, suggest pitch and diameter of lateral ties.

(H) Check for minimum eccentricity

Every column is designed for certain minimum eccentricity.

1) Actual emin is taken as

$$e\ min = \frac{L}{500} + \frac{D}{30}$$

but subjected to minimum 20 mm

2) Permissible minimum eccentricity is 5 % of least lateral dimension of column
i.e. permissible emin = 5 %
if actual emin ≤ Permissible emin•
Then ok.

Space for Design

X. Results (Summery of Design)

4. Size of column -
   b = ________________mm
   and D= ____________mm.

5. Longitudinal / Main steel
   Dia. of bar (0) = __________mm
   and No. of bars __________

6. Transverse steel
   Dia. of links __________mm
   and Spacing of links = ______mm
   c/c.

XI. Conclusions:

XIII. Practical Related Questions:

(Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO. Write answers of minimum three questions.)

1) Why is it important to check for minimum eccentricity in column design?
2) If a column carries both axial load and bending moment, how does the design approach change?
3) What will happen if the column ties are spaced too far apart?
4) On-site, if the cover to reinforcement is found to be less than required, what action should be taken?
5) Why are rectangular columns often preferred along walls and corners in buildings?
6) How does increasing the grade of concrete affect the column size?

Space to Write Answers

XIII. References / Suggestions for further Reading:

- IS 456:2000 – Plain and Reinforced Concrete - Code of Practice
- IS 875:1987 (Part 1 and 4) – Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures.

XIV. Assessment Scheme:

Sr. No.	Performance Indicators	Weightage
A.	**Process Related (15 marks)**	**60%**
1.	Identify and draw column details	20%
2.	AutoCAD Drawing skills	20%
3.	Teamwork and collaboration	20%
B.	**Product Related (10 marks)**	**40%**
4.	Interpretation of given data.	10%
5.	Answers to practical related questions.	10%
6.	Timely submission and addressing identified COs (Completeness, accuracy of suggestions)	20%
C.	**Total marks (25 marks)**	**100%**

Marks Obtained			**Dated sign of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 12: Design the footing for the axially loaded Square column designed in Sr. no. 10 and draw reinforcement details.

I. Practical Significance: Footing or foundation is a sub-structural component which safely transmits load carried by column to supporting strata without exceeding its safe bearing capacity. Reinforced concrete footings design is based on column loads, moments at base and the soil bearing capacity. If these loads are to be properly transmitted, footings must be designed to transfer the load to soil safely. This practical will help the students to identify type of footing and the procedure of design of footing using Limit State Method along with the knowledge of placing of reinforcement in actual practice.

II. Industry/Employer expected outcome(s):

This practical is expected to develop the following skills for the industry identified competency, ***"Identify, design, laying and placing the reinforcement of isolated column footing on the site."***

a. Follow design steps as per IS 456: 2000
b. Know IS specifications for depth and placement of steel reinforcement.

III. Course Level Learning Outcome (COs):

CO4 - Design of axially loaded short columns and footings.

IV. Laboratory Learning Outcome (LLO):

LLO 12.1 Use the given data to Design footing for axially loaded Square column designed in Sr. no.10 and draw reinforcement details.

V. Relevant Affective Domain related Outcome(s):

- Maintain precision, clarity, and cleanliness in technical drawings.
- Exhibit effective teamwork and leadership skills in collaborative tasks

VI. Relevant Theoretical Background:

Types of column footing

There are different types of column footing classified on the basis of depth of foundation, magnitude of load, bearing capacity of soil and use of structure. The most common types of footings used for concrete structures are Isolated footing, Combined footing, Strap footing, Mat foundation (Raft foundation).

- Different criterion used in design of Column Footing

In the design of column footing its depth is calculated by different considerations which are flexure, one-way shear and two-way action i.e. punching shear.

Flexure consideration - In this consideration the critical section is at the face of column. The depth of footing is determined to resist bending moment at this section due to upward soil pressure acting on shaded area as shown in figure no.(a) . The greatest bending moment is to be used in the design.

One way shear consideration (Wide beam theory) -In this consideration the footing acting essentially as a wide beam, with a potential diagonal crack extending in a plane across the entire width; the critical section for this condition sha11 be assumed as a vertical section located from the face of the column, pedestal or wall at a distance equal to the effective depth of footing. The critical section is taken at a distance 'd' from the face of column as shown in figure no. (b)

Two way shear consideration (Punching shear) - In this consideration central portio of footing is assumed to be punched in while remaining portion is assumed to be lifted upwards due to upward soil pressure. Depth is calculated for resisting this two way shear force. The critical section is taken at a distance 'd/2' around the face of column as shown in figure no. (c)

VII. Required resources/equipment:

Sr. No.	Particulars	Specification	Quantity
1	IS 456:2000	Plain and Reinforced concrete code of practice	1 No. per 5 Students
2	SP 34 - 1987	Handbook on concrete reinforcement and Detailing	1 No. per 5 Students

Abbreviations used:

Af - Area of footing D - Overall depth

Mu - Ultimate moment of resistance Pu _Design axial load

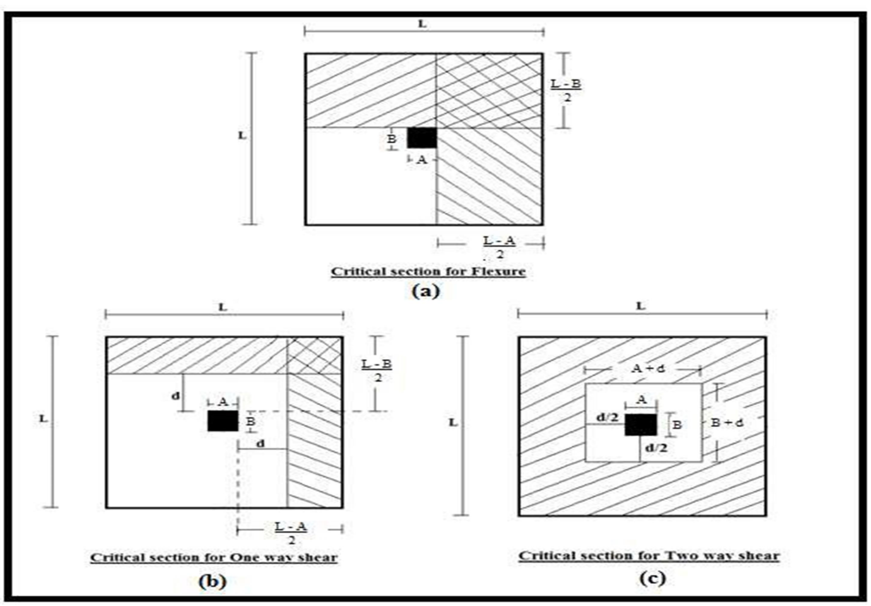
d - Effective depth L - Side of footing

p - Upward soil pressure W - Working load

VIII. Precautions to be followed:

- Select suitable bar diameter for footing.
- Use appropriate cover for reinforcement according to available environmental exposure conditions at site.

IX. Experimental Set-up:



X. Procedure:

1. Collect suitable working drawing/ blue print from the site for a RCC framed building
2. Study the plan and identify the type of footing.
3. Teacher shall divide the batch of 20 students in four groups.
4. Each group shall design at least one footing.
5. Students should identify the footing type and design the same as per IS 456: 2000.
6. Use following steps for design:

a. Design of isolated column footing for Gr. No.

Design axial load for group Pu = ----

Size of column ---------

Assumed SBC of strata = ---

b. Calculation of size of footing

- Factored load (kN) on column,

$$Pu = P \, x \, \gamma f$$

- Determine required area of footing
  (Considering self-weight of footing as 5% or 10% of the factored load on column)

$$\text{Af required} = \frac{1.05\, pu}{qu} \quad or \quad \frac{1.1\, pu}{qu}$$

Where, qu = 2x SBC.

- Assuming square footing, calculate side required as -

  Length of one side= $\sqrt{Af}$ required

  Round off value of Length to next integer on higher side.

  Suggested size of square footing ---------

  Calculate actual Af

- Calculate actual upward soil pressure (p) in kN/m^2= $\frac{Pu}{actual\ Af}$

c. Determination of depth of footing for flexure

- Refer figure (a).
- Determine ultimate bending moments in (kN.m) due to cantilever action along both projections i.e.

$$Mux = 1\, x\, shaded\ area\ x\ upward\ soil\ pressure\ x\ c.g.of\ shaded\ area$$

$$= 1\, x\, \frac{\frac{L-B}{2}\, x\, \rho\, x\, \frac{L-B}{2}}{2}.$$

$$Muy = 1\, x\, shaded\ area\ x\ upward\ soil\ pressure\ x\ c.g.of\ shaded\ area$$

$$= 1\, x\, \frac{\frac{L-B}{2}\, x\, \rho\, x\, \frac{L-B}{2}}{2}.$$

Consider maximum bending moment value of above (Mu).

Determine required effective depth to resist larger moment as a balanced section using,

$$dreqd = \sqrt{\frac{Mu}{Ru.lim\ x\ b}}$$

Considering effective cover

Calculate Dreqd = d reqd + effective cover

Suggest suitable overall depth 'D' (Depth shall be more than 150 mm)

Hence, d provided = D provided - effective cover

d. Check the depth for One way shear

Refer figure (b).

$$\tau_v \leq k_s \tau_c$$

Where, ks= 0.5 + βc but $\ngtr$ 1

$\boldsymbol{\beta}$c = Longer side of column / Shorter side of column

$\tau_c = 0.25\sqrt{fck}$

$\tau_v = \tau_c$

Convert $\boldsymbol{\tau_v}$ in kN/m^2.

Draw plan of footing showing size of footing, size of column and mark critical section for one way shear.

Calculate projections of footing beyond critical section for one way shear action in both directions. Consider greater of these.

Consider 1m width of footing slab for provided 'd';

Shear force on shaded area,

$$Vu = Lx\frac{L-B}{2} - d\ x\ p \text{------------ (i)}$$

Shear resisted by concrete

$Vu = \tau_c(b * d)$…………….. (ii)

Equating equation (i) and (ii), calculate 'd'.

Depth calculated for one way shear < Depth calculated for flexure.

e. Check the depth for Two way shear

Refer figure (c).

Draw plan of footing showing size of footing, size of column and mark critical section for two way shear.

Shear force on shaded area, $Vu = L^2 - [(A + d)\ (B + d)]\ x\ p$ - (iii)

Calculate, $b = 2(A + d) + 2(B + d)$

Shear resisted by concrete

$$Vu = \tau_c(b * d) \text{ …………….(iv)}$$

Equating equation (iii) and (iv), calculate 'd'.

Depth calculated for two way shear < Depth calculated for flexure.

f. Find area of steel and number of bars to be provided.

Ast $_{req}$ to resist Mu with provided 'd' is given by

$$Ast_{req} = \frac{0.5\,fck}{fy}\ x\left[1-\sqrt{1-\frac{4.6\ x\ Mu}{fck\ bd^2}}\right] x\ (b\ x\ d)$$

Assuming suitable bar diameter calculate required spacing using,

$$Sp_{req} = \frac{1000\ x\ A1}{Ast_{req}}$$

g. Development length L_d

$$L_d = \frac{0.87.\,fy\,.\,\emptyset}{4\,.\,\tau_{bd}}$$

Space for Design

XI. Results (Summery of Design)

1. Size of footing =

2. Overall depth D =
3. Effective depth d =
4. Steel in x-x direction ___ mm Ø bars @____ mm c/c
5. Steel in y-y direction ___ mm Ø bars @____ mm c/c

XII. Conclusions:

XIII. Practical Related Questions:

(Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO. Write answers of minimum three questions.)

1. Enlist various types of footings.
2. Depth of foundation depends on the nature of
3. Write the situation when combined footing is used.
4. Write three criteria on which depth of footing is based.
5. State the function of footing or foundation.
6. State when raft foundation is provided.
7. Sketch the critical sections used in the design of pad footings for bending.
8. Sketch the critical sections used in the design of pad footings for shear.
9. The minimum bar diameter used for footing reinforcement is ________

Space to Write Answers

XIII. References / Suggestions for further Reading:

- IS 456:2000 – Plain and Reinforced Concrete - Code of Practice
- IS 875:1987 (Part 1 and 4) – Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures.

XIV. Assessment Scheme:

Sr. No.	Performance Indicators	Weightage
A.	**Process Related (15 marks)**	**60%**
1.	Design and draw Footing details	20%
2.	AutoCAD Drawing skills	20%
3.	Teamwork and collaboration	20%
B.	**Product Related (10 marks)**	**40%**
4.	Interpretation of given data.	10%
5.	Answers to practical related questions.	10%
6.	Timely submission and addressing identified COs (Completeness, accuracy of suggestions)	20%
C.	**Total marks (25 marks)**	**100%**

Marks Obtained			Dated sign of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

<u>Practical No. 13</u>: Design the footing for the axially loaded rectangular column designed in Sr. no. 11 and draw reinforcement details.

I. Practical Significance: Footing or foundation is a sub-structural component which safely transmits load carried by column to supporting strata without exceeding its safe bearing capacity. Reinforced concrete footings design is based on column loads, moments at base and the soil bearing capacity. If these loads are to be properly transmitted, footings must be designed to transfer the load to soil safely. This practical will help the students to identify type of footing and the procedure of design of footing using Limit State Method along with the knowledge of placing of reinforcement in actual practice.

II. Industry/Employer expected outcome(s):

This practical is expected to develop the following skills for the industry identified competency, ***"Identify, design, laying and placing the reinforcement of isolated column footing on the site."***

c. Follow design steps as per IS 456: 2000
d. Know IS specifications for depth and placement of steel reinforcement.

II. Course Level Learning Outcome (COs):

CO4 - Design of axially loaded short columns and footings.

III. Laboratory Learning Outcome (LLO):

LLO 13.1 Use the given data to Design footing for axially loaded Rectangular column designed in Sr. no.10 and draw reinforcement details.

IV. Relevant Affective Domain related Outcome(s):

- Maintain precision, clarity, and cleanliness in technical drawings.
- Exhibit effective teamwork and leadership skills in collaborative tasks

V. Relevant Theoretical Background:

Types of column footing

There are different types of column footing classified on the basis of depth of foundation, magnitude of load, bearing capacity of soil and use of structure. The most common types of footings used for concrete structures are Isolated footing, Combined footing, Strap footing, Mat foundation (Raft foundation).

- Different criterion used in design of Column Footing

In the design of column footing its depth is calculated by different considerations which are flexure, one-way shear and two-way action i.e. punching shear.

Flexure consideration - In this consideration the critical section is at the face of column. The depth of footing is determined to resist bending moment at this section due to upward soil pressure acting on shaded area as shown in figure no.(a) . The greatest bending moment is to be used in the design.

One way shear consideration (Wide beam theory) -In this consideration the footing acting essentially as a wide beam, with a potential diagonal crack extending in a plane across the entire width; the critical section for this condition sha11 be assumed as a vertical section located from the face of the column, pedestal or wall at a distance equal to the effective depth of footing. The critical section is taken at a distance 'd' from the face of column as shown in figure no. (b)

Two way shear consideration (Punching shear) - In this consideration central portio of footing is assumed to be punched in while remaining portion is assumed to be lifted upwards due to upward soil pressure. Depth is calculated for resisting this two way shear force. The critical section is taken at a distance 'd/2' around the face of column as shown in figure no. (c)

VI. Required resources/equipment:

Sr. No.	Particulars	Specification	Quantity
1	IS 456:2000	Plain and Reinforced concrete code of practice	1 No. per 5 Students
2	SP 34 - 1987	Handbook on concrete reinforcement and Detailing	1 No. per 5 Students

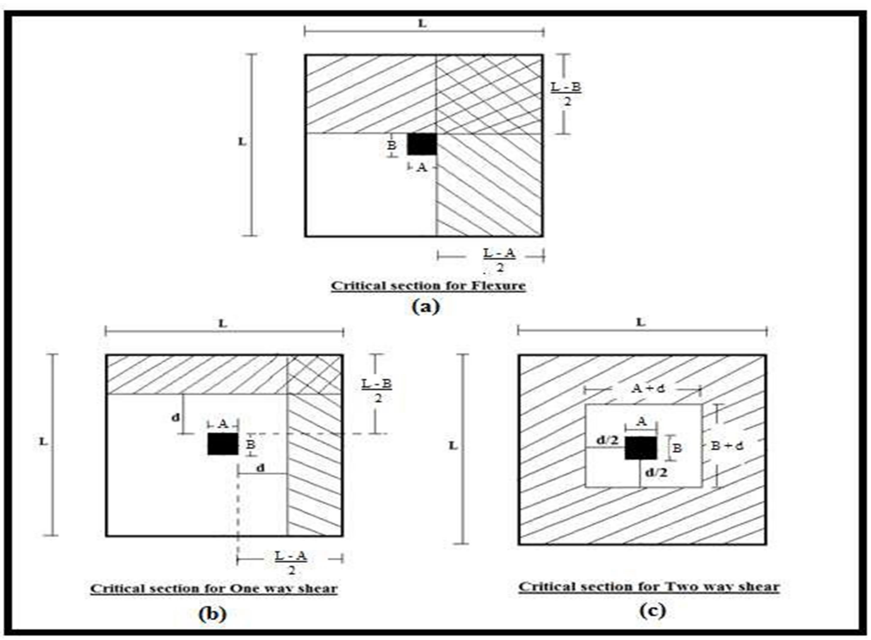
Abbreviations used:

Af - Area of footing
Mu - Ultimate moment of resistance
d - Effective depth
p - Upward soil pressure
D - Overall depth
Pu _Design axial load
L - Side of footing
W - Working load

VII. Precautions to be followed:

- Select suitable bar diameter for footing.
- Use appropriate cover for reinforcement according to available environmental exposure conditions at site.

VIII. Experimental Set-up:



IX. Procedure:

1. Collect suitable working drawing/ blue print from the site for a RCC framed building
2. Study the plan and identify the type of footing.
3. Teacher shall divide the batch of 20 students in four groups.
4. Each group shall design at least one footing.
5. Students should identify the footing type and design the same as per IS 456: 2000.
6. Use following steps for design:

a. Design of isolated column footing for Gr. No.

Design axial load for group Pu = ----

Size of column ---------

Assumed SBC of strata = ---

b. Calculation of size of footing

- Factored load (kN) on column,

$$Pu = P \; x \; \gamma f$$

- Determine required area of footing

(Considering self-weight of footing as 5% or 10% of the factored load on column)

$$\text{Af required} = \frac{\mathbf{1.05}\, \boldsymbol{pu}}{\boldsymbol{qu}} \quad \boldsymbol{or} \quad \frac{\mathbf{1.1}\, \boldsymbol{pu}}{\boldsymbol{qu}}$$

Where, qu = 2x SBC.

- Assuming square footing, calculate side required as -

Length of one side= $\sqrt{Af}$ required

Round off value of Length to next integer on higher side.

Suggested size of rectangular footing (B x D) ------

Calculate actual Af

- Calculate actual upward soil pressure (p) in kN/m^2= $\dfrac{\boldsymbol{Pu}}{\boldsymbol{actual\ Af}}$

c. Determination of depth of footing for flexure

- Refer figure (a).
- Determine ultimate bending moments in (kN.m) due to cantilever action along both projections i.e.

$$Mux \; = \; 1 \; x \; shaded \; area \; x \; upward \; soil \; pressure \; x \; c.g. of \; shaded \; area$$

$$= \; 1 \; x \; \frac{\frac{L-B}{2} \; x \; \rho \; x \; \frac{L-B}{2}}{2}.$$

$$Muy \; = \; 1 \; x \; shaded \; area \; x \; upward \; soil \; pressure \; x \; c.g. of \; shaded \; area$$

$$= \; 1 \; x \; \frac{\frac{L-B}{2} \; x \; \rho \; x \; \frac{L-B}{2}}{2}.$$

Consider maximum bending moment value of above (Mu).

Determine required effective depth to resist larger moment as a balanced section using,

$$dreqd = \sqrt{\frac{Mu}{Ru.lim\ x\ b}}$$

Considering effective cover

Calculate D_{req} = d_{req} + effective cover

Suggest suitable overall depth 'D' (Depth shall be more than 150 mm)

Hence, d provided = D provided - effective cover

d. Check the depth for One way shear

- Refer figure (b).

$$\tau_v \le k_s \tau_c$$

Where, ks= 0.5 + βc but $\ngtr$ 1

$\boldsymbol{\beta}$c = Longer side of column / Shorter side of column

$\tau_c = 0.25\sqrt{fck}$

$\tau_v = \tau_c$

Convert $\boldsymbol{\tau_v}$ in kN/m^2.

- Draw plan of footing showing size of footing, size of column and mark critical section for one way shear.
- Calculate projections of footing beyond critical section for one way shear action in both directions. Consider greater of these.
- Consider 1m width of footing slab for provided 'd';

  Shear force on shaded area,

  $$Vu = Lx\,\frac{L-B}{2} - d\ x\ p \text{ ------------ (i)}$$

  Shear resisted by concrete

  $Vu = \tau_c(b * d)$................ (ii)

- Equating equation (i) and (ii), calculate 'd'.
- Depth calculated for one way shear < Depth calculated for flexure.

e. Check the depth for Two way shear

- Refer figure (c).
- Draw plan of footing showing size of footing, size of column and mark critical section for two way shear.
- Shear force on shaded area, $Vu = L^2 - [(A+d)\,(B+d)]\ x\ p$ - (iii)
- Calculate, $b = 2(A+d) + 2(B+d)$
- Shear resisted by concrete

  $$Vu = \tau_c(b * d) \text{ ....(iv)}$$

- Equating equation (iii) and (iv), calculate 'd'.
- Depth calculated for two way shear < Depth calculated for flexure.

f. Find area of steel and number of bars to be provided.

Ast $_{req}$ to resist Mu with provided 'd' is given by

$$Ast_{req} = \frac{0.5\, fck}{fy}\ x \left[1 - \sqrt{1 - \frac{4.6\ x\ Mu}{fck\ bd^2}}\right] x\ (b\ x\ d)$$

Assuming suitable bar diameter calculate required spacing using,

$$Sp_{req} = \frac{1000\ x\ A1}{Ast_{req}}$$

g. Development length L_d

$$L_d = \frac{0.87.\, fy\, .\, \emptyset}{4\, .\, \tau_{bd}}$$

<u>Space for Design</u>

X. Results (Summery of Design)

1. Size of footing =
2. Overall depth D =
3. Effective depth d =
4. Steel in x-x direction ___ mm Φ bars @___ mm c/c
5. Steel in y-y direction ___ mm Φ bars @___ mm c/c

XI. Conclusions:

XII. Practical Related Questions:

(Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO. Write answers of minimum three questions.)

1) Why is it necessary to check for punching shear in footing design?
2) What are the consequences of providing insufficient reinforcement in a footing?
3) How can we prevent uneven settlement of footings?
4) Why is the thickness of footing usually more at the center and less at the edges?
5) What type of footing is preferred when two columns are closely spaced?
6) What precautions should be taken while placing concrete in footing trenches?
7) How does water table level influence footing design and placement?
8) What happens if the soil under one side of the footing is weaker than the other side?

Space to Write Answers

XIII. References / Suggestions for further Reading:

- IS 456:2000 – Plain and Reinforced Concrete - Code of Practice
- IS 875:1987 (Part 1 and 4) – Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures.

XIV. Assessment Scheme:

Sr. No.	Performance Indicators	Weightage
A.	**Process Related (15 marks)**	**60%**
1.	Design and draw Footing details	20%
2.	AutoCAD Drawing skills	20%
3.	Teamwork and collaboration	20%
B.	**Product Related (10 marks)**	**40%**
4.	Interpretation of given data.	10%
5.	Answers to practical related questions.	10%
6.	Timely submission and addressing identified COs (Completeness, accuracy of suggestions)	20%
C.	**Total marks (25 marks)**	**100%**

Marks Obtained			**Dated sign of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No: 14 **Draw the reinforcement details for cantilever slab, one way simply supported slab and two way simply supported slab designed in Sr. no. 06 to 08 using Auto-CAD software (A2 Size Sheet).**

I. Practical Significance:

In practical application for building construction, it is crucial to comprehend and carry out tasks in accordance with the specifications outlined in the structural drawing. The details provided in the structural drawing are vital for implementing the dimensions of each RCC section and the reinforcement within each RCC section. This practical will assist in reading and interpreting the structural drawing in relation to the design.

II. Industry/Employer expected outcome(s):

This practical is expected to develop the following skills for the industry identified competency, "Ensure precise accuracy in dimensions and material requirements on site."

III. Course Level Learning Outcome (COs):

CO1 - Design the given type of slab for the given edge condition.

IV. Laboratory Learning Outcome (LLO):

LLO 14.1 - Draw the reinforcement details for the given type of slab under specific loading conditions.

V. Relevant Affective Domain related Outcome(s):

- Maintain precision, clarity, and cleanliness in technical drawings.
- Exhibit effective teamwork and leadership skills in collaborative tasks.

VI. Relevant Theoretical Background:

- Structural drawings are crucial for implementing the correct dimensions and reinforcement specifications for each RCC section. The reinforcement detailing of a slab depends on its support conditions—whether it is supported by walls, beams, or columns.
- In cantilever slabs, the main reinforcement is placed at the top near the fixed support, running parallel to the span, and extended towards the free end. Alternate bars are provided with bends (springs) for additional anchorage.
- In a one-way slab, the main reinforcement is placed parallel to the shorter span, while distribution steel runs along the longer span.
- In a two-way slab, main reinforcement is provided in both directions, as the slab spans and distributes loads in both the shorter and longer spans.

VII. Required resources/equipment:

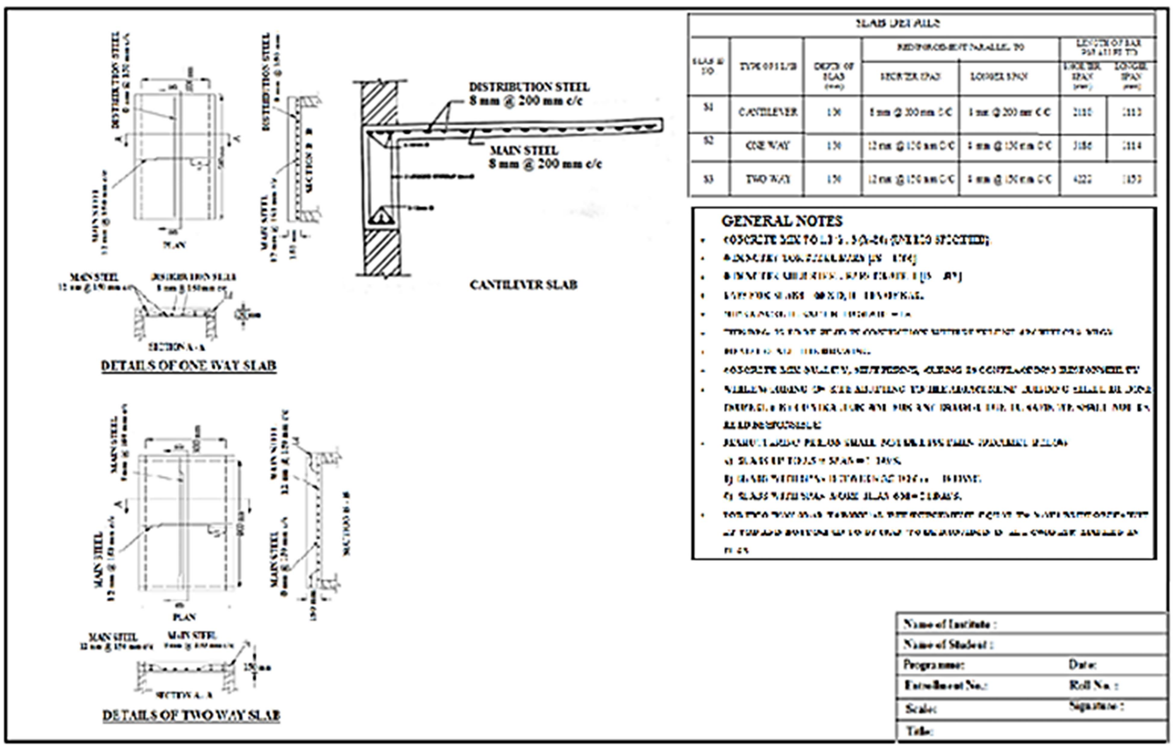
S.N.	Resource required	Particulars	Quantity
1.	Limit State Theory and Design of Reinforced Concrete	Dr. V. L. Shah & Dr. S. R. Karve	1 no. per 5 students

	Structures		
2.	Auto-CAD Software	A2 Size Sheet	1 no. each student

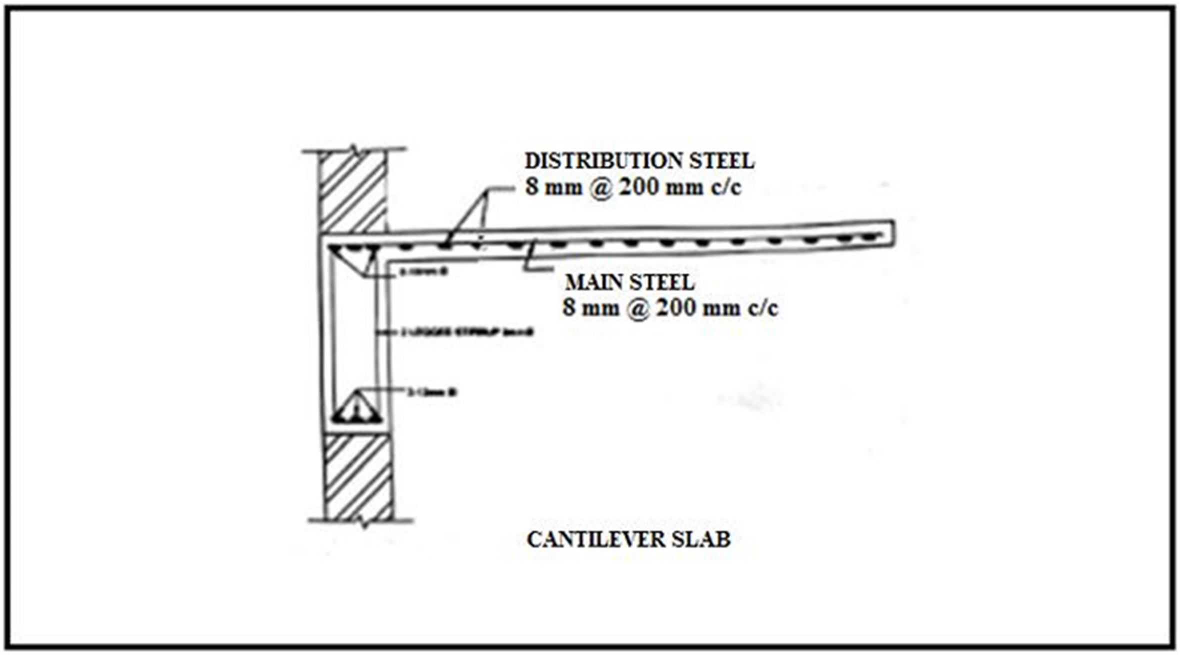
VIII. Precautions to be followed:

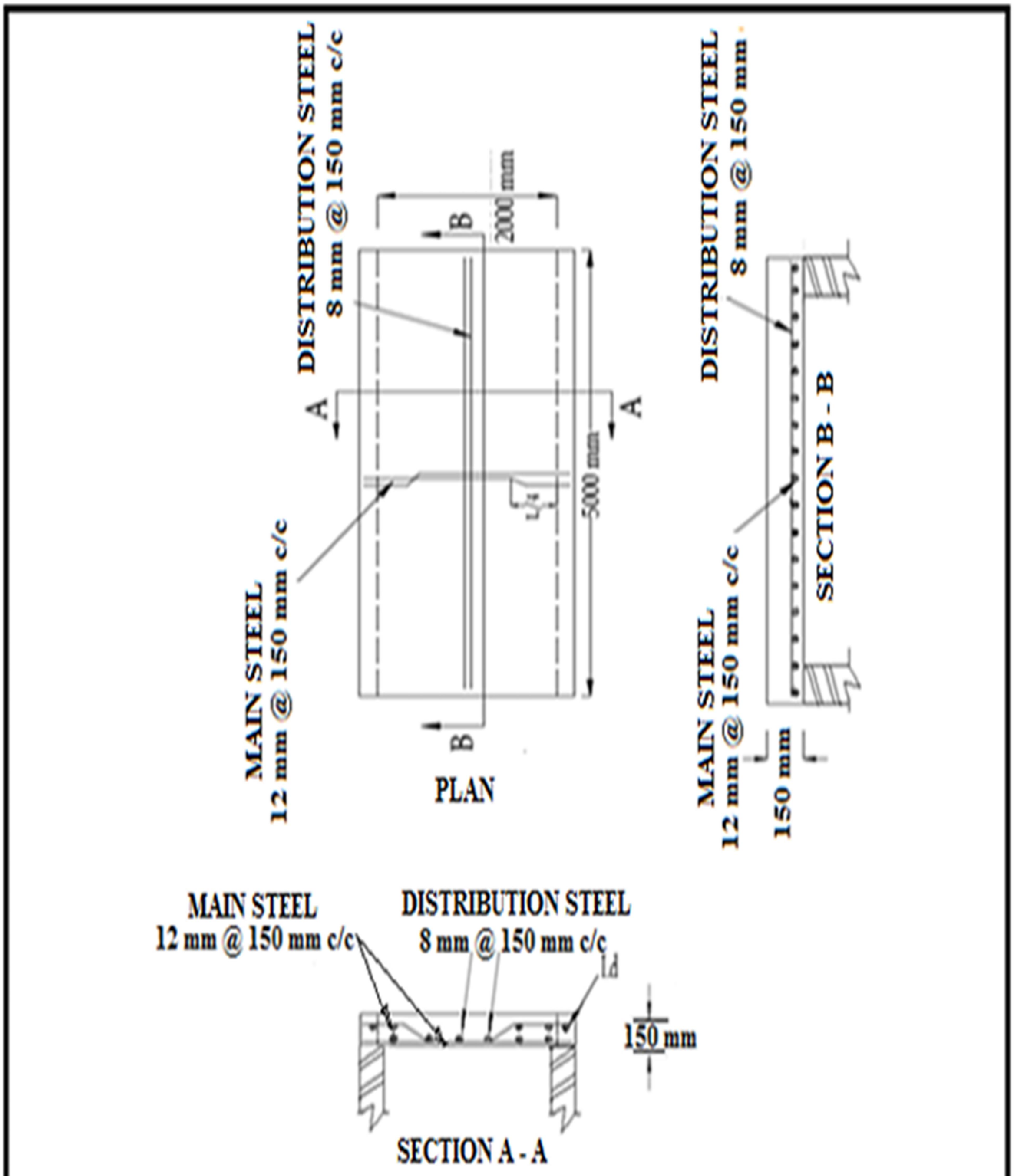
- Identify the correct type of slab based on support and span.
- Draw neat, scaled sketches with proper font size for labelling.
- Double-check dimensions and reinforcement details.
- Use standard symbols as per IS 456:2000.
- Keep drawings precise and easy to read.

XII. Experimental Set-up:

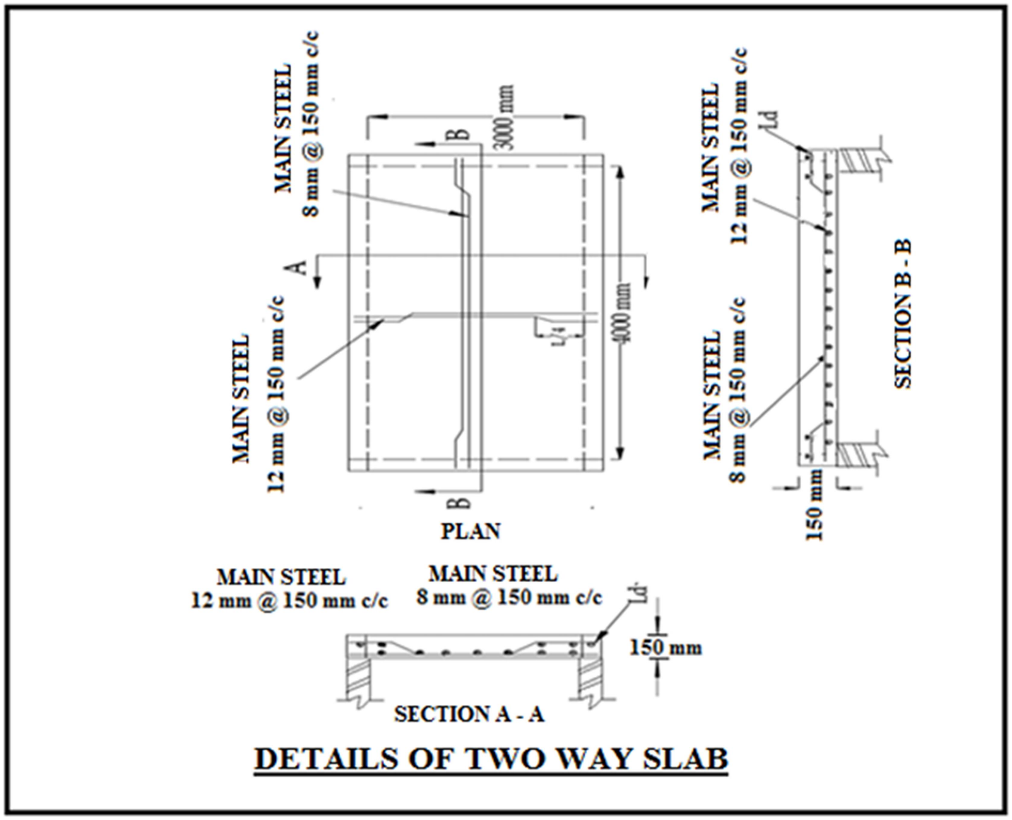


Sample Layout of A2 Size Drawing Sheet


DISTRIBUTION STEEL
8 mm @ 200 mm c/c
MAIN STEEL
8 mm @ 200 mm c/c
CANTILEVER SLAB



DETAILS OF ONE WAY SLAB



SLAB DETAILS						
SLAB ID NO.	TYPE OF SLAB	DEPTH OF SLAB (mm)	REINFORCEMENT PARALLEL TO		LENGTH OF BAR PARALLEL TO	
			SHORTER SPAN	LONGER SPAN	SHORTER SPAN (mm)	LONGER SPAN (mm)
S1	CANTILEVER	100	8 mm @ 200 mm C/C	8 mm @ 200 mm C/C	2110	2110
S2	ONE WAY	150	12 mm @ 150 mm C/C	8 mm @ 150 mm C/C	5186	2114
S3	TWO WAY	150	12 mm @ 150 mm C/C	8 mm @ 150 mm C/C	4222	3150

GENERAL NOTES:-

- CONCRETE MIX TO 1:1 ½ : 3 (M-20) {UNLESS SPECIFIED}.
- Ø DENOTES TOR STEEL BARS {IS – 1786}.
- # DENOTES MILD STEEL BARS GRADE 1 {IS – 432}.
- LAPS FOR SLABS = 60 X D, D= DIA OF BAR.
- MIN CONCRETE COVER TO SLABS = 20 mm.
- THIS DRG. IS TO BE READ IN CONJUCTION WITH REVELENT ARCHITECTS DRGS.
- DO NOT SCALE THE DRAWING.
- CONCRETE MIX QUALITY, SHUTTERING, CURING IS CONTRACTOR'S RESPONSIBILTY.
- WHILE WORKING ON SITE ABUTTING TO THE ADJACEMENT BUILDING SHALL BE DONE PROPERLY BY CONTRACTOR AND FOR ANY DAMAGE DUE TO SAME WE SHALL NOT BE HELD RESPONSIBLE.
- DESHUTTERING PERIOD SHALL NOT BE LESS THAN SPECIFIED BELOW –
  A) SLABS UP TO 4.5 m SPAN = 7 DAYS.
  B) SLABS OVER 4.5 m SPAN = 14 DAYS.
- FOR TWO WAY SLAB TORSIONAL REINFORCEMENT EQUAL TO MAIN REINFORCEMENT AT TOP AND BOTTOM UP TO 1/5 SPAN TO BE PROVIDED IN ALL CORNERS MARKED IN PLAN.

XIII. Procedure:

1. Teacher should give list of slab details to be drawn that is one way, two way and cantilever slab.
2. Students should identify the designed slabs and should draw it in the Auto-CAD. (Refer point no. IX Experimental set-up.)

XIV. . Conclusions:

XV. . Practical Related Questions:

(Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO. Write answers of minimum three questions.)

1. State the formula for calculation of main steel.
2. Explain torsional steel requirement in case of slab having four edges discontinuous.
3. State de-shuttering time for slab as per IS 456-2000.
4. State value of basic (l/d) ratio for Cantilever slab and simply supported slab.
5. Differentiate between one way slab and two way slab.

Space to Write Answers

XIII. References / Suggestions for further Reading:

- IS 456:2000 – Plain and Reinforced Concrete - Code of Practice
- IS 875:1987 (Part 1 and 4) – Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures.

XIV. Assessment Scheme:

Sr. No.	Performance Indicators	Weightage
A.	**Process Related (15 marks)**	**60%**
1.	Identify and draw slab details	20%
2.	AutoCAD Drawing skills	20%
3.	Teamwork and collaboration	20%
B.	**Product Related (10 marks)**	**40%**
4.	Interpretation of given data.	10%
5.	Answers to practical related questions.	10%
6.	Timely submission and addressing identified COs (Completeness, accuracy of suggestions)	20%
C.	**Total marks (25 marks)**	**100%**

Marks Obtained			**Dated sign of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No: 15 **Draw the reinforcement details for the beam, column and footing designed in Sr. no. 09 to 13 using Auto-CAD software (A2 Size Sheet).**

I. Practical Significance:

In real-world construction, it is crucial to follow the structural drawings accurately to ensure proper execution and safety of the structure. Detailing in these drawings plays a vital role, as it provides specific information about the dimensions and reinforcement of each RCC (Reinforced Cement Concrete) element. Understanding these details is key to implementing the design correctly. This practical aims to develop the skills needed to read and interpret structural drawings effectively, in line with the design specifications.

II. Industry/Employer expected outcome(s):

This practical is expected to develop the following skills for the industry identified competency, "Ensure precise accuracy in dimensions and material requirements on site."

III. Course Level Learning Outcome (COs):

CO2 - Design the reinforced concrete beams for given condition as per IS codes

CO4 - Design of axially loaded short columns and footings.

IV. Laboratory Learning Outcome (LLO):

LLO 15.1 - Draw the reinforcement details for the given type of beam, column and footing under specific loading conditions.

V. Relevant Affective Domain related Outcome(s):

- Maintain precision, clarity, and cleanliness in technical drawings.
- Exhibit effective teamwork and leadership skills in collaborative tasks.

VI. Relevant Theoretical Background:

- Proper detailing of reinforcement in beams and slabs is essential for ensuring structural strength, durability, and cost efficiency. The reinforcement details should clearly specify the cover to reinforcement, bar lengths, curtailment positions, number of bars, and their diameters.
- For columns, the main reinforcement bars and lateral ties must be accurately represented in both plan and sectional views.
- In footings, reinforcement should be placed as a mesh at the bottom in both directions. Bars running parallel to the longer side of the footing should be placed beneath the bars in the shorter direction. Typically, each bar includes a standard bend of at least 100 mm at both ends. It is recommended that foundations be detailed in both plan and elevation views within the drawings.

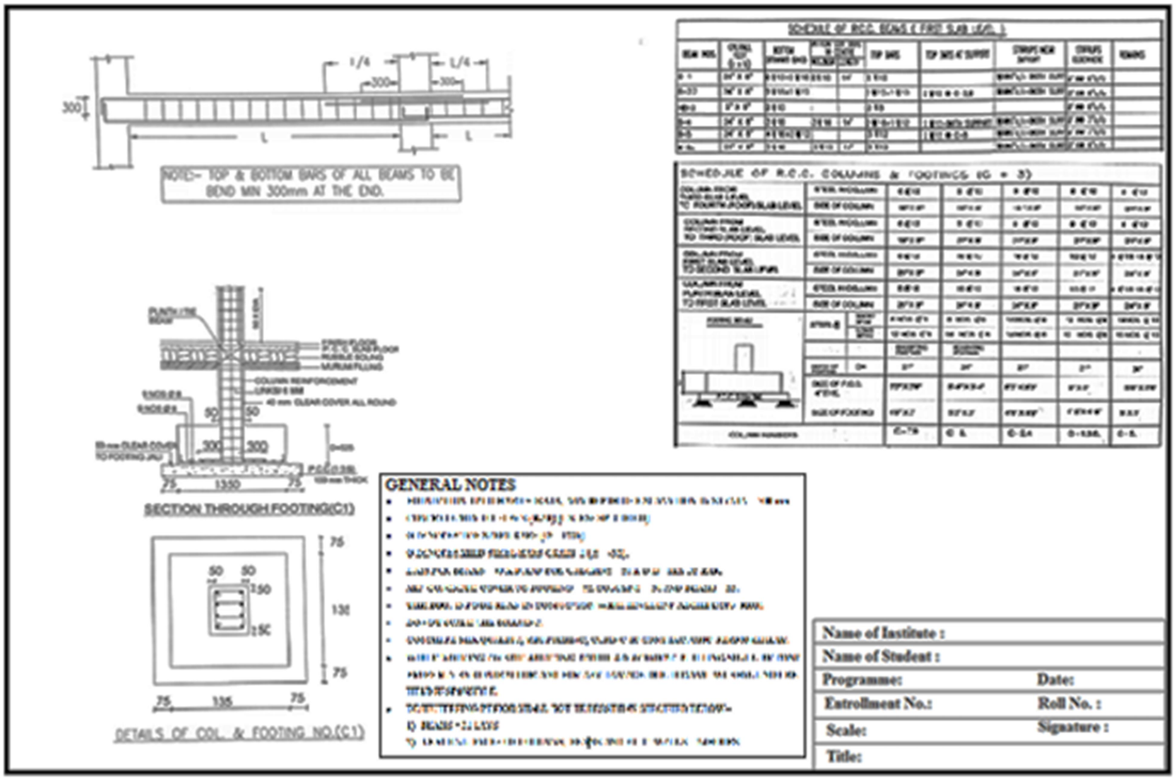
VII. Required resources/equipment:

S.N.	Resource required	Particulars	Quantity
1.	Limit State Theory and Design of Reinforced Concrete Structures	Dr. V. L. Shah & Dr. S. R. Karve	1 no. per 5 students
2.	Auto-CAD Software	A2 Size Sheet	1 no. each student

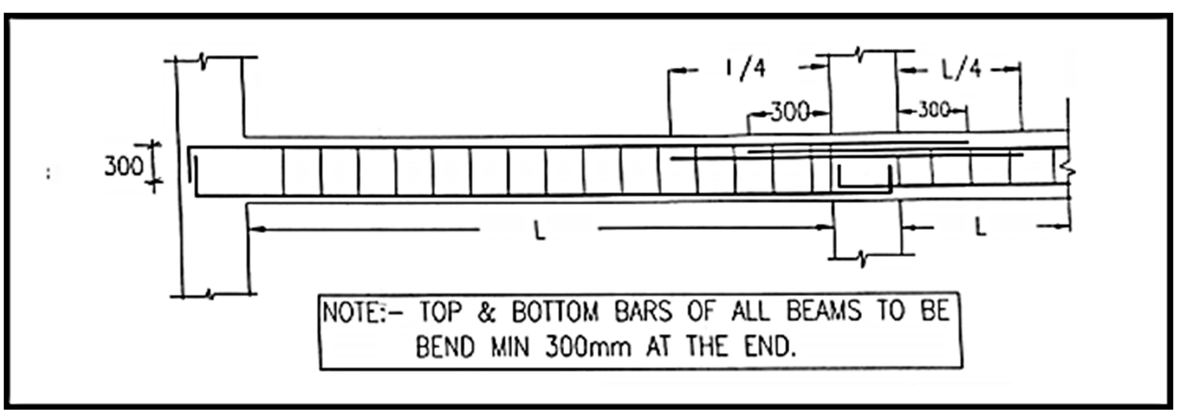
VIII. Precautions to be followed:

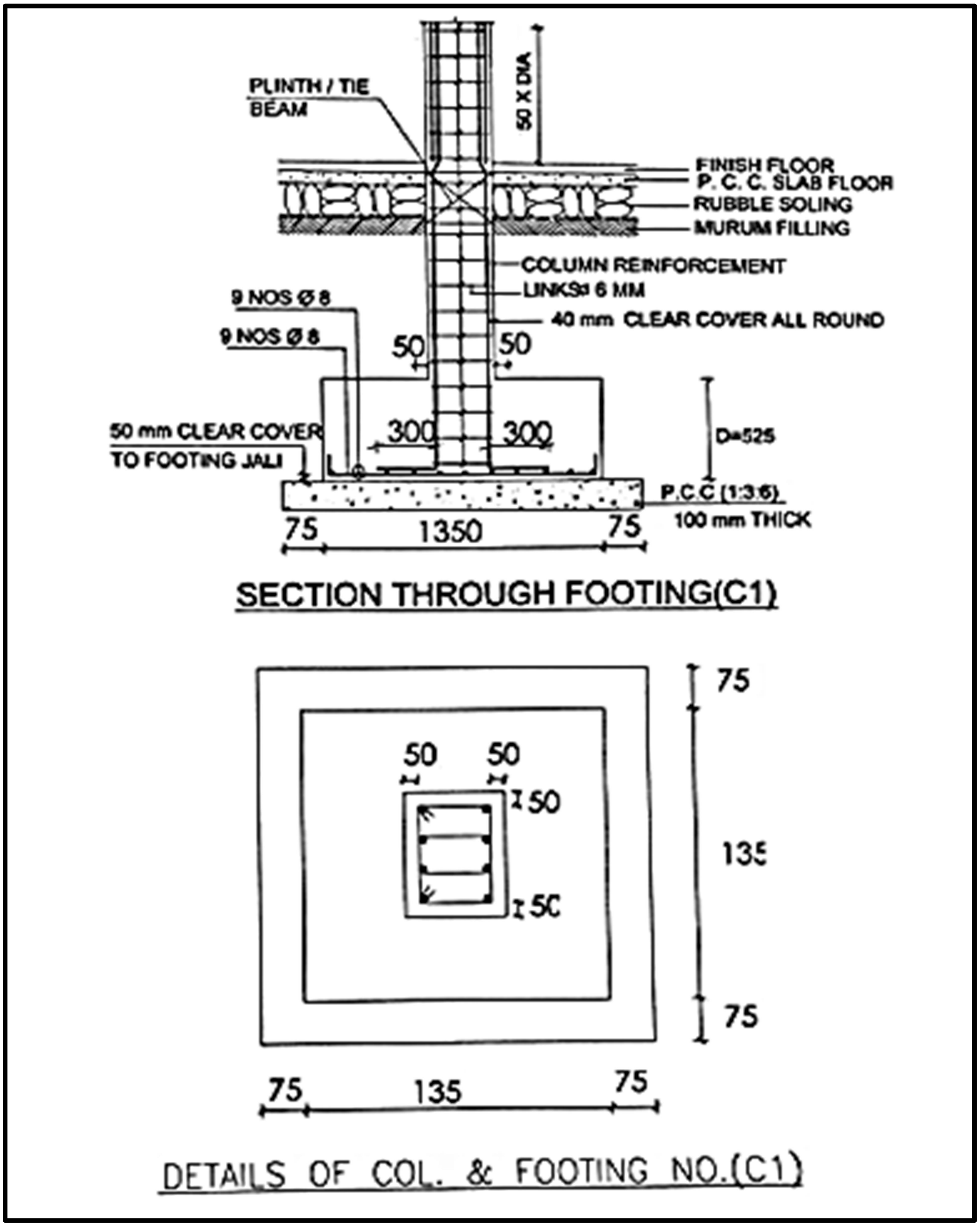
- Draw neat, scaled sketches with proper font size for labelling.
- Double-check dimensions and reinforcement details.
- Use standard symbols as per IS 456:2000.
- Keep drawings precise and easy to read.

IX. Experimental Set-up:



Sample Layout of A2 Size Drawing Sheet




PLINTH / TIE
BEAM
50 X DIA
FINISH FLOOR
P. C. C. SLAB FLOOR
RUBBLE SOLING
MURUM FILLING
COLUMN REINFORCEMENT
LINKS 6 MM
40 mm CLEAR COVER ALL ROUND
9 NOS Ø 8
9 NOS Ø 8
50
50
50 mm CLEAR COVER
TO FOOTING JALI
300
300
D=525
P.C.C (1:3:6)
100 mm THICK
75
1350
75
SECTION THROUGH FOOTING(C1)
75
135
75
50
50
50
50
75
135
75
DETAILS OF COL. & FOOTING NO.(C1)

GENERAL NOTES:-

- FOUNDATION UPTO HARD STRATA, MIN DEPTH OF EXCAVATION IN STRATA = 300 mm.
- CONCRETE MIX TO 1:1 ½: 3 (M-20) {UNLESS SPECIFIED}.
- Ø DENOTES TOR STEEL BARS {IS – 1786}.
- ≠ DENOTES MILD STEEL BARS GRADE 1 {IS – 432}.
- LAPS FOR BEAMS = 60 X D AND FOR COLUMNS = 50 X D, D= DIA OF BAR.
- MIN CONCRETE COVER TO FOOTING = 50 mm, COLUMNS = 40 mm AND BEAMS = 25 mm.
- THIS DRG. IS TO BE READ IN CONJUCTION WITH REVELENT ARCHITECTS DRGS.
- DO NOT SCALE THE DRAWING.
- CONCRETE MIX QUALITY, SHUTTERING, CURING IS CONTRACTOR'S RESPONSIBILTY.
- WHILE WORKING ON SITE ABUTTING TO THE ADJACEMENT BUILDING SHALL BE DONE PROPERLY BY CONTRACTOR AND FOR ANY DAMAGE DUE TO SAME WE SHALL NOT BE HELD RESPONSIBLE.
- DESHUTTERING PERIOD SHALL NOT BE LESS THAN SPECIFIED BELOW –
  1) BEAMS
     A) SPANNING UP TO 6 m = 14 DAYS.
     B) SPANNING OVER 6 m = 21 DAYS.
  2) VERTICAL FACES OF COLUMNS, BEAMS AND R.C.C. WALLS = 16 - 24 HOURS.

X. Procedure:

1. Teacher should give list of beam and column footing details to be drawn.
2. Students should identify the designed beams, columns, footings and should draw it in the Auto-CAD. (Refer point no. IX Experimental set-up.)

XI. Conclusions:

XII. Practical Related Questions:

(Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO. Write answers of minimum three questions.)

1. State the function of bent up bars in beams.
2. State the function of anchor bars in beams.
3. State the value of cover used for column.
4. Draw a typical two legged vertical stirrup and label its legs.
5. State the reason for providing a lesser spacing of shear stirrups near supports than in the middle zone of beams.
6. State the minimum percentage of steel provided for column.

7. State the maximum percentage of steel provided for beam.
8. Explain one way shear check in case of square footing provided for column.
9. Explain two way shear check in case of square footing provided for column.

<u>Space to Write</u>
<u>Answers</u>

XIII. References / Suggestions for further Reading:

- IS 456:2000 – Plain and Reinforced Concrete - Code of Practice
- IS 875:1987 (Part 1 and 5) – *Code of Practice for* Design Loads (Other than Earthquake) for Buildings and Structures.

XIV. Assessment Scheme:

Sr. No.	Performance Indicators	Weightage
A.	**Process Related (15 marks)**	**60%**
1.	Draw details of beam, column and footing	20%
2.	Auto-CAD Drawing skills	20%
3.	Teamwork and collaboration	20%
B.	**Product Related (10 marks)**	**40%**
4.	Interpretation of given data.	10%
5.	Answers to practical related questions.	10%
6.	Timely submission and addressing identified COs (Completeness, accuracy of suggestions)	20%
C.	**Total marks (25 marks)**	**100%**

Marks Obtained			**Dated sign of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No: 16 Prepare a report of site visit to a RCC work under construction for slab and beam reinforcement with neat sketches.

I. Practical Significance:

The purpose of this visit is to provide students with a practical understanding of RCC (Reinforced Cement Concrete) construction and the necessary safety measures to be observed on-site. By organizing this site visit, faculty can inspire and engage students, enhancing their learning experience. This hands-on exposure will help clarify any doubts related to RCC construction and enable students to connect theoretical concepts from the classroom with real-world field applications.

II. Industry/Employer expected outcome(s):

- This practical is designed to develop the following skills aligned with the industry-identified competency: ***"Effective execution of on-site activities with the required level of performance."***

III. Course Level Learning Outcome (COs):

CO2 - Design the reinforced concrete beams for given condition as per IS codes

CO3 - Design the given type of slab for the given edge condition.

IV. Laboratory Learning Outcome (LLO):

LLO 16.1 - Prepare a report of site visit to a RCC work under construction for slab and beam reinforcement with neat sketches.

V. Relevant Affective Domain related Outcome(s):

- Adhere to safety protocols.
- Demonstrate leadership and teamwork skills.
- Uphold ethical standards in practice.

VI. Relevant Theoretical Background:

- **Site Visit:** The RCC site visit involves observing reinforcement details and verifying them against the structural drawings.
- **Objectives of the Site Visit:**
  1. To understand how theoretical knowledge is applied in real-life construction practices.
  2. To observe various construction activities, techniques, and procedures on-site.
  3. To gain awareness of large-scale construction environments and observe the implementation of safety precautions.
  4. To study reinforcement detailing of structural elements at the construction site.
- **Expected Outcomes of the Site Visit:**
  1. The teacher will divide the students into groups, assigning each group the responsibility of collecting data for different structural elements such as slabs, beams etc., as observed on-site.
  2. Prior to the visit, the teacher will clearly assign specific tasks to each group.
  3. During the visit, each group will observe and record relevant details based on their assigned tasks. (A sample checklist for data collection will be provided; teachers may add more points as needed for student learning.)

4. Each group should carry a 3-meter metallic measuring tape to record necessary dimensions accurately.

- **Data to be Collected for Slab during Site Visit:**
  - Grade of concrete and type of steel used in the slab.
  - Total number of slabs present on site.
  - Type of slabs (e.g., one-way, two-way, flat slab, etc.).
  - Minimum and maximum dimensions of the slab.
  - Thickness of the slab.
  - Maximum and minimum diameter of reinforcement bars used in the slab.
  - Type and thickness of cover used for the slab, and method of providing it.
  - Spacing of main bars and distribution bars.
  - Number of cement bags used for casting a specific slab area.
  - Number of slabs casted in a single pour.
  - Material used for slab formwork (e.g., plywood, steel, timber).
  - Concrete mix proportion per cement bag, expressed in terms of ghamelas or pharma (wooden boxes).
  - Method of concrete mixing (manual or machine mixing).
  - List of tools and equipment used for slab casting, including those for transportation, placement, and compaction of concrete, along with their local site terminology.
  - Method of compaction/vibration of concrete (manual or mechanical).
  - Time duration before removing formwork (stripping time) for the slab.
  - Method of curing adopted for the slab.
  - Number of masons and labourers involved in slab casting, along with their wage rates.
  - List of any admixtures used, if applicable.
  - Any special precautions or additional measures taken during slab casting.
- **Data to be Collected for Beam during Site Visit:**
  - Grade of concrete and type of steel used in beam construction.
  - Total number of beams on site.
  - Types of beams (e.g., primary, secondary, cantilever, lintel, etc.).
  - Minimum and maximum dimensions of the beam (depth and width).
  - Span of the beam between supports.
  - Maximum and minimum diameter of reinforcement bars used.
  - Type and thickness of cover used for the beam and the method of providing it.
  - Number of main bars and their spacing for a given beam size.
  - Stirrup spacing at mid-span and near the supports.
  - Number of cement bags used for casting a particular number of beams.
  - Number of beams casted together in one operation.
  - Formwork material used for beams (e.g., timber, steel, plywood).
  - Concrete mix proportion per cement bag, expressed in number of *ghamela* or *pharma* (wooden box).
  - Method of concrete mixing (manual or machine).
  - List of tools and equipment used for beam casting, including those for transportation, placement, and compaction of concrete, along with their local names used on site.

- Method of compaction/vibration of concrete (manual or mechanical).
- Formwork stripping time for beams.
- Curing method adopted for beams (e.g., ponding, wet covering, curing compounds).
- Number of masons and labourers required for casting beams, along with their daily wage rates.
- List of admixtures used, if any (e.g., plasticizers, retarders, etc.).
- Additional precautions taken during beam casting (e.g., during rainy conditions, temperature control, vibration techniques).

- The teacher and students should verify the reinforcement details of various structural elements by referring to the blueprints or working drawings available at the site.
- All groups should compile their collected data to prepare a comprehensive site visit report, which must include a minimum of four relevant photographs.
- Personal photographs, such as selfies, should not be included in the visit report.

VII. Required resources/equipment:

S.N.	Resource required	Particulars	Quantity
1.	RCC construction site nearby college premises	…………………………..	Total number of students

VIII. Precautions to be followed:

- Every student must strictly follow the instructions given by the site engineer.
- All necessary safety precautions should be observed as per the site's safety guidelines.
- Students should wear the prescribed college uniform (if applicable), along with safety shoes, a cap, sunglasses, and must carry water bottles.
- Exercise caution while walking on or beneath formwork structures.
- Extra care must be taken when visiting high-rise structures or buildings.
- Students are strictly prohibited from operating any switches, equipment, or machinery on site.
- While taking photographs, students should remain orderly and avoid rushing or causing disturbances.
- Taking selfies on-site is not allowed under any circumstances.

IX. Procedure:

1. The institute should contact the site authorities in advance to confirm the date of the visit.
2. A formal request letter, signed by the Principal, must be prepared and submitted to the site authorities.
3. Students must procure the structural drawings of the site before the visit.
4. The construction site should be visited as per the scheduled date and time.
5. Students are expected to observe and record relevant site details during the visit.
6. After the visit, the institute should send a letter of thanks to the site authorities for their support and cooperation.

Space to Write Visit Report

Title of the Visit:

Date of visit:

Name of site/Project:

Address of site:

Faculty Coordinator:

Name of site engineer:

Name of Architecture:

Name of structural consultant:

Type and description of structure:

Detail Report:

X. Photographs (Minimum four):

Photo-1:

Photo-2:

Photo-3:

Photo-4:

XI. Assessment Scheme:

Sr. No.	Performance Indicators	Weightage
A.	**Process Related (15 marks)**	**60%**
1.	Interpretation of given data	20%
2.	Writing visit report	30%
3.	Teamwork and collaboration	10%
B.	**Product Related (10 marks)**	**40%**
4.	Interpretation of given data.	20%
5.	Timely submission and addressing identified COs (Completeness, accuracy of suggestions)	20%
C.	**Total marks (25 marks)**	**100%**

Marks Obtained			**Dated sign of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No: 17 Prepare a report of site visit to a RCC work under construction for column and footing reinforcement with neat sketches.

I. Practical Significance:

The purpose of this visit is to provide students with a practical understanding of RCC (Reinforced Cement Concrete) construction and the necessary safety measures to be observed on-site. By organizing this site visit, faculty can inspire and engage students, enhancing their learning experience. This hands-on exposure will help clarify any doubts related to RCC construction and enable students to connect theoretical concepts from the classroom with real-world field applications.

II. Industry/Employer expected outcome(s):

- This practical is designed to develop the following skills aligned with the industry-identified competency: ***"Effective execution of on-site activities with the required level of performance."***

III. Course Level Learning Outcome (COs):

CO4 - Design of axially loaded short columns and footings.

IV. Laboratory Learning Outcome (LLO):

LLO 17.1 - Inspecting the reinforcement of RCC column and footing to write a detailed report on it with neat sketches.

V. Relevant Affective Domain related Outcome(s):

- Adhere to safety protocols.
- Demonstrate leadership and teamwork skills.
- Uphold ethical standards in practice.

VI. Relevant Theoretical Background:

- **Site Visit:** The RCC site visit involves observing reinforcement details and verifying them against the structural drawings.
- **Objectives of the Site Visit:**
  1. To understand how theoretical knowledge is applied in real-life construction practices.
  2. To observe various construction activities, techniques, and procedures on-site.
  3. To gain awareness of large-scale construction environments and observe the implementation of safety precautions.
  4. To study reinforcement detailing of structural elements at the construction site.
- **Expected Outcomes of the Site Visit:**
  1. The teacher will divide the students into groups, assigning each group the responsibility of collecting data for different structural elements such as slabs, beams etc., as observed on-site.
  2. Prior to the visit, the teacher will clearly assign specific tasks to each group.
  3. During the visit, each group will observe and record relevant details based on their assigned tasks. (A sample checklist for data collection will be provided; teachers may add more points as needed for student learning.)

4. Each group should carry a 3-meter metallic measuring tape to record necessary dimensions accurately.

- **Data to be Collected for Column during Site Visit:**
    - Grade of concrete and type of steel used for the column.
    - Total number of columns on the site.
    - Number of columns supporting two, three, and four beams respectively.
    - Minimum and maximum dimensions of columns.
    - Length/height of the column from footing to slab or beam level.
    - Maximum and minimum diameter of reinforcement bars used in the column.
    - Type and thickness of cover provided for the column and the method of its placement.
    - Number of vertical bars used for a particular column size and spacing of ties/stirrups (links).
    - Number of cement bags used for casting a specified number of columns.
    - Number of columns casted together in one operation.
    - Material used for formwork (e.g., plywood, steel, timber).
    - Concrete mix proportion per cement bag, represented in number of ghamela or pharma (wooden boxes).
    - Method of concrete mixing (manual or mechanical).
    - List of tools and equipment used for column casting, including those used for transportation, placement, and compaction of concrete, along with their local site terminology.
    - Method of concrete compaction/vibration (manual or mechanical).
    - Formwork stripping time for the column.
    - Curing method adopted for the column (e.g., wet gunny bags, water sprinkling).
    - Number of masons/labourers involved in casting, along with their wage rates.
    - List of admixtures used, if any (e.g., plasticizers, retarders).
    - Special precautions taken during column casting (e.g., vertical alignment, avoiding segregation, temperature management).
- **Data to be Collected for Column Footing during Site Visit:**
    - Grade of concrete and type of steel used for the footing.
    - Total number of footings on site.
    - Type of footings (e.g., isolated, combined, raft, etc.).
    - Minimum and maximum dimensions of footings.
    - Depth of each footing from ground level.
    - Maximum and minimum diameter of reinforcement bars used.
    - Type and thickness of cover provided for the footing, and how it is placed.
    - Spacing of main reinforcement bars in both directions.
    - Number of cement bags used for casting a specific area or number of footings.
    - Number of footings casted together during a single operation.
    - Material used for formwork (e.g., wooden planks, steel sheets, etc.).
    - Safe Bearing Capacity (SBC) of soil at the site.
    - Depth of excavation carried out for the footing.

  - Concrete mix proportion per cement bag, represented in *ghamela* or *pharma* (wooden boxes).
  - Method of concrete mixing (manual or with concrete mixer).
  - Tools and equipment used for footing casting, including those for transportation, placing, and compaction of concrete, with their local terminology.
  - Method of compaction/vibration of concrete (manual or mechanical).
  - Formwork stripping time for footings.
  - Method of curing used (e.g., ponding, covering with wet hessian cloth).
  - Number of masons and labourers required for footing work, along with their wage rates.
  - List of admixtures used, if any (e.g., waterproofing compounds, retarders).
  - Any special precautions taken during casting (e.g., water removal, base leveling, protection from rain, etc.).
- The teacher and students should verify the reinforcement details of various structural elements by referring to the blueprints or working drawings available at the site.
- All groups should compile their collected data to prepare a comprehensive site visit report, which must include a minimum of four relevant photographs.
- Personal photographs, such as selfies, should not be included in the visit report.

VII. Required resources/equipment:

S.N.	Resource required	Particulars	Quantity
1.	RCC construction site nearby college premises	…………………………..	Total number of students

VIII. Precautions to be followed:

- Every student must strictly follow the instructions given by the site engineer.
- All necessary safety precautions should be observed as per the site's safety guidelines.
- Students should wear the prescribed college uniform (if applicable), along with safety shoes, a cap, sunglasses, and must carry water bottles.
- Exercise caution while walking on or beneath formwork structures.
- Extra care must be taken when visiting high-rise structures or buildings.
- Students are strictly prohibited from operating any switches, equipment, or machinery on site.
- While taking photographs, students should remain orderly and avoid rushing or causing disturbances.
- Taking selfies on-site is not allowed under any circumstances.

IX. Procedure:

1. The institute should contact the site authorities in advance to confirm the date of the visit.
2. A formal request letter, signed by the Principal, must be prepared and submitted to the site authorities.
3. Students must procure the structural drawings of the site before the visit.
4. The construction site should be visited as per the scheduled date and time.

5. Students are expected to observe and record relevant site details during the visit.
6. After the visit, the institute should send a letter of thanks to the site authorities for their support and cooperation.

Space to Write Visit Report

Title of the Visit:

Date of visit:

Name of site/Project:

Address of site:

Faculty Coordinator:

Name of site engineer:

Name of Architecture:

Name of structural consultant:

Type and description of structure:

Detail Report:

X. Photographs (Minimum four):

Photo-1:

Photo-2:

Photo-3:

Photo-4:

XI. Assessment Scheme:

Sr. No.	Performance Indicators	Weightage
A.	**Process Related (15 marks)**	**60%**
1.	Interpretation of given data	20%
2.	Writing visit report	30%
3.	Teamwork and collaboration	10%
B.	**Product Related (10 marks)**	**40%**
4.	Interpretation of given data.	20%
5.	Timely submission and addressing identified COs (Completeness, accuracy of suggestions)	20%
C.	**Total marks (25 marks)**	**100%**

Marks Obtained			Dated sign of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No: 18 **Write five IS clauses related to load from IS 875:1987.**

I. Practical Significance:

A structure is constantly subjected to various forces exerted by the loads it supports. It is often challenging to accurately predict the exact loads a structure will experience throughout its lifespan. Common types of loads include dead load, live load, wind load, and earthquake load. This practical aims to help students understand the key provisions of IS: 875-1987, which outlines the design loads (excluding earthquake loads) to be considered for buildings and other structures.

II. Industry/Employer expected outcome(s):

- This practical is expected to develop the following skills for the industry identified competency, ***"Utilize knowledge of loading standards in the design of buildings and structures."***

  a. Know IS clauses for loads.

  b. Follow design steps as per IS 456: 2000.

III. Course Level Learning Outcome (COs):

CO1 - Explain the given criteria in relation to RCC and steel structures.
CO2 - Design the reinforced concrete beams for given condition as per IS codes.
CO3 - Design the given type of slab for the given edge condition.
CO4 - Design of axially loaded short columns and footings.

IV. Laboratory Learning Outcome (LLO):

LLO 18.1 - Identify the relevant IS clauses related to loads from IS 875:1987.

V. Relevant Affective Domain related Outcome(s):

- Exhibit leadership and teamwork skills.
- Adhere to ethical standards and professional conduct.

VI. Relevant Theoretical Background:

- Structures are commonly subjected to different types of loads such as dead load, live load, wind load, and earthquake load.
- Usually, two or more loads act on a structure at the same time. Therefore, load combinations like DL + LL, DL + WL, DL + LL + WL, DL + EL, etc., are used to calculate the total load on the structure.
- IS: 875-1987 (Parts 1 to 5) is the Indian Standard code that provides guidelines and values for different types of loads typically acting on buildings and structures.
- The five parts of the code cover the following:

  Part 1 – Dead Loads (DL)
  Part 2 – Imposed Loads (LL)
  Part 3 – Wind Loads (WL)
  Part 4 – Snow Loads
  Part 5 – Special Loads and Load Combinations

VII. Required resources/equipment:

S.N.	Resource required	Particulars	Quantity
1.	Code of practice for Design loads (other than Earthquake) for buildings and Structures	IS 875:1987 (Part 1 to 5)	1 no. per batch

VIII. Precautions to be followed:

- Careful reading is essential to extract accurate information.
- Students should write the clauses clearly and concisely.

IX. Procedure:

1. Teacher should give list of slab details to be drawn that is one way, two way and cantilever slab.
2. Take a general look through the relevant section of the code and enter the required information under "Observations."
3. Study each section carefully with reference to the specific information requested, then record the extracted information accordingly.
4. Write Clause 1 (Page 4) of IS 875-1987 Part 1 related to the Scope of the code.
5. Write Clause 2 (Page 4) of IS 875-1987 Part 1 related to Unit Weights of Common Building Materials.
6. Write Clauses 1.1 and 1.2 (Page 5) of IS 875-1987 Part 2 related to the Scope of that code.
7. Write Clauses 3.1, 3.1.1 and 4.1 of IS 875-1987 Part 2 on Live Load on floors due to use and occupancy.
8. Write Clause 1.1 (Page 5) of IS 875-1987 Part 3 related to the Scope of the code.
9. Write Clause 5.3 (Page 8) of IS 875-1987 Part 3 on Design Wind Speed.
10. Write Clause 5.4 (Page 12) of IS 875-1987 Part 3 on Design Wind Pressure.
11. Write Clause 6.2.1 (Page 13) of IS 875-1987 Part 3 related to wind load on individual members.

Space to Write Clauses

X. Conclusions:

XI. Practical Related Questions:

(Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO. Write answers of minimum three questions.)

1. List the different types of loads specified in IS 875:1987 that should be considered in structural design.
2. State the unit weight of asbestos sheets as per IS 875 Part 1.
3. State the unit weight of engineering bricks as per IS 875 Part 1.
4. Mention the live load value for a library floor as per IS 875 Part 2.
5. Mention the live load value for a hospital floor as per IS 875 Part 2.
6. Calculate the self-weight of an RCC column with dimensions 230 mm × 500 mm and 3.2 m in height.
7. State the basic wind speed for Pune as per IS 875 Part 3.
8. List the typical load combinations considered in structural design for final load calculation.
9. Explain why wind loads and live loads are not considered simultaneously in some cases.

Space to Write Answers

XII. References / Suggestions for further Reading:

- IS 875:1987 (Part 1 and 5) – Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures.

XIII. Assessment Scheme:

Sr. No.	Performance Indicators	Weightage
A.	**Process Related (15 marks)**	**60%**
1.	Use of IS: 875-1987.	40%
2.	Precision in writing and neatness.	20%
B.	**Product Related (10 marks)**	**40%**
3.	Interpretation of given clauses	10%
4.	Answers to practical related questions.	10%
5.	Timely submission and addressing identified COs (Completeness, accuracy of suggestions)	20%
C.	**Total marks (25 marks)**	**100%**

Marks Obtained			**Dated sign of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No: 19 Write five IS clauses related to joints in steel structure from IS 800:2007.

I. Practical Significance:

The design and detailing of joints between structural members are covered in IS 800:2007. Connection elements include components like cleats, gusset plates, brackets, connecting plates, and connectors such as rivets, bolts, pins, and welds. These connections must be designed to align with the assumptions made during structural analysis and must meet the requirements specified in the code.This practical is intended to help students understand the key provisions of IS 800:2007 related to the design of joints in steel structures.

II. Industry/Employer expected outcome(s):

- This practical is expected to develop the following skills for the industry identified competency, ***"Design joints in steel structures with its detailing."***
  a. Know IS clauses for joints in steel structures.
  b. Follow design steps as per IS: 800-2007

III. Course Level Learning Outcome (COs):

CO5 - Design the connections for the given steel joints.

IV. Laboratory Learning Outcome (LLO):

LLO 19.1 - Identify the relevant IS clauses related to joints in steel structures from IS 800:2007.

V. Relevant Affective Domain related Outcome(s):

- Exhibit leadership and teamwork skills.
- Adhere to ethical standards and professional conduct.

VI. Relevant Theoretical Background:

- Structural members are joined using either bolts or welds.
- Connections must be designed to safely transmit the required design forces.
- While designing connections, ease of fabrication and erection should also be taken into account.
- In general, using different types of fasteners (e.g., bolts and welds together) to transfer the same force should be avoided.
- The partial safety factors for determining design strength must be applied as specified in the IS code.

VII. Required resources/equipment:

S.N.	Resource required	Particulars	Quantity
1.	General Construction in Steel - Code of Practice	IS 800:2007	1 no. per batch

VIII. Precautions to be followed:

- Careful reading is essential to extract accurate information.
- Understand the different types of connection for its design.

IX. Procedure:

1. Take a general browse through the IS code and enter the information.
2. Study section / clause 10 with reference to the information asked and enter the information extract accordingly.
3. Teacher should guide the students for writing any five clauses from the following – Clause 10.2.2, Clause 10.2.3, Clause 10.2.4, Clause 10.3.1.1, Clause 10.3.1.2, Clause 10.3.3, Clause 10.3.4 related to bolts from IS: 800-2007.
4. Write Clause 10.5 related to weld from IS: 800-2007. Clause 6.2.1 (Page 13) of IS 875-1987 Part 3 related to wind load on individual members.

Space to Write Clauses

X. Conclusions:

XI. Practical Related Questions:

(Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO. Write answers of minimum three questions.)

1. Define edge distance.
2. Define end distance.
3. State function of tacking fasteners.
4. The distance between the centres of any two adjacent fasteners shall not exceed
5. Draw neat sketch of lap joint.
6. State types of welds.
7. Define side fillet.
8. Define end return.
9. The size of fillet weld shall not be less than…………

Space to Write Answers

XII. References / Suggestions for further Reading:

- IS 800:2007: General Construction in Steel - Code of Practice.

XIII. Assessment Scheme:

Sr. No.	Performance Indicators	Weightage
A.	**Process Related (15 marks)**	**60%**
1.	Use of IS 800:2007.	40%
2.	Precision in writing and neatness.	20%
B.	**Product Related (10 marks)**	**40%**
3.	Interpretation of given clauses	10%
4.	Answers to practical related questions.	10%
5.	Timely submission and addressing identified COs (Completeness, accuracy of suggestions)	20%
C.	**Total marks (25 marks)**	**100%**

Marks Obtained			**Dated sign of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No: 20 Design a bolted connection for the given data.

I. Practical Significance:

Truss members are typically subjected to axial loads and are connected through gusset plates using bolts. To prevent eccentricity, it is essential that the centroids of the connecting members coincide at the joint. The gusset plate should be thicker than the members it connects to ensure adequate strength. The design of the truss joint is determined by the number of bolts needed to transfer the applied forces. This practical exercise enables students to identify the type of connection and the procedure for designing bolted connections using the Limit State Method. It also provides insights into the proper placement of bolts in real-world applications.

II. Industry/Employer expected outcome(s):

- This practical is expected to develop the following skills for the industry identified competency, ***"Identifying, designing, laying out, and installing bolted connections on-site."***
  a. Follow design steps as per IS 800: 2007.
  b. Know IS specifications for axially loaded single and double angle sections.

III. Course Level Learning Outcome (COs):

CO5 - Design the connections for the given steel joints.

IV. Laboratory Learning Outcome (LLO):

LLO 20.1 - Use the given data to Design a bolted connection.

V. Relevant Affective Domain related Outcome(s):

- Exhibit leadership and teamwork skills.
- Adhere to ethical standards and professional conduct.

VI. Relevant Theoretical Background:

- The design of a bolted connection involves calculating the design shear strength of the bolt, the design bearing strength of the bolt, the bolt value, and determining the number of bolts required to safely carry the given factored load at the joint.

VII. Required resources/equipment:

S.N.	Resource required	Particulars	Quantity
1.	Limit State Theory and Design of Reinforced Concrete Structures	Dr. V. L. Shah & Dr. S. R. Karve	1 no. per batch
2.	General Construction in Steel	IS 800: 2007	1 no. per batch

VIII. Precautions to be followed:

- Identify the type of connection based on the provided data.
- Design the connection in accordance with IS specifications.

IX. Procedure:

1. For design of bolted connection following data shall be provided
   a) Size of Single or double angle sections

b) Nature of connections between sections
c) Type of bolt and bolt diameter
d) Load to be resisted

2. Teacher shall prepare four groups for a batch of 20 students.
3. Each group shall design at least one connection.
4. Students should observe the connection type and design the same as per IS 800:2007.
5. Students should follow below steps for design.

a) Calculate bolt hole diameter

b) Calculate design shear strength and design bearing strength

i) The Design shear strength of Bolt is calculated by using,

$$V_{dsb} = \frac{Vnsb}{\gamma mb} = \frac{\left(\frac{fu}{\sqrt{3}}\right)(nn.Anb + ns.Asb)}{1.25}$$

A_{sb}= Nominal plane shank area of the bolt

A_{nb} = Net shear area of bolt at threads may be taken as area corresponding to root diameter at the thread

f_u = Ultimate tensile strength of bolt

n_n = Number of shear planes with threads intercepting the shear plane

n_s= Number of shear planes without threads intercepting the shear plane

ii) The Design bearing strength of Bolt on any plane is calculated by using,

$$V_{dpb} = \frac{Vnpb}{\gamma mb} = \frac{2.5\ kb.d.tp.fu}{1.25}$$

Where, kь is smaller of $\left[\left(\frac{e}{3do}\right)\ ;\ \left(\frac{p}{3do} - 0.25\right);\ \left(\frac{fub}{fup}\right)\ ;1\right]$

In design kь is normally taken equal to unity

e, p = End and pitch distances of fastener along bearing direction

d_o = Diameter of the bolt hole

d = Nominal diameter of the bolt

f_{ub} = Ultimate tensile stress of bolt

f_u = Ultimate tensile stress of plate

t_p = thickness of connected plates experiencing bearing stress in the same direction

c) Calculate design strength; it is lesser of shearing and bearing strength Calculate number of bolts (n) as

d) No. of bolts = Design Load on member / Design strength of single bolt

6. Draw neat plan showing the arrangement of bolts provided.

Space to Write Design

X. Results (Summery of Design):

No. of bolts =

Arrangement of bolts =

XI. Practical Related Questions:

(Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO. Write answers of minimum three questions.)

1. Bolts are classified as i)……………………… ii)………………………….
2. State types of bolted joints.
3. State formula for net tensile stress area of bolt at threads.
4. State two modes of failure of bolted joints.
5. Define bolt value.
6. Define pitch distance.
7. Define gauge distance.
8. State two disadvantages of bolted connection.
9. Draw typical plan and section of double bolted lap joint.

Space to Write Answers

XIII. References / Suggestions for further Reading:

- IS 800:2007 – General Construction in Steel - Code of Practice
- Limit State Design of Steel Structures – Dr. V. L. Shah & Gore Veena.

XIV. Assessment Scheme:

Sr. No.	Performance Indicators	Weightage
A.	**Process Related (15 marks)**	**60%**
1.	Design of bolted connection	30%
2.	Proper calculation	20%
3.	Teamwork and collaboration	10%
B.	**Product Related (10 marks)**	**40%**
4.	Interpretation of given data.	10%
5.	Answers to practical related questions.	10%
6.	Timely submission and addressing identified COs (Completeness, accuracy of suggestions)	20%
C.	**Total marks (25 marks)**	**100%**

Marks Obtained			**Dated sign of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No: 21 Design a welded connection for the given data.

I. Practical Significance:

Many steel structures consist of various components joined together using rivets, bolts, or welds. With advancements in welding equipment, electrodes, and the evolving science of welding design, welding has become a vital tool in the construction industry. The increased trust and acceptance of welding, along with its ability to shorten production cycles, have accelerated the pace of new construction projects. As more individuals gain deeper knowledge and experience with welding, its significance will continue to grow. This practical exercise aims to provide a comprehensive understanding of the design process for welded connections.

II. Industry/Employer expected outcome(s):

- This practical is expected to develop the following skills for the industry identified competency, ***"Designing the welded connection for the given conditions."***
  a. The ability to design a welded connection based on the specified conditions.
  b. The ability to apply IS 800: 2007 for the design of welded connections.

III. Course Level Learning Outcome (COs):

CO5 - Design the connections for the given steel joints.

IV. Laboratory Learning Outcome (LLO):

LLO 21.1 - Use the given data to Design of a welded connection.

V. Relevant Affective Domain related Outcome(s):

- Exhibit leadership and teamwork skills.
- Adhere to ethical standards and professional conduct.

VI. Relevant Theoretical Background:

- **Welded connection:** When various members of steel structures are connected together by means of welding, the connection is called "Welded connection".
- **Throat thickness:** It is the perpendicular distance from the root of the fillet weld to the line joining its toes.

  t_t = k x size of fillet weld

  = 0.7 x size of fillet weld --------- (k = 0.7 for angle between fusion faces 60 to 90 degree.)
- **Permissible stresses in weld:** The permissible stresses in weld for tension or compression section through throat of butt weld is taken as 150 N/mm^2.
- **Size of weld:** When size of weld is not given, it is taken with reference to following-

Type of member	S_{min}	S_{max}
Plate	3 mm	Thickness of plate – 1.5 mm
Angle section	3 mm	3/4 x Thickness of angle section

- **Effective Length:** It is the length of the fillet weld for which the specified size and throat thickness of weld exists.

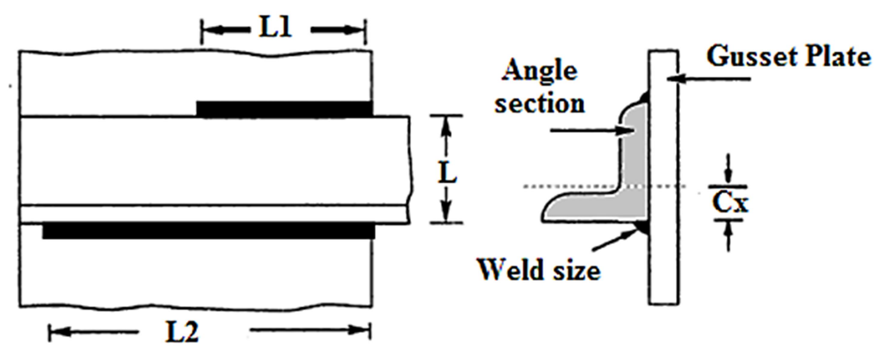
VII. Required resources/equipment:

S.N.	Resource required	Particulars	Quantity
1.	Limit State Design of Steel Structures	Dr. V. L. Shah & Gore Veena	1 no. per group of 5 students
2.	General Construction in Steel	IS 800: 2007	1 no. per group of 5 students

VIII. Precautions to be followed:

- IS code provisions must be followed while designing the connection.
- Caution should be exercised when considering moments for calculating weld length.
- Calculations should be performed with accuracy.

IX. Experimental Set-up:



Single angle connected to gusset plate using welded connection

X. Procedure:

1. Teacher should form group of 4 to 5 students.
2. Teacher should give following details required to design the welded connection to each group.
   a) Section details - Single angle / Double angle, size of angle, position of C.G.
   b) Thickness of gusset plate.
   c) Force -Either the load to be given for design of section or section is to be designed for its full strength.
      Full strength of section = Cross-sectional area x Permissible stress.
   d) Size of weld should be given or it should be considered within the range of maximum or minimum size of weld.
      S_{max} = 3/4 x Thickness of angle section and S_{min} = 3 mm.
   e) Welding on two sides or three sides.

3. Calculate force resisted by the weld at the lower side of angle.
4. Calculate force resisted by the weld at the upper side of angle.

5. Taking moment about top or bottom weld length and find weld length L1 or L2 accordingly.
6. Draw sketch showing connection details.

Space to Write Design

X. Results (Summery of Design):

Weld Length L1 =

Weld Length L2 =

XI. Practical Related Questions:

(Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO. Write answers of minimum three questions.)

1. State the criteria to decide size of weld for angle section when size of weld is not given.
2. State the criteria to decide size of weld for plate when size of weld is not given. Write the formula to calculate full strength of section.
3. Enlist two advantages and two disadvantages of welded connection over bolted connection.
4. Write formula to calculate effective length of weld.
5. Write the relation between size of fillet weld and throat thickness.
6. Find out the strength of welded joint for the connection shown in fig. 1. (*Teacher should provide values of P, b, t and size of weld*.)
   Take P = ……….. , b = ……….. mm, t = ……….. mm and Size of weld = ………… mm.

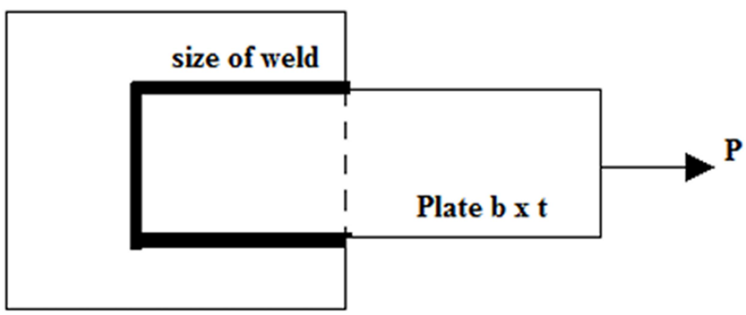


Figure -1

7. Calculate size of weld for plate size b = ………… mm and t = ………….. mm.
   (Teacher should provide values of b and t.)
8. Calculate size of weld for angle of thickness t = …………… mm.
   (Teacher should provide thickness of angle.)

Space to Write Answers

XIII. References / Suggestions for further Reading:

- IS 800:2007 – General Construction in Steel - Code of Practice
- Limit State Design of Steel Structures – Dr. V. L. Shah & Gore Veena.

XIV. Assessment Scheme:

Sr. No.	Performance Indicators	Weightage
A.	**Process Related (15 marks)**	**60%**
1.	Design of Welded connection	30%
2.	Proper calculation	20%
3.	Teamwork and collaboration	10%
B.	**Product Related (10 marks)**	**40%**
4.	Interpretation of given data.	10%
5.	Answers to practical related questions.	10%
6.	Timely submission and addressing identified COs (Completeness, accuracy of suggestions)	20%
C.	**Total marks (25 marks)**	**100%**

Marks Obtained			**Dated sign of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No: 22 Write three IS clauses related to tension member and compression member in steel structure from IS 800:2007.

I. Practical Significance:

Tension members are designed to resist tensile forces (pulling forces), which are common in structural systems like trusses, bridges, and roofs. Compression members are designed to resist compressive forces (pushing forces), which are typically found in columns, braces, and vertical members. In both cases, the practical significance of tension and compression members as outlined in IS 800:2007 is to ensure safety, stability, cost-effectiveness, and long-term durability of steel structures. The standards ensure that these members are capable of handling the forces they are subjected to without failure, all while optimizing material use to make the structure economically viable.

II. Industry/Employer expected outcome(s):

- This practical is expected to develop the following skills for the industry identified competency, ***"Interpret and apply IS 800:2007 provisions for design of tension and compression members in steel structures."***
  a. Know IS clauses related to design of tension and compression members in steel structures..
  b. Apply design provisions from IS 800:2007.

III. Course Level Learning Outcome (COs):

CO5 - Design the connections for the given steel joints.

IV. Laboratory Learning Outcome (LLO):

LLO 22.1 - Identify the relevant IS clauses related to tension member and compression member steel structures from IS 800:2007.

V. Relevant Affective Domain related Outcome(s):

- Exhibit leadership and teamwork skills.
- Adhere to ethical standards and professional conduct.

VI. Relevant Theoretical Background:

- In steel structures, tension and compression members are the primary load-carrying elements that resist axial forces. Their design is governed by the provisions of IS 800:2007 – General Construction in Steel – Code of Practice, which provides guidelines to ensure safety, strength, and economy in structural design.
- **Tension Members:**
  1. Tension members are structural components subjected to axial tensile forces (pulling forces). Common examples include members of trusses, bracings, and suspenders.
  2. The design of tension members as per IS 800:2007 considers three main limit states:
     a. Yielding of the gross section (overall elongation),
     b. Rupture of the net section (fracture through bolt holes or weak sections), and
     c. Block shear failure around connections.
  3. Relevant clauses (e.g., Clause 6.2.1–6.2.4) define how to calculate design strength based on these failure modes.
- **Compression Members:**

1. Compression members, such as columns and struts, are subjected to axial compressive forces (pushing forces).
2. Their design is primarily governed by buckling behaviour, which depends on the slenderness ratio, effective length, and end conditions.
3. IS 800:2007 (especially Clause 7.1–7.3) provides methods to determine the design compressive strength, ensuring that members remain stable and do not buckle under load.

VII. Required resources/equipment:

S.N.	Resource required	Particulars	Quantity
1.	General Construction in Steel - Code of Practice	IS 800:2007	1 no. per batch

VIII. Precautions to be followed:

- Careful reading is essential to extract accurate information.
- Students should write the clauses clearly and concisely.

IX. Procedure:

1. Take a general browse through the IS code and enter the information.
2. Study section 6 and 7 with reference to the information asked and enter the information extract accordingly.
3. Teacher should guide the students for writing clauses from the following – Clause 6.1, Clause 6.2, Clause 6.3, Clause 6.4 related to tension members (any three) and Clause 7.1.2, Clause 7.1.2.1, Clause 7.1.2.2, Clause 7.2.1, Clause 7.2.2 (Table 11- Page 45) related to compression members (any three) from IS: 800-2007.

<u>Space to Write Clauses</u>

X. Conclusions:

XI. Practical Related Questions:

(Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO. Write answers of minimum three questions.)

1. Define tension members.
2. Define compression members.
3. State the formula for design tensile strength as per IS 800:2007.
4. Explain the difference between yielding and rupture in tension members.
5. The Effective length is important in compression member design. Justify.

Space to Write Answers

XII. References / Suggestions for further Reading:

- IS 800:2007: General Construction in Steel - Code of Practice.

XIII. Assessment Scheme:

Sr. No.	Performance Indicators	Weightage
A.	**Process Related (15 marks)**	**60%**
1.	Use of IS 800:2007.	40%
2.	Precision in writing and neatness.	20%
B.	**Product Related (10 marks)**	**40%**
3.	Interpretation of given clauses	10%
4.	Answers to practical related questions.	10%
5.	Timely submission and addressing identified COs (Completeness, accuracy of suggestions)	20%
C.	**Total marks (25 marks)**	**100%**

Marks Obtained			**Dated sign of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No: 23 Write the stepwise procedure for Design of tension member.

I. Practical Significance:

The design of a tension member is a fundamental aspect of steel structure design. This practical helps in understanding and applying IS 800:2007 provisions for the safe design of tension members. It develops skills in selecting sections, calculating areas, and checking failure modes to ensure economical and reliable steel structures. The procedure prepares learners for real-world steel design challenges in industry.

II. Industry/Employer expected outcome(s):

- This practical is expected to develop the following skills for the industry identified competency, ***"Design tension members in steel structures as per IS 800:2007 with appropriate section selection, strength verification, and detailing."***

  a. Use IS 800:2007 to design tension members safely.

  b. Select sections and detail connections economically.

III. Course Level Learning Outcome (COs):

CO5 - Design the connections for the given steel joints.

IV. Laboratory Learning Outcome (LLO):

LLO 23.1 - Write the stepwise procedure for Design of tension member..

V. Relevant Affective Domain related Outcome(s):

- Exhibit leadership and teamwork skills.
- Adhere to ethical standards and professional conduct.

X. Relevant Theoretical Background:

- In steel structures, tension members are elements subjected to axial tensile forces. Designing these members involves ensuring that they can safely resist applied loads without failure. According to IS 800:2007, the design of tension members follows the limit state method, considering three primary failure modes:
  1. Yielding of the gross section – when the entire cross-section yields under tension.
  2. Rupture of the net section – fracture occurring at reduced areas due to bolt holes or other discontinuities.
  3. Block shear failure – a combination of tension and shear failure around bolt groups or welds.
- The design procedure includes determining the factored tensile load, selecting a suitable steel section, calculating the gross and net effective areas, and checking the member strength against these failure modes. The member is considered safe if its design tensile strength is greater than or equal to the applied factored load.

XI. Required resources/equipment:

S.N.	Resource required	Particulars	Quantity
1.	General Construction in Steel - Code of Practice	IS 800:2007	1 no. per batch

XII. Precautions to be followed:

- Accurately interpret IS clauses related to the design of tension members in steel structures.
- Students should write Design procedure of tension members in accordance with IS specifications.

XIII. Procedure:

- As per IS 800:2007 – Code of Practice for General Construction in Steel, the design of tension members involves checking the member against various possible failure modes, including yielding of the gross section, rupture of the net section, and block shear failure.
- The stepwise procedure for the design of a tension member as per IS 800:2007:

1. **Determine Factored Load:**

   Calculate the factored tensile load T_u acting on the member using load factors,

   T_u = 1.5 × working load (for limit state design)

2. **Select a Trial Section:**

   Choose a suitable steel section (angle, channel, plate, etc.) based on expected load and availability. **(Select from steel tables -IS 808)**

3. **Calculate Gross Area (A_g):**

   Find the total cross-sectional area of the chosen section.

4. **Calculate Net Effective Area (A_n):**

   Deduct the area lost due to bolt holes or other discontinuities:

   $A_n = A_g - (n \times d_h \times t)$

   Where, n = number of holes in tension, d_h = hole diameter, t = thickness.

5. **Check Design Strength for Yielding of Gross Section:**

   $$T_{dg} = \frac{0.9\ fy\ Ag}{\gamma m0}$$

   Where, fy = yield strength, γ_{m0} = partial safety factor (usually 1.10).

6. **Check Design Strength for Rupture of Net Section:**

   $$T_{dn} = \frac{0.9\ fu\ An}{\gamma m1}$$

   Where, fu = ultimate strength, γm1 = partial safety factor (usually 1.25).

7. **Check Design Strength for Block Shear Failure:**

   The block shear strength, T_{db} of connection shall be taken as the smaller of,

   $$T_{db1} = \frac{Avg.fy}{(\sqrt{3}\ .\gamma mo)} + \frac{0.9\ Atn\ fu}{\gamma m}$$

   $$T_{db2} = \frac{0.9\ Avn.fu}{(\sqrt{3}\ .\gamma m\ \ )} + \frac{Atg\ fy}{\gamma mo}$$

Where,

A_{vg} and A_{vn}= minimum gross and net area in shear along bolt line parallel respectively.

A_{tg} and A_{tn} = minimum gross and net area in tension from the bolt hole to the toe of the angle, end bolt line, perpendicular to the line of force, respectively and

f_u and f_y = ultimate and yield stress of the material, respectively.

8. **Determine Design Tensile Strength (T_d):**

   Take the minimum of T_{dg}, T_{dn}, and T_{db}

9. **Compare T_d with Factored Load T_u:**

   Ensure:

   $T_d \geq T_u$

   If not, select a stronger or larger section and repeat the calculations.

<u>Space to Write Stepwise Procedure</u>

X. Conclusions:

XI. Practical Related Questions:

(Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO. Write answers of minimum three questions.)

1. List the types of sections commonly used for tension members.
2. Differentiate between gross area and net area of a tension member.
3. Mention the maximum allowable slenderness ratio for a tension member as per IS 800:2007.
4. The value of partial safety factor γ_{m0} for yielding is ……………
5. A tension member carries a factored load of 300 kN. Determine the required gross area if fy=250 MPa.
6. Select a suitable single angle section to carry a factored tensile load of 200 kN. Assume Fe 250 steel.
7. For a given angle section ISA 90×90×8, calculate the design strength in tension considering rupture of net section.

Space to Write Answers

XII. References / Suggestions for further Reading:

- IS 800: 2007: General Construction in Steel - Code of Practice.
- IS 808: 1989: Dimensions for Hot Rolled Steel Beam, Column, Channel and Angle Sections.

XIII. Assessment Scheme:

Sr. No.	Performance Indicators	Weightage
A.	**Process Related (15 marks)**	**60%**
1.	Use of IS 800:2007 and IS 808: 1989 Steel table.	40%
2.	Precision in writing and neatness.	20%
B.	**Product Related (10 marks)**	**40%**
3.	Interpretation of design procedure.	10%
4.	Answers to practical related questions.	10%
5.	Timely submission and addressing identified COs (Completeness, accuracy of suggestions)	20%
C.	**Total marks (25 marks)**	**100%**

Marks Obtained			**Dated sign of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No: 24 Write the stepwise procedure for Design of compression member.

I. Practical Significance:

The design of a compression member is an essential part of steel structure design. This practical helps in understanding and applying the provisions of IS 800:2007 for the safe and efficient design of compression members such as columns and struts. It enables learners to analyze buckling behavior, determine effective lengths, calculate design strengths, and select appropriate steel sections. The procedure prepares learners for real-world steel design challenges in industry.

II. Industry/Employer expected outcome(s):

- This practical is expected to develop the following skills for the industry identified competency, ***"Design Compression members in steel structures as per IS 800:2007 with appropriate section selection, strength verification, and detailing."***
  a. Use IS 800:2007 to design compression members safely.
  b. Select sections and detail connections economically.

III. Course Level Learning Outcome (COs):

CO5 - Design the connections for the given steel joints.

IV. Laboratory Learning Outcome (LLO):

LLO 24.1 - Write the stepwise procedure for Design of compression member.

V. Relevant Affective Domain related Outcome(s):

- Exhibit leadership and teamwork skills.
- Adhere to ethical standards and professional conduct.

VI. Relevant Theoretical Background:

- A compression member is a structural element that primarily resists axial compressive forces. When subjected to compression, such members tend to fail either by material yielding (crushing) or by buckling (lateral instability). The design of compression members in steel structures is carried out as per the provisions of IS 800:2007 (Limit State Design) to ensure adequate strength and stability.

VII. Required resources/equipment:

S.N.	Resource required	Particulars	Quantity
1.	General Construction in Steel - Code of Practice	IS 800:2007	1 no. per batch

VIII. Precautions to be followed:

- Accurately interpret IS clauses related to the design of compression members in steel structures.
- Students should write Design procedure of compression members in accordance with IS specifications.

IX. Procedure:

- The stepwise procedure for the design of a Compression member as per IS 800:2007:

1. **Identification of Member and End Conditions:**
   - Determine the type of compression member — column, strut, or compression diagonal — and note its effective length based on how it is connected at both ends (pinned, fixed, etc.).
   - End conditions affect the member's buckling length and consequently its strength.
2. **Determine Factored Load (Pu):**
   Calculate the factored axial load using appropriate load combinations from IS 875 (Part 5) or IS 800 : 2007 (Cl. 5.3.1).

   Pu = 1.5 × (Dead Load + Live Load)

   (or other relevant combinations).
3. **Choose a Trial Section:**
   - Select a suitable rolled steel section (e.g., ISHB, ISMB, ISCH, ISA, or built-up section) from the steel tables.
   - Initial choice may be based on an assumed allowable compressive stress or experience.
4. **Obtain Sectional Properties:**
   From standard steel tables, note the following:
   - Area 'A'
   - Moment of inertia I_x, I_y
   - Radius of gyration r_x, r_y
   - Least radius of gyration r_{min}
5. **Determine Effective Length (Le):**

   Le = K × L

   Where, L = actual unsupported length,

   K = effective length factor depending on end restraints.

End Condition	Effective Length (Le)
Both ends hinged	1.0L
Both ends fixed	0.65L
One end fixed, other hinged	0.8L
One end fixed, other free	2.0L

6. **Compute Slenderness Ratio:**

$$\lambda = \frac{Le}{rmin}$$

This parameter governs the column's susceptibility to buckling.

7. **Determine Non-Dimensional Slenderness Parameter:**

Ensure:

$$\lambda e = \sqrt{\frac{fy}{fcc}}$$

or as defined in **Clause 7.1.2.1** of IS 800 : 2007.
It is used to locate the design compressive stress f_{cd} from design curves.

8. **Find Design Compressive Stress (f_{cd}):**
   - Using the appropriate buckling curve (a, b, c, or d) depending on the type of cross-section and buckling axis (Table 10, IS 800: 2007).
   - From Table 9 or Annex E, obtain f_{cd} corresponding to the computed slenderness ratio.

9. **Calculate Design Axial Strength:**

$P_d = A \times f_{cd}$
Where, A = gross cross-sectional area (mm²),
f_{cd} = design compressive stress (MPa).

10. **Check for Adequacy:**
The section is safe if:

Pd ≥ Pu

If not safe, choose a heavier section or provide additional bracing to reduce slenderness ratio and repeat the calculations.

Space to Write Stepwise Procedure

X. Conclusions:

XI. Practical Related Questions:

(Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO. Write answers of minimum three questions.)

1. Define slenderness ratio and its significance.
2. Classify columns based on IS 800:2007.
3. Give examples of compression members in real structures.
4. A column has a factored axial load of 600 kN. Select ISMB 250 with A = 4880 mm² and f_{cd} = 120 MPa. Is the section safe?
5. A column has L = 4 m, Both ends pinned, r_{min} = 40 mm. Find slenderness ratio.
6. A column is subjected to an axial load of 500 kN. ISMB 300 (A=6171 mm²) is used. f_{cd} = 121 MPa. Check safety.

Space to Write Answers

XII. References / Suggestions for further Reading:

- IS 800: 2007: General Construction in Steel - Code of Practice.
- IS 808: 1989: Dimensions for Hot Rolled Steel Beam, Column, Channel and Angle Sections.

XIII. Assessment Scheme:

Sr. No.	Performance Indicators	Weightage
A.	**Process Related (15 marks)**	**60%**
1.	Use of IS 800:2007 and IS 808: 1989 Steel table.	40%
2.	Precision in writing and neatness.	20%
B.	**Product Related (10 marks)**	**40%**
3.	Interpretation of design procedure.	10%
4.	Answers to practical related questions.	10%
5.	Timely submission and addressing identified COs (Completeness, accuracy of suggestions)	20%
C.	**Total marks (25 marks)**	**100%**

Marks Obtained			**Dated sign of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No: 25 Prepare a report on a site visit for joints in steel structures.

I. Practical Significance:

The primary objective of this visit is to gain familiarity with the industrial environment and acquire practical knowledge of construction processes. The demand for steel in the construction industry is continuously increasing due to several factors, including cost-effectiveness, eco-friendliness, safety, and efficiency. Another important focus of the visit is to understand various structural connections, such as bolted and welded joints, as well as roof trusses used in steel structures. For civil engineering students, observing how these structures are constructed is particularly engaging. This visit will provide students with a clear understanding of the significance of different components of industrial buildings. It also offers an excellent opportunity to gain comprehensive insight into industrial practices. Overall, this practical experience will enhance students' knowledge about steel components and their applications in construction.

II. Industry/Employer expected outcome(s):

- This practical is designed to develop the following skills aligned with the industry-identified competency: ***"Effective execution of on-site activities with the required level of performance."***
  a. Observation skill.
  b. Ability to understand the joints in steel structures.
  c. Ability to correlate the field work with the theoretical aspects of the course work.
  d. Ability to inspect construction site.
  e. Ability to understand points of supervision for Steel construction.

III. Course Level Learning Outcome (COs):

- CO5 - Design the connections for the given steel joints.

IV. Laboratory Learning Outcome (LLO):

- LLO 25.1 - Inspecting the joints in Steel structures and write a detailed report on it.

V. Relevant Affective Domain related Outcome(s):

- Adhere to safety protocols.
- Demonstrate leadership and teamwork skills.
- Uphold ethical standards in practice.

VI. Relevant Theoretical Background:

- **Site Visit:** It is the process of inspecting the site before erection to ensure the accurate implementation of the structural drawings on site.
- **Objectives of the Site Visit:**
  1. To understand how theoretical knowledge is applied in practical situations.
  2. To observe various activities and techniques carried out on the construction site.
  3. To experience the actual site conditions and recognize the importance of safety.
  4. To examine complex detailing at the joints of structural members.
- **Expected Outcomes of the Site Visit:**

1. The teacher should divide the total number of students into groups, ensuring that each group can be assigned a specific data collection task.
2. Before the site visit, the teacher should assign tasks to each group.
3. During the site visit, each group will observe and record information related to their assigned task. (A sample list of data to be collected is provided below; the teacher may add additional points that would be beneficial for the students.)
4. It is recommended that each group carry a three-meter metallic tape to measure the required dimensions.

- **Data to be Collected for connections during Site Visit:**
  - Identify types of sections.
  - Understand properties of sections used.
  - Identify type of truss and its span.
  - Measure bolt diameter used.
  - Write total number of column supports.
  - Identify type of roof covering.
  - For inclined braces write type of section used.
  - Write size of section used for it.
  - Check thickness of gusset plate and write it.
  - Count number of cleat angles.
  - Write size of cleat angle.
  - Write weld length and weld size.
  - Write types of connections in Foot Bridge.
- The teacher and students should check connections provided for various structural elements by referring to the blueprints or working drawings available at the site.
- All groups should compile their collected data to prepare a comprehensive site visit report, which must include a minimum of four relevant photographs.
- Personal photographs, such as selfies, should not be included in the visit report.

VII. Required resources/equipment:

S.N.	Resource required	Particulars	Quantity
1.	Steel structure construction site nearby college premises	…………………………..	Total number of students

VIII. Precautions to be followed:

- Every student must strictly follow the instructions given by the site engineer.
- All necessary safety precautions should be observed as per the site's safety guidelines.
- Students should wear the prescribed college uniform (if applicable), along with safety shoes, a cap, sunglasses, and must carry water bottles.
- Exercise caution while walking on or beneath formwork structures.
- Extra care must be taken when visiting high-rise structures or buildings.
- Students are strictly prohibited from operating any switches, equipment, or machinery on site.

- While taking photographs, students should remain orderly and avoid rushing or causing disturbances.
- Taking selfies on-site is not allowed under any circumstances.

X. Procedure:

1. The institute should contact the site authorities in advance to confirm the date of the visit.
2. A formal request letter, signed by the Principal, must be prepared and submitted to the site authorities.
3. Students must procure the structural drawings of the site before the visit.
4. The construction site should be visited as per the scheduled date and time.
5. Students are expected to observe and record relevant site details during the visit.
6. After the visit, the institute should send a letter of thanks to the site authorities for their support and cooperation.

Space to Write Visit Report

Title of the Visit:

Date of visit:

Name of site/Project:

Address of site:

Faculty Coordinator:

Name of site engineer:

Name of Architecture:

Name of structural consultant:

Type and description of structure:

Detail Report:

X. Photographs (Minimum four):

Photo-1:

Photo-2:

Photo-3:

Photo-4:

XI. Assessment Scheme:

Sr. No.	Performance Indicators	Weightage
A.	**Process Related (15 marks)**	**60%**
1.	Interpretation of given data	20%
2.	Writing visit report	30%
3.	Teamwork and collaboration	10%
B.	**Product Related (10 marks)**	**40%**
4.	Interpretation of given data.	20%
5.	Timely submission and addressing identified COs (Completeness, accuracy of suggestions)	20%
C.	**Total marks (25 marks)**	**100%**

Marks Obtained			Dated sign of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	