I

Name _____

Roll No. _____ Year 20____20____

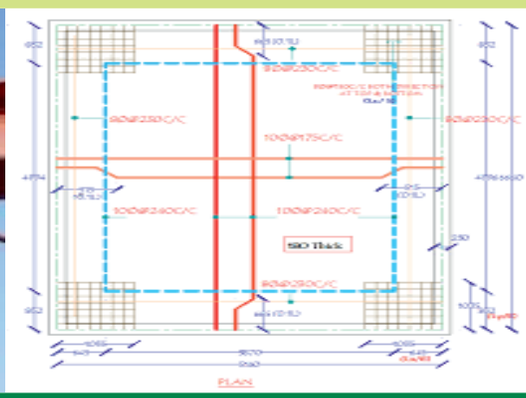
Exam Seat No. _____

CIVIL GROUP | SEMESTER - V | DIPLOMA IN ENGINEERING AND TECHNOLOGY

A LABORATORY MANUAL

FOR

DESIGN OF STEEL AND RCC STRUCTURES (22502)



MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION, MUMBAI

(Autonomous) (ISO 9001 : 2015) (ISO / IEC 27001 : 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 changing technological and 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 programmes.

CORE VALUES

MSBTE believes in the followings:

- Education industry produces live products.
- Market requirements do not wait for curriculum changes.
- Question paper is the reflector of academic standards of educational organization.
- Well designed curriculum needs effective implementation too.
- Competency based curriculum is the backbone of need based program.
- Technical skills do need support of life skills.
- Best teachers are the national assets.
- Effective teaching learning process is impossible without learning resources.

A Laboratory Manual

for

Design of Steel and RCC Structures

(22502)

Semester – V

(CE, CR, CS)

Maharashtra State
Board of Technical Education, Mumbai
(Autonomous) (ISO:9001:2015) (ISO/IEC 27001:2013)

Maharashtra State Board of Technical Education,
(Autonomous) (ISO:9001:2015) (ISO/IEC 27001 : 2013)
4th Floor, Government Polytechnic Building, 49, Kherwadi,
Bandra (East), Mumbai - 400051.
(Printed on May,2019)

Maharashtra State
Board of Technical Education
Certificate

This is to certify that Mr. / Ms. …….

Roll No…….of Fifth Semester of Diploma in ……. of Institute ……..

(Code……..) has attained predefined practical outcomes (PROs) satisfactorily in course **Design of Steel and RCC Structures (22502)** for the academic year 20…….to 20…..... as prescribed in the curriculum.

Place ……. Enrollment No……

Date:…..... Exam Seat No. …….....

Course Teacher **Head of Department** **Principal**

Seal of the Institute

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 programmes with outcome-base 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 'I' scheme laboratory manual development team designed the practicals to ***focus*** on the ***outcomes***, rather than the traditional age old practice of conducting practicals to 'verify the theory' (which may become a byproduct along the way).

This 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 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 competency, industry relevant skills, course outcomes and practical 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.

Design of Steel and RCC Structures is important as it is the methodical investigation of the stability, strength and rigidity of structures. The basic objective in structural analysis and design is to produce a structure capable of resisting all applied loads without failure

during its intended life. Structural engineering is one of the most fundamental engineering disciplines because it deals directly with the structural integrity and strength of a building or structure. Thus all construction projects must utilize the principles of structural engineering in order for the new building or structure to bear its own load and to be able to withstand the demands that will be placed upon it. Structures must be designed so that they can withstand their own weight as well as the loads and pressures that will be placed upon them. Structural engineers provide crucial information about structural elements such as foundations, columns, beams, slabs etc. A structure that does not consider structural engineering in its design runs the risk of collapsing under its own weight or due to external loads acting on it.

Although best possible care has been taken to check for errors (if any) in this 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 Outcomes (POs) to be achieved through practicals of this course:

PO 1. Basic knowledge: Apply knowledge of basic mathematics, science and basic engineering to solve the broad-based Civil engineering problems.

PO 2. Discipline knowledge: Apply Civil engineering knowledge to solve broad-based Civil engineering related problems.

PO 3. Experiments and practice: Plan to perform experiments and practices to use the results to solve the broad-based Civil engineering problems.

PO 4. Engineering tools: Apply relevant Civil technologies and tools with an understanding of the limitations.

PO 5. The engineer and society: Assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to practice in field of Civil engineering.

PO 6. Environment and sustainability: Apply Civil engineering solutions also for sustainable development practices in societal and environmental contexts.

PO 7. Ethics: Apply ethical principles for commitment to professional ethics, responsibilities and norms of the practice also in the field of Civil engineering.

PO 8. Individual and Team Work: Function effectively as leader and team member in diverse / multidisciplinary teams.

PO 9. Communication: Communicate effectively in oral and written form.

PO 10. Life-long learning: Engage in independent and life-long learning activities in the context of technological changes also in the Civil engineering and allied industry.

PSO 1 Construction Planning and Designing: Perform optimal civil engineering construction, planning and designing activities of desired quality at optimal cost.

PSO 2 Construction Execution and Maintenance: Execute civil engineering construction and maintenance using relevant materials and equipment.

Practical- Course Outcome Matrix

Course Outcomes (COs)

a. Use steel table and IS code 800:2007 at work site.
b. Design the connections for the given steel joints.
c. Analysis and design of singly reinforced rectangular beams.
d. Design of shear reinforcement and development length for beam and slabs.
e. Design various slabs for the given edge condition.
f. Design of axially loaded short columns and footings.

S. No.	Practical Outcome	CO a.	CO b.	CO c.	CO d.	CO e.	CO f.
1.	Draw five standard rolled steel sections showing all details.	√	--	--	--	--	--
2.	Write five IS clauses related to load from IS 875:1987.	√	--	--	--	--	--
3.	Draw five commonly used built up sections.	√	--	--	--	--	--
4.	Write five IS clauses related to joints in steel structure from IS 800:2007.	--	√	--	--	--	--
5.	Draw types of bolts with their modes of failure.	--	√	--	--	--	--
6.	Design a bolted connection for the given data and compare it with design using open source software/IS code.	--	√	--	--	--	--
7.	Draw types of welds and types of welded joints.	--	√	--	--	--	--
8.	Draw modes of failure for bolted connections.	--	√	--	--	--	--
9.	Write five IS clauses related to partial safety factors, characteristic strengths, characteristic load and design load from IS 456:2000.	--	--	√	--	--	--
10.	Draw cross section, strain –stress diagram for singly reinforced section giving design parameters and constants.	--	--	√	--	--	--
11.	Draw stress block diagram for Under-reinforced, Over-reinforced and Balanced sections showing all details.	--	--	√	--	--	--
12.	Write five IS clauses related to shear reinforcement in beams and slabs from IS 456:2000.	--	--	--	√	--	--
13.	Write the procedure to calculate development length of main reinforcement in slabs and beams.	--	--	--	√	--	--
14.	Write four IS clauses related to each for slab, beam and column from IS 456:2000.	--	--	√	--	√	--
15.	Draw diagrams showing transfer of loads from one way simply supported slab and two way simply supported slab to the supporting beams as per IS 456:2000.	--	--	--	--	√	--

S. No.	Practical Outcome	CO a.	CO b.	CO c.	CO d.	CO e.	CO f.
16.	Draw the table showing details of deflected shape along with effective length of column as per IS 456:2000.	--	--	--	--	--	√
17.	Design of a welded connection for the given data and compare it using open source software/IS code.	--	√	--	--	--	--
18.	Draw reinforcement detailing of dog legged stair.	--	--	--	--	√	--
19.	Check the given drawing as per IS 456:2000 specifications with respect to reinforcement detailing. (Working drawing / Blue print should be collected from the suitable site.)	--	--	√	√	√	√
20.	Design one cantilever slab from the given data.	--	--	--	--	√	--
21.	Design a one way simply supported slab from the given data.	--	--	--	--	√	--
22.	Design a two way simply supported slab from the given data.	--	--	--	--	√	--
23.	Design the beam/s each supporting cantilever slab, one way simply supported slab and two way simply supported slab from the given data.	--	--	√	--	--	--
24.	Design one axially loaded short column each supporting two given beams (corner column), three beams and four beams from the given field situation from the given data.	--	--	--	--	--	√
25.	Design footing for axially loaded short column designed in Sr. no.24.	--	--	--	--	--	√
26.	Draw the reinforcement details for cantilever slab, one way simply supported slab and two way simply supported slab designed in Sr. no. 20 to 22.	--	--	--	--	√	--
27.	Draw the reinforcement details for the beam, column and footing designed in Sr. no 23 to 25.	--	--	√	--	--	√
28.	Prepare a report on site visit for joints in Steel structures.	√	√	--	--	--	--
29.	Prepare a report on site visit for reinforcement detailing for various structural elements.	--	--	√	√	√	√

List of Industry Relevant Skills

The following industry relevant skills of the competency **'Use the concepts of Steel and RCC structure design with Limit State Method at the site'** are expected to be developed in you by undertaking the practicals of this laboratory manual.

1. Identify and draw different types of steel sections.
2. Understand, interpret and design the given structural component using relevant IS Code.
3. Preparing the working drawing of structural design using software.
4. Detailing and placing of reinforcement for the given structural component on site.

Brief Guidelines to Teachers

Hints regarding strategies to be used:

1. Teacher shall explain the prior concepts to the students of the practical emphasizing of the skills which the student should achieve.
2. Teachers should give opportunity to students for hands-on after the demonstration.
3. Teacher should give relevant information (including safety measures) to students prior to visit arranged for effective utilization of time and understanding.
4. Teachers shall organize the work in the group and ensure it's timely completion.
5. Teacher may provide additional knowledge and skills to the students even though not covered in the manual but are expected from the students by the industries.
6. Assess the skill achievement of the students and COs of each unit.
7. One or two questions ought to be added in each practical for different batches. For this teachers can maintain various practical related question banks for each course.
8. 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.
9. 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.
10. During practical, ensure that each student gets chance and takes active part in designing the structural elements.
11. Teacher ought to assess the performance of students continuously according to the MSBTE guidelines.
12. Teacher should distribute all the questions among all the three batches so as to attempt all questions. It is recommended that every year the combination of question must be changed for each batch.
13. Preferably teacher should guide students to come along with separate blue print / working drawing for each batch.
14. Teacher should divide each batch into group of four to five students.

Instructions for Students

1. For effective implementation and attainment of practical outcomes, in the beginning it-self of each practical, students 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, internet websites etc.
3. Student should not hesitate to ask any difficulties they face during the conduct of practical /visits.
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 type of precautionary measures by students during site visit.
10. Students should take photographs (which may be different for each student) on their own for deep understanding of the concepts and same should be attached (pasted in separate sheet) in respective practical/visit.
11. Each student must follow the instructions given by the site engineer during site visit.
12. For site visit students should wear college uniform (if any), college I card, safety shoes, cap, sun glasses and should carry water bottles.
13. Students must take precautions while walking on formwork and below the formwork on site.
14. Special precautions must be taken if site visit is to be arranged for high rise structures / buildings.
15. On site, do not operate switches of any of the equipment / machinery present on site.
16. No students take selfie photograph on site.

Content Page

List of Practicals and Progressive Assessment Sheet

Name of the Student- _____ Roll No. _____

Sr. No	Title of the Practical	Page No.	Date of Performance	Date of Submission	Assessment Marks (25)	Dated Sign. of Teacher	Remark (If Any)
13	Write the procedure to calculate development length of main reinforcement in slabs and beams.	75					
14	Write four IS clauses related to each for slab, beam and column from IS 456:2000.	83					
15	Draw diagrams showing transfer of loads from one way simply supported slab and two way simply supported slab to the supporting beams as per IS 456:2000.	92					
16	Draw the table showing details of deflected shape along with effective length of column as per IS 456:2000.	97					
17	Design of a welded connection for the given data and compare it using open source software/IS code.	103					
18*	Draw reinforcement detailing of dog legged stair.	111					
19	Check the given drawing as per IS 456:2000 specifications with respect to reinforcement detailing. (Working drawing / Blue print should be collected from the suitable site.)	116					
20*	Design one cantilever slab from the given data.	122					
21*	Design a one way simply supported slab from the given data.	132					
22*	Design a two way simply supported slab from the given data.	143					

Sr. No	Title of the Practical	Page No.	Date of Performance	Date of Submission	Assessment Marks (25)	Dated Sign. of Teacher	Remark (If Any)
23*	Design the beam/s each supporting cantilever slab, one way simply supported slab and two way simply supported slab from the given data.	152					
24*	Design one axially loaded short column each supporting two given beams (corner column), three beams and four beams from the given field situation from the given data.	165					
25*	Design footing for axially loaded short column designed in Sr. no. 24.	176					
26*#	Draw the reinforcement details for cantilever slab, one way simply supported slab and two way simply supported slab designed in Sr. no. 20 to 22.	188					
27*#	Draw the reinforcement details for the beam, column and footing designed in Sr. no 23 to 25.	196					
28	Prepare a report on site visit for joints in Steel structures.	203					
29*	Prepare a report on site visit for reinforcement detailing for various structural elements.	211					
Total							

1) ***The term work should consist of manual, A3 size sketchbook and A2 size drawing sheets.***
2) ***A judicial mix of minimum eight (8) or more practical are to be performed from Sr. No. 1 to 18 and minimum nine (9) or more practical are to be performed from Sr. No. 19 to 29 out of which Sr. Nos. marked with' (*)' are compulsory i.e. total minimum seventeen (17) practical or more.***
3) ***Use A3 size sketchbook for Sr. No. 1,3,5,7,8,10,11,16,17,19.***
4) ***Collect suitable working drawing /blue print from the site for the data required for the Sr.No.19 to 25 preferably separate drawing for each batch.***
5) ***For Sr. No. 23 and 24, divide each batch into three groups. Each group will design only one type of beam and one type of column from the given types so that all types of beams and columns will get designed.***
6) ***For Sr. No. marked with (#), use AutoCAD software for drawing.***

Note: To be transferred to Proforma of CIAAN-2017.

Practical No. 1: Draw five standard rolled steel sections showing all details

I. Practical Significance

In actual practice for design purpose, sectional properties of the section are required. These sectional properties help to suggest the section which will be safe and economical for given loading condition. These sectional properties are given in steel table with certain symbol. This practical will help students to understand different notations used for different properties and drawing of sections will also helpful to the students to know standard shapes of the sections.

II. Relevant Program Outcomes

PO. 2 ***Discipline knowledge****: An ability to apply Civil engineering knowledge to solve broad-based Civil engineering related problems.*

PO. 4 ***Engineering Tools:*** *An ability to apply relevant civil technologies and tools with an understanding of the limitations.*

PO. 8 ***Individual and Team Work:*** *Function effectively as leader and team member in diverse /multidisciplinary team*

PO. 9 ***Communication:*** *An ability to communicate effectively in oral and written form.*

III. Relevant Course Outcomes

a. Use steel table and IS code 800:2007 at work site.

IV. Practical Outcome

Draw five Standard Rolled Steel Sections showing all details.

V. Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency, ***"Proper selection of section for the various situations."***

a. Observation skill.
b. Ability to suggest the different types of sections for various end conditions.
c. Ability of classifying sections based on their designation.

VI. Relevant Affective domain related

a. Practice precision in drawing, neatness and cleanliness.
b. Demonstrate working as a leader / a team member.

VII. Minimum Theoretical Background

Bureau of Indian Standard (BIS): The **Bureau of Indian Standards** (**BIS**) is the national Standards Body of India working under the aegis of Ministry of Consumer Affairs, Food and Public Distribution, Government of India. One of the major functions of the Bureau is the formulation, recognition and promotion of the Indian Standards. BIS sets

the standards of quality and uniformity in various engineering products, processes and practices in the jurisdiction of India.

Standard Steel Sections: The steel sections manufactured in rolling mills and used as structural members are known as rolled steel sections. The steel sections are named according to their cross sectional shapes. These are specific cross-sectional shapes to be used for the members in steel structures as recommended by the Bureau of Indian Standard (BIS).

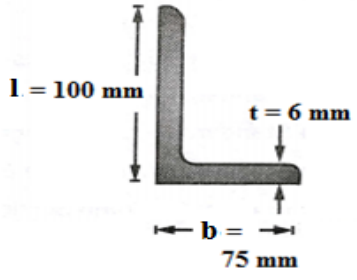
Steel tables are the books published by the Bureau of Indian Standard (BIS) specifying all the standard steel sections and there sectional properties like dimensions, weight/m, area, radius of gyration, section modulus and moment of inertia etc. required at the time of design

Common abbreviations used for steel sections:

A	- Angle	J	- Junior
B	- Beam	L	- Light
C	- Channel	M	- Medium
H	- Heavy	N	- Normal
IS	- Indian Standard	W	- Wide flange

VIII. Experimental Set-up

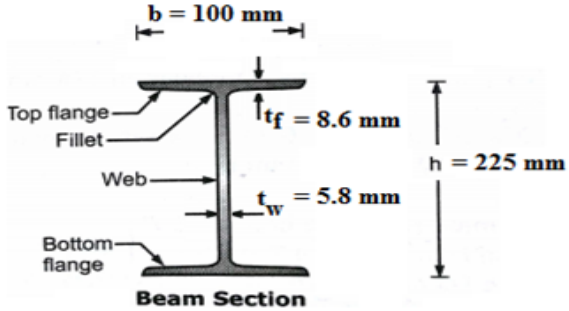
e.g. ISA 100 X 75 X 6mm = ISA l X b X t



Here,
l = length of longer leg
b = width of shorter leg
t = thickness of section

Unequal Angle Section

e.g. For ISLB 225 = ISLB (h)



Beam Section

Here,
b = Width of Flange
h = Depth of section
t_f = Thickness of Flange
t_w = Thickness of Web

Extract of steel table for Rolled Steel Beams

Designation	Wt/m	Sect-ional Area	Depth of section	Width of flange	Thick-ness of flange	Thick-ness of web	Moment of Inertia		Radii of Gyration		Moduli of section	
	w (kg)	a (cm^2)	h (mm)	b (mm)	t_f (mm)	t_w (mm)	I_{xx} (cm^4)	I_{yy} (cm^4)	r_{xx} (cm)	r_{yy} (cm)	Z_{xx} (cm^3)	Z_{yy} (cm^3)
ISLB 225	23.5	29.92	225	100	8.6	5.8	2501.9	112.7	9.15	1.94	222.4	22.5
ISMB 225	31.2	39.72	225	110	11.8	6.5	3441.8	218.3	9.31	2.34	305.9	39.7

IX. Resources required

Sr. No.	Particulars	Specification	Quantity	Remark
1	Steel Table	--------	1 No.	Per batch
2	A3 size sketchbook and Drawing tools (scale, pencil, eraser etc.)	--------	1set	Per student

X. Procedure

1. Teacher should give list of five sections to be drawn consisting of all types of sections.
2. Discuss the types of sections and categories according to their designation with batch mates.
3. Students should identify the given sections from steel table and should draw it in sketchbook by mentioning its properties. (Refer Point no. VIII experimental set-up.)

XI. Precautions to be followed

1. Write the properties of given steel section carefully as the section of same height is available in steel table under different category.

   e.g. ISLB 225, ISMB 225

2. Sketches should be drawn with appropriate height/depth (h/d) ratio along with the font size used for labeling.

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 full forms of ISA, ISLB, ISMC, and ISNT.

2. Write properties Weight/m, area, depth of section, thickness of flange and web of two sections. *(Teacher should provide any two sections).*
3. Identify minimum three sections used for steel furniture in your college premises such as drawing table, stool, door gate etc.
4. Write the sizes of sections identified in Que. No. 3 and compare it with steel table.
5. Centre of gravity about x and y axis for equal angle section is _____ (same / different).
6. Suggest three channel sections from steel table whose radius of gyration is 15% to 20 % more than the radius of gyration = _____. *(Teacher should provide value of radius of gyration.)*
7. Suggest three I (beam) section from steel table whose modulus of section is 15% to 20 % more than the modulus of section = _____. *(Teacher should provide value of modulus of section.)*
8. Suggest three equal angle sections from steel table whose area is 15% to 20 % more than an area = _____. *(Teacher should provide value of area of section.)*
9. Suggest suitable I section which will be economical on site if available sections are - ISMB 100 and ISMB 125. The selected section should have c/s area more than = 1400 mm^2. *(Student has to refer steel table to get an area of ISMB 100 and ISMB 125.)*
10. State minimum radius of gyration for given unequal angle section. *(Teacher should provide min two angle sections).*

Space to Write Answers

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XIII. References / Suggestions for further Reading

Sr. No.	Title of Book/ Website Links	Author	Publication
1.	Steel Table	---------	---------
2.	IS 800 : 2007	---------	---------

XIV. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related:15 Marks		**60%**
1	Use of steel table.	25%
2	Precision in sketchbook, neatness, cleanliness.	30 %
3	Working in team.	5 %
Product related:10 Marks		**40%**
3	Interpretation of given data.	10%
4	Answers to practical related questions.	20%
5	Submission of report in time.	10%
Total: 25 Marks		**100%**

List of Student Team Members (Roll No.)

1. ……
2. ……
3. ……
4. ……

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

Practical No. 2: Write five IS clauses related to load from IS 875:1987

I. Practical Significance

The force is exerted by a body on its supporting structure. It is very difficult to anticipate the actual load to which structure is subjected throughout the life of structure. Dead load, live load, wind load, earthquake load are some of the common types of loads on a structure. This practical will help the students to understand salient provisions of IS: 875-1987 for design loads other than earthquake for buildings and structures.

II. Relevant Program Outcomes

PO. 1 ***Basic knowledge:*** *An ability to apply knowledge of basic mathematics, science and engineering to solve the engineering problems.*

PO. 2 ***Discipline knowledge****: An ability to apply discipline - specific knowledge to solve core and / or applied engineering problems.*

PO. 4 ***Engineering tools:*** *Apply relevant Civil technologies and tools with an understanding of the limitations.*

PO. 7 ***Ethics:*** *Apply ethical principles for commitment to professional ethics, responsibilities and norms of the practice also in the field of Civil engineering.*

PO. 8 ***Individual and Team Work:*** *Function effectively as leader and team member in Diverse / multidisciplinary team.*

III. Relevant Course Outcomes

a. Design the connections for the given steel joints.
b. Analysis and design of singly reinforced rectangular beam.
c. Design various slabs for the given edge condition.
d. Design of axially loaded short columns and footings.

IV. Practical Outcome

Write five IS clauses related to load from IS: 875-1987.

V. Competency and Practical Skills

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

a. Know IS clauses for loads.
b. Follow design steps as per IS 456: 2000.

VI. Relevant Affective domain related

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

VII. Minimum Theoretical Background

- Dead load, live load, wind load, earthquake load are some of the common types of loads on a structure.
- Two and more than two types of loads are generally acting on the structure so the combinations of various types of loads are made to determine the final load eg. DL + LL, DL + WL, DL+ LL +WL, DL+EL etc.
- IS: 875-1987 (Part 1 to 5) this is the IS code in which the values of various loads that occur generally on a structure are specified.
- The five parts of the code refer to Dead Load (DL), Imposed Load (LL), Wind Load (WL), Snow Loads and special Loads and Load combinations respectively.

VIII. Resources required

Sr. No.	Particulars	Specification	Quantity	Remark
1	IS 875:1987 (Part 1 to 5)	Code of practice for Design loads (other than Earthquake) for buildings and Structures	1 No.	Per batch

IX. Procedure

1. Take a general browse through the IS code and enter the information in Observation.
2. Study each section with reference to the information asked and enter the information extract accordingly.
3. Write Clause 1 (Page No. 4) of IS: 875-1987 Part1 related to Scope of the code.
4. Write Clause 2 (Page No. 4) of IS: 875-1987 Part1 related to Unit Weights of Common Building Materials.
5. Write Clause 1.1 and 1.2 (Page No. 5) of IS: 875-1987 Part 2 related to Scope of the code.
6. Write Clause 3.1, 3.1.1 and 4.1 of Live Load on floors due to use and occupancy.
7. Write Clause 1.1 (Page No.5) of IS: 875-1987 Part 3 related to Scope of the code.
8. Write Clause 5.3 (Page No. 8) of IS: 875-1987 Part 3 related to Design wind speed.
9. Write Clause 5.4 (Page No. 12) of IS: 875-1987 Part 3 related to Design wind pressure.
10. Write Clause 6.2.1 (Page No. 13) of IS: 875-1987 Part 3 related to wind load on individual members.

X. Precautions to be followed

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

Space to write Clauses

XI. Resources used

Sr. No.	Name of Resource	Broad Specifications		Quantity	Remark
		Make	Details		
1					
2					

XII. Conclusions

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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 the different types of loads to be considered from IS 875:1987.
2. Write unit weight of asbestos sheets.
3. Write unit weight of engineering bricks.
4. Write the live load to be taken for a library floor.
5. Write the live load to be taken for a hospital building floor.
6. Calculate self-weight of an RCC column 230 mm X 500 mm in size and 3.2 m height.
7. Write the value of basic wind speed in Pune.
8. Enlist the load combinations to be considered in final load calculation.
9. Wind loads and live loads are not considered simultaneously. Justify.

Space to Write Answers

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XIV. References / Suggestions for further Reading

Sr. No.	Title of Book/ Website Links	Author	Publication
1.	IS 875:1987(Part 1 to 5) Indian Standard Code for Loading Standards	BIS	-

XV. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related:15 Marks		**60%**
1	Use of IS: 875- 1987	25 %
2	Precision in sketchbook, neatness, cleanliness.	30 %
Product related:10 Marks		**40%**
3	Interpretation of given clauses	5%
4	Answers to practical related questions.	25%
5	Submission of report in time.	10%
Total: 25 Marks		**100%**

List of Student Team Members (Roll No.)

1. ……
2. ……
3. ……
4. ……

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

Practical No. 3: Draw five commonly used built up sections

I. Practical Significance

When the single structural steel section is not capable of taking designed load and in some cases due to restriction in depth of section with respect to head room consideration, in such situation built up sections are provided in steel structures. In actual practice for design purpose, it is necessary to adopt built up sections for columns, roof trusses and beams. The sectional properties such as radius of gyration, section modulus etc. and some other related procedure will make it to select the section which will be safe and economical for given condition. This practical will help to understand different types of built up sections and their specific use as different structural steel members.

II. Relevant Program Outcomes

PO. 2 ***Discipline knowledge****: An ability to apply Civil engineering knowledge to solve broad-based Civil engineering related problems.*

PO. 4 ***Engineering Tools:*** *An ability to apply relevant civil technologies and tools with an understanding of the limitations.*

PO. 8 ***Individual and Team Work:*** *Function effectively as leader and team member in diverse / multidisciplinary team*

PO. 9 ***Communication:*** *An ability to communicate effectively in oral and written form.*

III. Relevant Course Outcomes

a. Use steel table and IS code 800:2007 at work site.

IV. Practical Outcome

Draw five commonly used built up sections.

V. Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency, ***"Proper selection of built up section for the various situations."***

a. Observation skill.
b. Ability to suggest the different types of sections for various end conditions.
c. Ability to select sections based on the situation.

VI. Relevant Affective domain related

a. Practice precision in drawing, neatness and cleanliness.
b. Demonstrate working as a leader / a team member.

VII. Minimum Theoretical Background

Bureau of Indian Standard (BIS): It is the important institution of Government of India that studies the various quality and uniformity parameters in the various engineering products, processes and practices in the country. BIS sets the standards of quality and uniformity in various engineering products, processes and practices in the jurisdiction on India.

Built up Sections

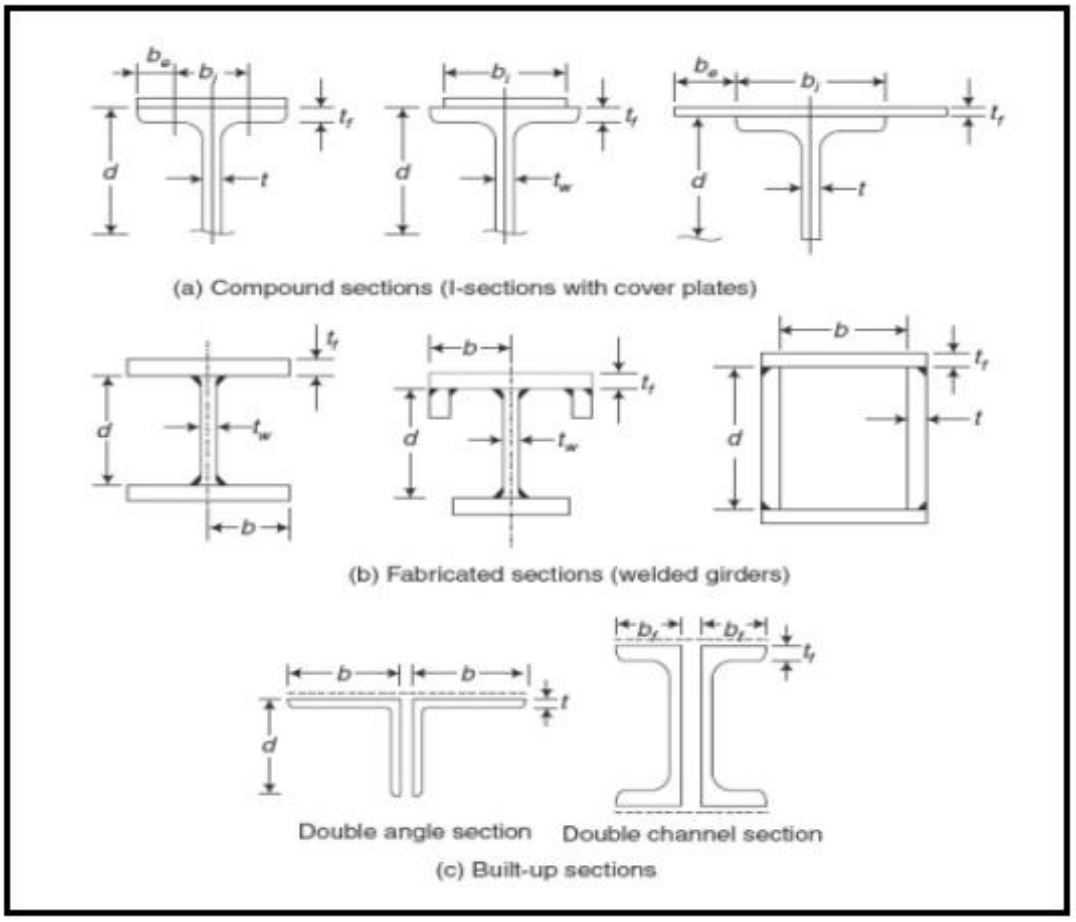
- A built-up beam is also known as compound beam.
- The built-up beams are used when the span, load and corresponding bending moment are of such magnitudes that rolled steel beam section becomes inadequate to provide required section modulus.
- Built-up beams are also used when rolled steel beams are inadequate for limited depth.
- In building construction, the depth of beam is limited by a space provided by the architect.
- Beam of small depth does not provide required section modulus. Therefore, plates are attached to the beams.
- The strength of rolled steel beams is increased by adding plates to its flange which is one of the methods forming built-in section.
- The other method is to compound a number of rolled steel sections themselves.

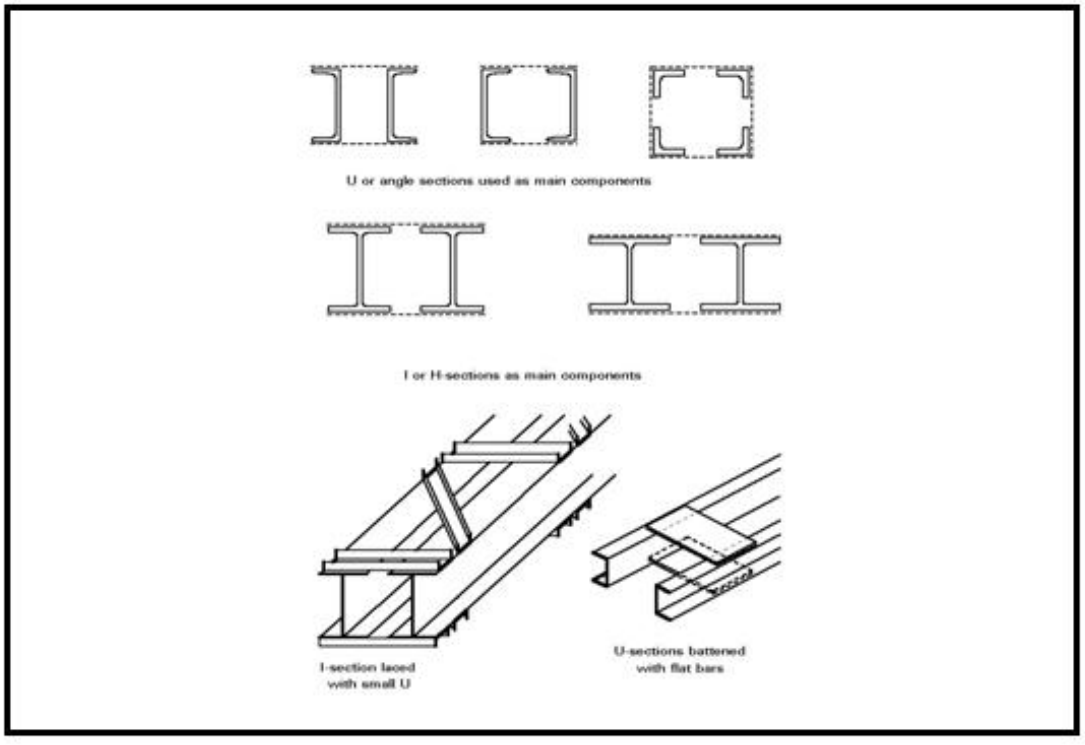
Steel tables are the books published by the Bureau of Indian Standard (BIS) specifying all the standard steel sections and there sectional properties generally required at the time of design like dimensions, weight/m, area, radius of gyration, section modulus and moment of inertia etc.

Commonly used abbreviations:

b - Outstanding width
b_f - Width of flange
d - Depth of section
t_f - Thickness of flange
t_w - Thickness of web

VIII. Experimental Set-up





IX. Resources required

Sr. No.	Particulars	Specification	Quantity	Remark
1	Limit State Design of Steel Structures	Shah V. L. Gore Veena	1 No.	Per 5 students
2	A3 size sketchbook and Drawing tools (scale, pencil, eraser etc.)	--------	1set	Per student

X. Procedure

1. Teacher should give list of five sections to be drawn consisting of all variety of sections.
2. Select the types of sections to be used to prepare built up sections and necessity of it with batch mates.
3. Students should identify the given sections and should draw it in sketchbook by mentioning its properties. (Refer point No. VIII Experimental set-up.)

XI. Precautions to be followed

1. Check the suitability of given steel section.
2. Sketches should be drawn with appropriate height/depth (h/d) ratio along with the font size used for labeling.

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 meaning of built up sections and rolled steel section.
2. Write the situations where built up sections are necessary to design.
3. Identify minimum three sections used for workshop, industrial shed and tower etc. in nearby premises.
4. Write different type of sections used to make built up sections.
5. Does centroid of individual section matches with centroid of built up section? Justify your answer.
6. State the best suited rolled steel section used as tension member in case of roof truss.
7. Prepare and draw built up section using four angle sections.
8. Draw built up section using two channel sections.
9. Draw built up section using beam and channel section.

Space to Write Answers

XIII. References / Suggestions for further Reading

Sr. No.	Title of Book/ Website Links	Author	Publication
1.	Steel Table	---------	---------
2.	IS 800 : 2007		

XIV. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related:15 Marks		**60%**
1	Identify and study the section	25%
2	Precision in sketchbook, neatness, cleanliness.	30 %
3	Working in team.	5 %
Product related:10 Marks		**40%**
3	Interpretation of given data.	10%
4	Answers to practical related questions.	20%
5	Submission of report in time.	10%
Total: 25 Marks		**100%**

List of Student Team Members (Roll No.)

1. ……
2. ……
3. ……
4. ……

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

Practical No. 4: Write five IS clauses related to joints in steel structure from IS 800:2007

I. Practical Significance

The design and detailing requirements for joints between members has been dealt in IS 800:2007. Connection elements consist of components such as cleats, gusset plates, brackets, connecting plates and connectors such as rivets, bolts, pins and welds. The connections in a structure shall be designed so as to be consistent with the assumptions made in the analysis of the structure and comply with the requirements specified in the code. This practical will help the students to understand salient provisions of IS 800:2007 for design of joints in steel structure.

II. Relevant Program Outcomes

PO. 1 Basic knowledge: *An ability to apply knowledge of basic mathematics, science and engineering to solve the engineering problems.*

PO. 2 Discipline knowledge*: An ability to apply discipline - specific knowledge to solve core and/or applied engineering problems.*

PO. 4 Engineering tools: *Apply relevant Civil technologies and tools with an understanding of the limitations.*

PO. 7 Ethics: *Apply ethical principles for commitment to professional ethics, responsibilities and norms of the practice also in the field of Civil engineering.*

PO. 8 Individual and Team Work: *Function effectively as leader and team member in diverse /multidisciplinary team.*

III. Relevant Course Outcomes

a. Use steel table and IS code 800:2007 at work sites.

IV. Practical Outcome

Write five IS clauses related to joints in steel structures from IS: 800-2007.

V. Competency and Practical Skills

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

VI. Relevant Affective domain related

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

VII. Minimum Theoretical Background

- Structural members are connected to one another through bolts or weld.
- Connections shall be capable of transmitting the calculated design actions.
- Ease of fabrication and erection should be considered in the design of connections.
- In general, use of different forms of fasteners to transfer the same force shall be avoided.
- The partial safety factor in the design strength shall be taken as per IS specification.

VIII. Resources required

Sr. No.	Particulars	Specification	Quantity	Remark
1	IS 800:2007	General Construction in Steel – Code of Practice	1 No.	Per batch

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.

X. Precautions to be followed

1. Careful reading for the extract of information is must.
2. Understand the different types of connection for its design.

Space to write Clauses

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XI. Resources used

Sr. No.	Name of Resource	Broad Specifications		Quantity	Remark
		Make	Details		
1					
2					

XII. Conclusions

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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. Define edge distance.
2. Define end distance.
3. State function of tacking fasteners.
4. The distance between the centers 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

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XIV. References / Suggestions for further Reading

Sr. No.	Title of Book/ Website Links	Author	Publication
1.	IS 800:2007 General Construction in Steel – Code of Practice	BIS	-

XV. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related:15 Marks		**60%**
1	Use of IS: 800- 2007	25 %
2	Precision in writing, neatness.	30 %
Product related:10 Marks		**40%**
3	Interpretation of given clauses	5%
4	Answers to practical related questions.	25%
5	Submission of report in time.	10%
Total: 25 Marks		**100%**

List of Student Team Members (Roll No.)

1. ……
2. ……
3. ……
4. ……

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

Practical No. 5: Draw types of bolts with their modes of failure

I. Practical Significance

In actual practice the various elements of a steel structure like tension member, compression member and flexural member are connected by fasteners (connectors). Many a times, built-up sections are provided to meet the requirements of heavy loads and long spans. Such sections also need to be connected together to act in unison as one unit. Only properly connected and detailed members and connections can transfer the forces safely from top to the foundation. Different types of fasteners available for making connections are rivets, bolts, pins, welds. Today, steel structures are constructed with bolting. In the past couple of decades high – strength bolts have become more popular, have replaced rivets and have rendered them obsolete. This practical will help to identify the type of bolt and to understand the failure modes of bolts so that failure can be avoided in future for the structure.

II. Relevant Program Outcomes

PO. 2 ***Discipline knowledge****: An ability to apply Civil engineering knowledge to solve broad-based Civil engineering related problems.*

PO. 4 ***Engineering Tools:*** *An ability to apply relevant civil technologies and tools with an understanding of the limitations.*

PO. 8 ***Individual and Team Work:*** *Function effectively as leader and team member in diverse /multidisciplinary team*

PO. 9 ***Communication:*** *An ability to communicate effectively in oral and written form.*

III. Relevant Course Outcomes

a. Design the connections for the given steel joints.

IV. Practical Outcome

Draw types of bolts with their modes of failure.

V. Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency, ***"Proper selection of type of bolt for the various situations and to understand their failure modes."***

a. Observation skill.
b. Ability to suggest the different types of bolt for various situations.
c. Ability to understand modes of failure for bolts.

VI. Relevant Affective domain related

a. Practice precision in drawing, neatness and cleanliness.
b. Demonstrate working as a leader / a team member.

VII. Minimum Theoretical Background

Bolt: A bolt may be defined as a metal pin with head at one end a shank threaded at the other end to receive a nut.

Types of bolts: There are several types of bolts used to connect the structural elements. However, the commonly used bolts are classified into two types:

(1) Unfinished / ordinary / common / rough / black bolts: These are made from mild steel rods with hexagonal or square head. These are used for light structures subjected to static loads for secondary members such as purlins, bracings, roof trusses etc. They are not recommended for connections subjected to impact load, vibration etc.

(2) High strength bolts: These are made from bars of medium carbon heat treated steel and from alloy steel. These bolts have a tensile strength several times that of ordinary bolt. Due to their high tensile strength as compared to black bolts, a few numbers of bolts are required for making the connection. High strength bolts are most suitable for bridges, for seismic loadings for fatigue loads etc.

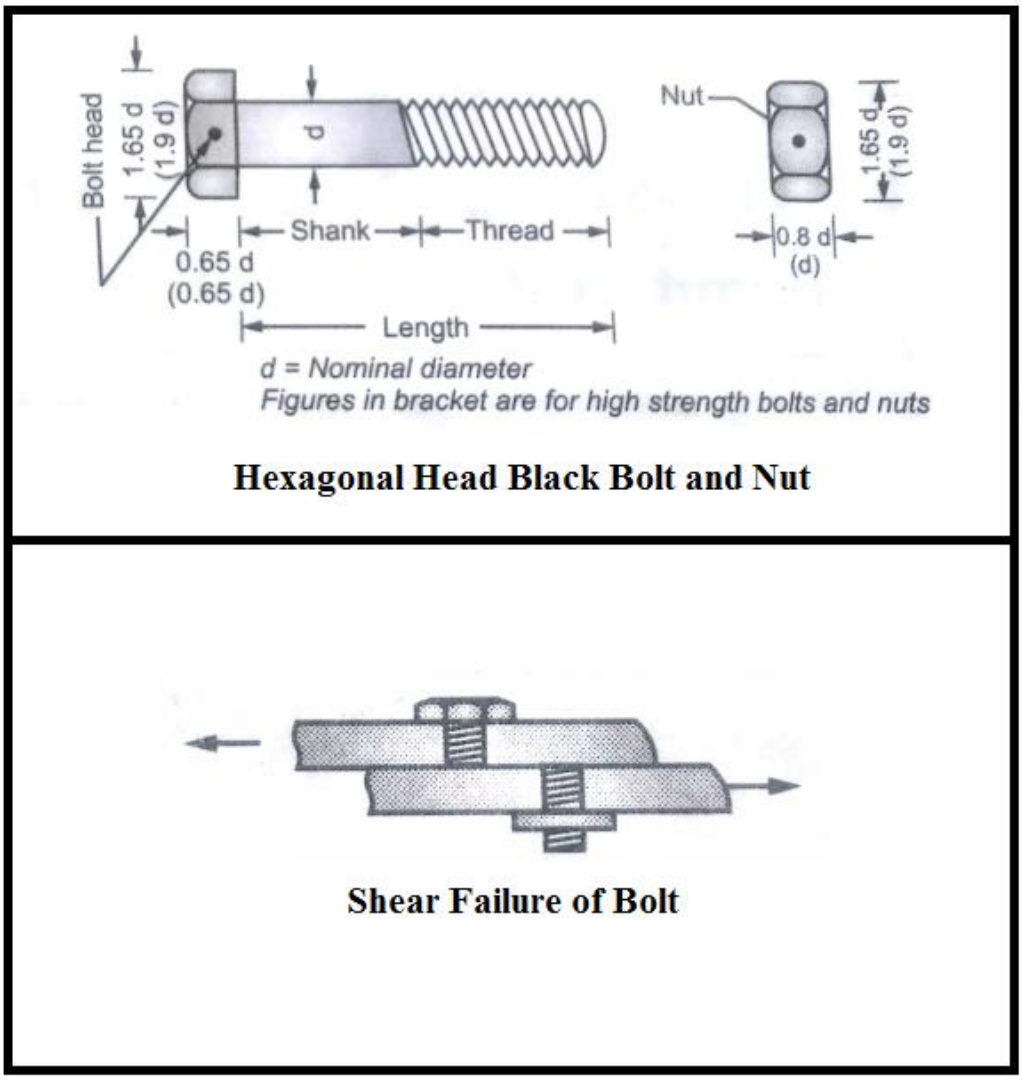
Modes of failure of bolts: Failure of bolts may be caused due to following reasons –

(1) Shear failure of bolts – When two plates slip due to applied forces and the maximum factored shear force in the bolt exceeds the nominal shear capacity of the bolt; shear failure of bolt may take place. It takes place at the bolt shear plane.

(2) Bearing Failure of bolts – The plate may be strong in bearing and the heaviest stressed plate may press the bolt shank. The bolt is crushed around half circumference.

(3) Tension failure of bolts – Bolts subjected to tension may fail at the stress area.

VIII. Experimental Set-up



Hexagonal Head Black Bolt and Nut

Shear Failure of Bolt

IX. Resources required

Sr. No.	Particulars	Specification	Quantity	Remark
1	Limit State Design of Steel Structures	Shah, V. L. Gore	1 No.	Per group of 4 students
2	A3 size sketchbook and Drawing tools (scale, pencil, eraser etc.)	--------	1set	Per student

X. Procedure

1. Teacher should discuss the necessity of bolts and their failure modes with the students.
2. Student should understand the types of bolts along with their properties and failure modes of bolts.
3. Students should draw types of bolts and their failure modes in sketchbook by mentioning its properties. (Refer Point no. VIII experimental set-up.)

XI. Precautions to be followed

1. Understand the difference between different failure modes of bolts.
2. Sketches should be drawn with appropriate height/depth (h/d) ratio along with the font size used for labeling.

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. The number of High strength bolts required for making the connections is less. Justify answer.
2. State the condition when shear failure of bolt occurs.
3. State the condition when bearing failure of bolt occurs.
4. State the condition when axial tensile failure of bolt occurs.
5. State the type of bolts suitable for impact type of loading.
6. State the type of bolts suitable for light structures.
7. Write the material used for making black bolts.
8. Write the material used for making high strength bolts.
9. Enlist the different modes of failure of bolts.

Space to Write Answers

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XIII. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related:15 Marks		**60%**
1	Precision in sketchbook, neatness, cleanliness.	50 %
2	Working in team.	10 %
Product related:10 Marks		**40%**
3	Interpretation of given data.	10%
4	Answers to practical related questions.	20%
5	Submission of report in time.	10%
Total: 25 Marks		**100%**

List of Student Team Members (Roll No.)

1. ……
2. ……
3. ……
4. ……

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

Practical No. 6: Design a bolted connection for the given data and compare it with design using open source software / IS code

I. Practical Significance

Generally the truss members are axially loaded and they are joined through gusset plate by bolting. The centroid of connecting members should meet at a joint to avoid eccentricity. The thickness of gusset plate should be more than the thickness of members meeting at the joint. The joint of the truss is designed, based on number of bolts required to transfer the force. This practical will help the students to identify type of connection and the procedure of design of bolted connection using Limit State Method along with the knowledge of placing of bolts in actual practice.

II. Relevant Program Outcomes

- ***PO. 1 Basic knowledge:*** *An ability to apply knowledge of basic mathematics, science and engineering to solve the engineering problems.*
- ***PO. 2 Discipline knowledge****: An ability to apply discipline - specific knowledge to solve core and / or applied engineering problems.*
- ***PO. 4 Engineering tools:*** *Apply relevant Civil technologies and tools with an understanding of the limitations.*
- ***PO. 7 Ethics:*** *Apply ethical principles for commitment to professional ethics, responsibilities and norms of the practice also in the field of Civil engineering.*
- ***PO. 8 Individual and Team Work:*** *Function effectively as leader and team member in Diverse / multidisciplinary team.*

III. Relevant Course Outcomes

a. Design the connections for the given steel joints.

IV. Practical Outcome

Design a bolted connection for the given data and compare it with design using open source software / IS code.

V. Competency and Practical Skills

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

a. Follow design steps as per IS 800: 2007.
b. Know IS specifications for axially loaded single and double angle sections.

VI. Relevant Affective domain related

a. Demonstrate working as a leader/ team member.

b. Follow ethical practices.

VII. Minimum Theoretical Background

The design of bolted connection consists of calculating design shearing strength of bolt, design bearing strength of bolt, bolt value and no. of bolts required to carry given factored load at the joint.

VIII. Resources required

Sr. No.	Particulars	Specification	Quantity	Remark
1	IS 800: 2007	General Construction in Steel Code of Practice	1 No.	Per batch
2	Shah V. L. Gore Veena	Limit State Design of Steel Structures	1 No.	Per batch

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

   The Design shear strength of Bolt is calculated by using,

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

   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

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

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

Where, k_b is smaller of [$\frac{e}{(3do)}$; $(\frac{p}{(3do)}) - 0.25$; $\frac{fub}{fup}$; 1.0]

In design k_b is normally taken equal to unity

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

d_o = Diameter of the bolt hole

d = Nominal diameter of the bolt

f_{ub} = Ultimate tensile stress of bolt

fu = 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

d) Calculate number of bolts (n) as

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

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

X. Precautions to be followed

1. Identify the type of connection from the given data.
2. Design the connection considering IS requirement

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XI. Resources used

Sr. No.	Name of Resource	Broad Specifications		Quantity	Remark
		Make	Details		
1					
2					

XII. Results (Summery of Design)

No. of bolts =

Arrangement of bolts =

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. Bolts are classified as i) _____ ii) _____ .
2. State types of bolted joints.
3. Write 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. Write two disadvantages of bolted connection.
9. Draw typical plan and section of double bolted lap joint.

Space to Write Answers

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XIV. References / Suggestions for further Reading

Sr. No.	Title of Book/ Website Links	Author	Publication
2.	Limit State Design of Steel Structures	Dr. V. L. Shah and Gore Veena	Structures Publications, Pune. ISBN-13:9788190371711
3.	IS 800:2007 General Construction in Steel Code of Practice	BIS	-

XV. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related:15 Marks		**60%**
1	Design of bolted connection	30 %
2	Proper calculation	30 %
Product related:10 Marks		**40%**
3	Design details	5%
4	Answers to practical related questions.	25%
5	Submission of report in time.	10%
Total: 25 Marks		**100%**

List of Student Team Members (Roll No.)

1. ……
2. ……
3. ……
4. ……

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

Practical No. 7: Draw types of welds and types of welded joints

I. Practical Significance

In actual practice the various elements of a steel structure like tension member, compression member and flexural member are connected by fasteners (connectors). Many a times, built-up sections are provided to meet the requirements of heavy loads and long spans. Such sections also need to be connected together to act in unison as one unit. Only properly connected and detailed members and connections can transfer the forces safely from top to the foundation. Different types of fasteners available for making connections are rivets, bolts, pins, welds. Today, steel structures are constructed with welding. This practical will help to identify the type of weld and to understand the type of welded joints.

II. Relevant Program Outcomes

PO. 2 Discipline knowledge*: An ability to apply Civil engineering knowledge to solve broad-based Civil engineering related problems.*

PO. 4 Engineering Tools: *An ability to apply relevant civil technologies and tools with an understanding of the limitations.*

PO. 8 Individual and Team Work: *Function effectively as leader and team member in diverse / multidisciplinary team.*

PO. 9 Communication: *An ability to communicate effectively in oral and written form.*

III. Relevant Course Outcomes

a. Design the connections for the given steel joints.

IV. Practical Outcome

Draw types of welds and types of welded joints.

V. Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency, ***"Proper selection of type of weld for the various situations and type of joint."***

a. Observation skill.
b. Ability to suggest the different types of weld for various situations.
c. Ability to understand type of joints.

VI. Relevant Affective domain related

a. Practice precision in drawing, neatness and cleanliness.
b. Demonstrate working as a leader / a team member.

VII. Minimum Theoretical Background

Weld: It is defined as when two metal parts are joined together by heating the surfaces to the point of melting with a blowpipe, electric arc, or other means, and uniting them by pressing, hammering, etc.

Types of welded joints

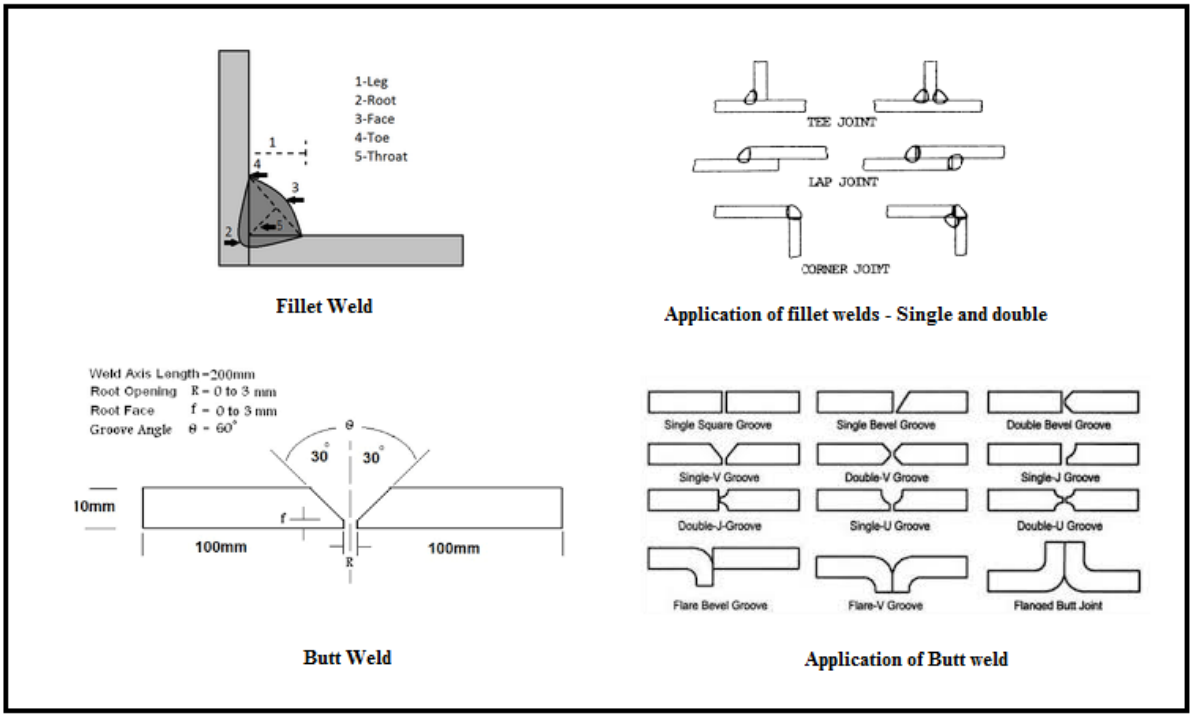
By means of welding, it is possible to make continuous, load bearing joints between the members of a structure.

Fillet welds: Fillet welding refers to the process of joining two pieces of metal together whether they are perpendicular or at an angle. These welds are commonly referred to as Tee

joints which are two pieces of metal perpendicular to each other or Lap joints which are two pieces of metal that overlap and are welded at the edges.

Butt welds: Butt welds are welds where two pieces of metal to be joined are in the same plane and edges to be joined are touching each other. These types of welds require only some kind of preparation and are used with thin sheet metals that can be welded with a single pass. Common issues that can weaken a butt weld are the entrapment of slag, excessive porosity, or cracking.

VIII. Experimental Set-up



IX. Resources required

Sr. No.	Particulars	Specification	Quantity	Remark
1	Limit State Design of Steel Structures	By Shah, V. L. Gore	1 No.	Per group of 4 students
2	A3 size sketchbook and Drawing tools (scale, pencil, eraser etc.)	--------	1set	Per student

X. Procedure

1. Teacher should discuss the necessity of welds and their joints with the students.
2. Student should understand the types of welds along with their joints.
3. Students should draw types of welds and their joints in sketchbook by mentioning its properties. (Refer point no. VIII Experimental set-up.)

XI. Precautions to be followed

1. Understand the different types of welds and their joints neatly.
2. Sketches should be drawn with appropriate height/depth (h/d) ratio along with the font size used for labeling.

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. Define size of fillet weld.
2. Define throat thickness of fillet weld.
3. State the condition where butt welds are suitable.
4. State the condition where fillet welds are suitable.
5. State the reference codes for welding.
6. Write advantages of welded connections.
7. Write disadvantages of welded connection.
8. State two types of welded joints.
9. Write two situations where welded connections are most suitable compared to bolted connections.

Space to Write Answers

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XIII. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related:15 Marks		**60%**
1	Precision in sketchbook, neatness, cleanliness.	50 %
2	Working in team.	10 %
Product related:10 Marks		**40%**
3	Interpretation of given data.	10%
4	Answers to practical related questions.	20%
5	Submission of report in time.	10%
Total: 25 Marks		**100%**

List of Student Team Members (Roll No.)

1. ……
2. ……
3. ……
4. ……

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

Practical No. 8: Draw modes of failure for bolted connections

I. Practical Significance

Often much attention is not given to the design of connections. If the necessary connections are inadequate, the result will be a poor structure in spite of the most efficiently designed member. Therefore the design of connections must be given due importance. Today, steel structures are constructed with bolting. In the past couple of decades high – strength bolts have become more popular, have replaced rivets and have rendered them obsolete. This practical will help to understand the failure modes of bolted connection so student will be able to design safe connection to avoid failure of the structure.

II. Relevant Program Outcomes

PO. 2 Discipline knowledge*: An ability to apply Civil engineering knowledge to solve broad-based Civil engineering related problems.*

PO. 4 Engineering Tools: *An ability to apply relevant civil technologies and tools with an understanding of the limitations.*

PO. 8 Individual and Team Work: *Function effectively as leader and team member in diverse /multidisciplinary team*

PO. 9 Communication: *An ability to communicate effectively in oral and written form.*

III. Relevant Course Outcomes

a. Design the connections for the given steel joints.

IV. Practical Outcome

Draw modes of failure for bolted connections.

V. Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency, ***"To understand the failure mode of bolted connection."***

a. Observation skill.
b. Ability to understand modes of failure for bolted connection.
c. Ability to design safe connection.

VI. Relevant Affective domain related

a. Practice precision in drawing, neatness and cleanliness.
b. Demonstrate working as a leader / a team member.

VII. Minimum Theoretical Background

In actual practice the various elements of a steel structure like tension member, compression member and flexural member are connected by fasteners (connectors) through gusset plate. Different types of fasteners available for making connections are rivets, bolts, pins, welds. The forces exerted by one element on another are transferred through these fasteners, which should therefore be adequate to transmit the forces safely. So, one should be in position to design the safe connection by considering failure modes of connection.

Modes of failure for bolted connection: The bolted joints may fail in one of the following modes:

(1) Shear failure mode
(2) Tensile failure mode
(3) Bearing failure mode

(1) Shear failure mode

(1.a) Shear failure of bolts: When two plates slip due to applied forces and the maximum factored shear force in the bolt exceeds the nominal shear capacity of the bolt; shear failure of bolt may take place. It takes place at the bolt shear plane.

(1.b) Shear failure of plate: The internal pressure of overdriven (shank length more than the grip) plates placed at a lesser edge distance than specified causes this failure.

(2) Tensile failure mode

(2.a) Tensile failure of bolt: Bolt subjected to tension may fail at the stress area if factored tensile force is greater than the tensile capacity of the bolt.

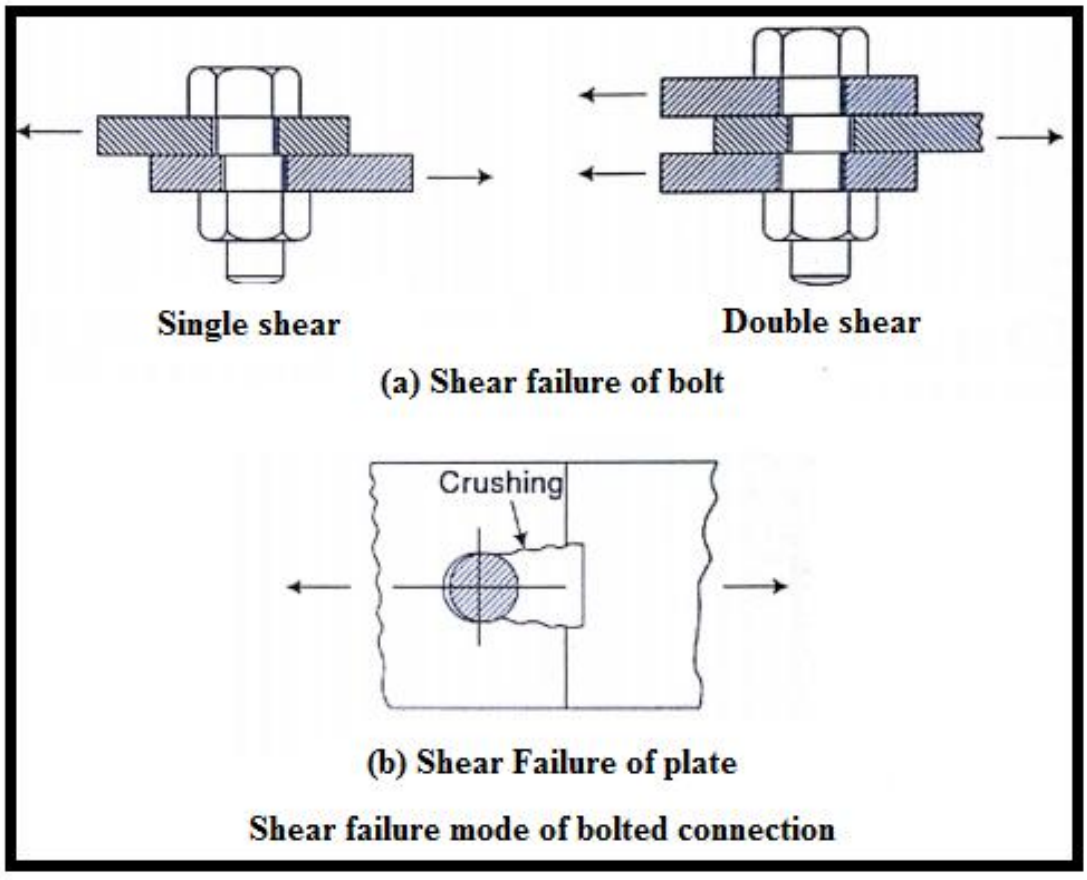
(2.b) Tensile failure of plate: The tensile stress in the plate at the net cross-section may exceed the working tensile stress. Tearing failure occurs when bolts are stronger than the plates.

(3) Bearing failure mode

(3.a) Bearing failure of bolt: The bolt may deform due to high local bearing stresses between the bolt and the plate. Due to this, the bolt is crushed around the half circumference.

(3.b) Bearing failure of plate: If the bolt material is of much higher strength than that of steel plate through which the plate passes, then bearing failure of plate takes place.

VIII. Experimental Set-up



Shear failure mode of bolted connection

IX. Resources required

Sr. No.	Particulars	Specification	Quantity	Remark
1	Limit State Design of Steel Structures	By Shah, V. L. Gore	1 No.	Per group of 4 students
2	A3 size sketchbook and Drawing tools (scale, pencil, eraser etc.)	--------	1set	Per student

X. Procedure

1. Teacher should discuss the failure modes of bolted connection with the students.
2. Student should understand the reasons and types failure modes of bolted connection.
3. Students should draw types of plates and their failure modes in sketchbook by mentioning its properties. (Refer point no. VIII Experimental set-up.)

XI. Precautions to be followed

1. Understand the difference between different failure modes of bolted connection.
2. Sketches should be drawn with appropriate height/depth (h/d) ratio along with the font size used for labeling.

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 condition when shear failure of bolt occurs.
2. State the condition when bearing failure of bolt occurs.
3. State the condition when axial tensile failure of bolt occurs.
4. State the condition when shear failure of plate occurs.
5. State the condition when bearing failure of plate occurs.
6. State the condition when tensile failure of plate occurs.
7. Explain single shear failure with neat sketch.
8. Explain double shear failure with neat sketch.
9. State the method by which tearing failure of plate can be avoided.

Space to Write Answers

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XIII. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related:15 Marks		**60%**
1	Precision in sketchbook, neatness, cleanliness.	50 %
2	Working in team.	10 %
Product related:10 Marks		**40%**
3	Interpretation of given data.	10%
4	Answers to practical related questions.	20%
5	Submission of report in time.	10%
Total: 25 Marks		**100%**

List of Student Team Members (Roll No.)

1. ……
2. ……
3. ……
4. ……

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

Practical No. 9: Write five IS clauses related to partial safety factors, characteristic strengths and characteristic load and design load 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. Relevant Program Outcomes

PO. 1 Basic knowledge: *An ability to apply knowledge of basic mathematics, science and engineering to solve the engineering problems.*

PO. 2 Discipline knowledge*: An ability to apply discipline - specific knowledge to solve core and/or applied engineering problems.*

PO. 4 Engineering tools: *Apply relevant Civil technologies and tools with an understanding of the limitations.*

PO. 7 Ethics: *Apply ethical principles for commitment to professional ethics, responsibilities and norms of the practice also in the field of Civil engineering.*

PO . 8 Individual and Team Work: *Function effectively as leader and team member in diverse / multidisciplinary team.*

III. Relevant Course Outcomes

a. Analysis and design of singly reinforced rectangular beams.
b. Design various slabs for the given edge condition.
c. Design of axially loaded short columns and footings.

IV. Practical Outcome

Write five IS clauses related to partial safety factors, characteristic strengths, characteristic load and design load from IS: 456-2000.

V. Competency and Practical Skills

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 for partial safety factors, characteristic strength, characteristic load and design load.
b. Follow design steps as per IS 456: 2000.

VI. Relevant Affective domain related

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

VII. Minimum Theoretical Background

- 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 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.

VIII. Resources required

Sr. No.	Particulars	Specification	Quantity	Remark
1	IS 456:2000	Plain and Reinforced Concrete Code of Practice	1 No.	Per batch

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 Clause 36.4.2.1 of IS 456:– 2000 related to partial safety factors for material strength.
5. Write Clause 36.1 of IS 456:– 2000 related to characteristic strength of materials.
6. Write Clause 36.2 of IS 456:– 2000 related to characteristic load.
7. Write Clause 36.3.1 of IS 456:– 2000 related to design strength of materials.
8. Write Clause 36.3.1 of IS 456:– 2000 related to design strength of materials.

X. Precautions to be followed

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

Space to write Clauses

XI. Resources used

Sr. No.	Name of Resource	Broad Specifications		Quantity	Remark
		Make	Details		
1					
2					

XII. Conclusions

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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. Define Characteristic strength.
2. Define Partial safety factor.
3. Write full forms of i) HYSD ii) TMT.
4. Out of M 20 and M25 grade concrete, which will consume more cement?
5. State assumptions in limit state of collapse.
6. Draw stress-strain graph for concrete given in IS: 456-2000.
7. Draw stress-strain graph for mild steel given in IS:456-2000.
8. Draw stress-strain graph for HYSD steel given in IS: 456-2000.
9. IS Code used for loading standards is IS_____: _____.

Space to Write Answers

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XIV. References / Suggestions for further Reading

Sr. No.	Title of Book/ Website Links	Author	Publication
1.	IS 875:1987(Part 1 to 5) Indian Standard Code for Loading Standards	BIS	-

XV. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related:15 Marks		**60%**
1	Use of IS: 875- 1987	25 %
2	Precision in sketchbook, neatness, cleanliness.	30 %
Product related:10 Marks		**40%**
3	Interpretation of given clauses	5%
4	Answers to practical related questions.	25%
5	Submission of report in time.	10%
Total: 25 Marks		**100%**

List of Student Team Members (Roll No.)

1. ……
2. ……
3. ……
4. ……

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

Practical No. 10: Draw cross section, strain-stress diagram for singly reinforced section giving design parameters and constants.

I. Practical Significance

In actual practice all structures are designed using limit state method. The limit state of collapse is normally the critical limit state, in limit state design. It is therefore, necessary to begin with the analysis of a structure for ultimate loads causing collapse. Singly reinforced section is designed using assumptions; according to limit state of collapse. This practical will help to understand the analysis and design of beam by taking into account design parameters and constants.

II. Relevant Program Outcomes

PO. 2 Discipline knowledge*: An ability to apply Civil engineering knowledge to solve broad-based Civil engineering related problems.*

PO. 4 Engineering Tools: *An ability to apply relevant civil technologies and tools with an understanding of the limitations.*

PO. 8 Individual and Team Work: *Function effectively as leader and team member in diverse / multidisciplinary team.*

PO. 9 Communication: *An ability to communicate effectively in oral and written form.*

III. Relevant Course Outcomes

a. Analysis and design of singly reinforced rectangular beams.

IV. Practical Outcome

Draw cross section, strain-stress diagram for singly reinforced section giving design parameters and constants.

V. Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency, ***"Design of rectangular beams and precautions to be taken to avoid its failure."***

a. Observation skill.

b. To know and understand assumptions made in limit state of collapse.

c. Ability to understand the type of section and design accordingly.

VI. Relevant Affective domain related

a. Practice precision in drawing, neatness and cleanliness.

b. Demonstrate working as a leader / a team member.

VII. Minimum Theoretical Background

Design for the limit state of collapse in flexure shall be based on the following assumptions:

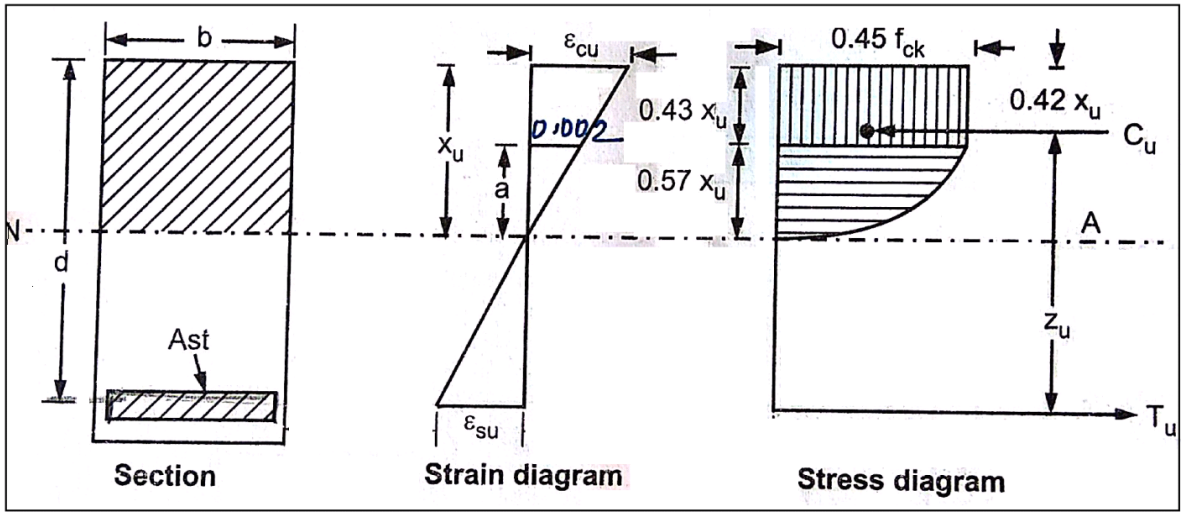
- Plain sections normal to the axis remain plane after bending.
- The maximum strain in concrete at the outermost compression fiber is taken as 0.0035 in bending.
- The relationship between the compressive stress distribution in concrete may be assumed to be rectangle, trapezoidal, parabola or any other shape which results in prediction of strength in substantial agreement with the test results.
- For design purpose, the compressive strength of concrete in the structure shall be assumed to be 0.67 times the characteristic strength. The partial safety factor $\gamma_m = 1.5$ shall be applied in addition to this.
- The tensile strength of the concrete is ignored.
- The stresses in the reinforcement are derived from representative stress-strain curve for the type of steel used. For design purpose the partial safety factor $\gamma_m = 1.15$ shall be applied.
- The maximum strain in the tension reinforcement in the section at failure shall not be less than:

$$\frac{fy}{1.15\ Es} + 0.002$$

Where, fy = characteristic of strength of steel

E_S = modulus of elasticity of steel

VIII. Experimental Set-up



Stress block diagram of Singly Reinforced Section

IX. Resources required

Sr. No.	Particulars	Specification	Quantity	Remark
1	Limit State Theory and Design of Reinforced Concrete	Dr. S. R. Karve and Dr. V. L. Shah	1 No.	Per group of 5 students
2	A3 size sketchbook and Drawing tools (scale, pencil, eraser etc.)	--------	1set	Per student

X. Procedure

1. Teacher should guide the students about stress block diagram of singly reinforced rectangular section.
2. Student should discuss the design parameters and constants required for the design of singly reinforced rectangular section.
3. Students should draw stress block diagram of singly reinforced rectangular section.
4. Students should write equations for total compressive force and total tensile force.
5. Students should write equation for Neutral axis (X_u).
6. Students should write Limiting (Max.) values of Neutral axis (X_u) for Mild steel, F_e 415, F_e 500 and write it in tabular form.

XI. Precautions to be followed

1. Draw stress block diagram of singly reinforced rectangular section.
2. Use IS 456: 2000 to write design parameters and constants.

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. Limiting (Max.) values of Neutral axis (X_u) for Mild steel is _____ .
2. If section is under-reinforced strain in _____ will reach to its maximum value first before strain in _____.
3. For balanced section state values of strain in concrete and strain in steel.
4. State four assumptions in limit state of collapse.
5. For F_e 415 and M20, calculate maximum percentage of reinforcement.
6. Maximum compressive stress in concrete is _____ .
7. In under-reinforced section percentage of steel provided is _____ (less or more) than critical section.
8. Write formula for moment of resistance for balanced section.
9. Write formula for moment of resistance for under-reinforced section.

Space to Write Answers

XIII. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related:15 Marks		**60%**
1	Understanding and drawing stress block diagram	20%
2	Precision in writing design parameters and constants	30%
3	Precision in sketchbook, neatness, cleanliness.	10 %
Product related:10 Marks		**40%**
3	Interpretation of given data.	10%
4	Answers to practical related questions.	20%
5	Submission of report in time.	10%
Total: 25 Marks		**100%**

List of Student Team Members (Roll No.)

1. ……
2. ……
3. ……
4. ……

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

Practical No. 11: Draw stress block diagram for Under-reinforced, Over-reinforced and Balanced section showing all details

I. Practical Significance

Now days, in actual practice all structures are designed using limit state method. The limit state of collapse is normally the critical limit state, in limit state design. It is therefore, necessary to begin with the analysis of a structure for ultimate loads causing collapse. If a member under flexure is subjected to increasing moment, failure occurs either due to crushing of concrete reaching its ultimate value, or due to yielding of steel as a result of maximum tensile strain in steel reaching its yield value. The deciding criterion of the failure is quantity of steel provided in section. This practical will help to understand the failure of beam and precautions to be taken to avoid it so that structure will remain safe.

II. Relevant Program Outcomes

PO. 2 ***Discipline knowledge****: An ability to apply Civil engineering knowledge to solve broad-based Civil engineering related problems.*

PO. 4 ***Engineering Tools:*** *An ability to apply relevant civil technologies and tools with an understanding of the limitations.*

PO. 8 ***Individual and Team Work:*** *Function effectively as leader and team member in diverse /multidisciplinary team.*

PO. 9 ***Communication:*** *An ability to communicate effectively in oral and written form.*

III. Relevant Course Outcomes

a. Analysis and design of singly reinforced rectangular beams.

IV. Practical Outcome

Draw stress block diagram for Under-reinforced, Over-reinforced and Balanced section showing all details.

V. Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency, ***"Failure of rectangular beams and precautions to be taken to avoid it."***

a. Observation skill.

b. Ability to identify the different types of sections based on position of neutral axis. (N.A.)

c. Ability to understand the failure of the section and reason behind it.

VI. Relevant Affective domain related

a. Practice precision in drawing, neatness and cleanliness.

b. Demonstrate working as a leader / a team member.

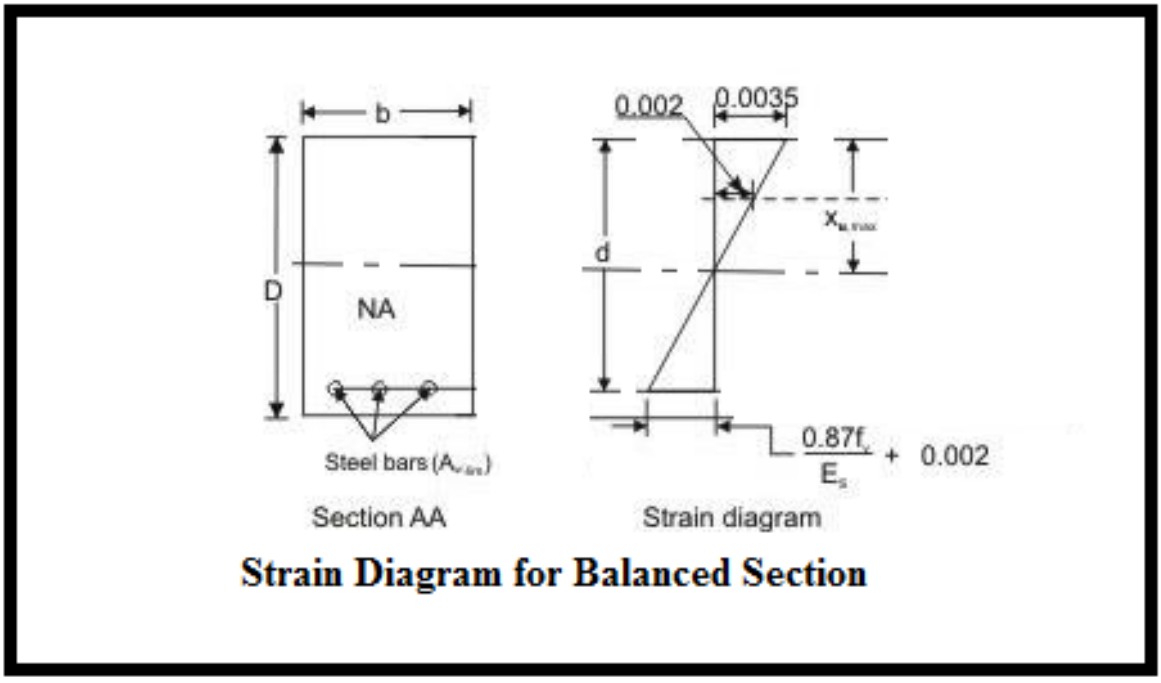
VII. Minimum Theoretical Background

Balanced Section: A RC section in which maximum compressive strain in concrete reaches to its ultimate value and maximum tensile strain in reinforcement reaches its yield value simultaneously is known as Balanced section. In this case, failure occurs by yielding of steel in tension and crushing of concrete in compression simultaneously.

Under-reinforced section: A section having steel percentage less than the critical percentage is known as Under-reinforced section. Since steel is insufficient to balance compression in concrete, the tensile strain in steel reaches yield value while the maximum compressive stain in concrete is less than its ultimate crushing value. Since this failure is initiated by yielding of steel in tension, it is known as primary tension failure. Such sections give sufficient warning before failure.

Over-reinforced section: A section having steel percentage greater than the critical percentage is known as Over-reinforced section. Since concrete is insufficient to balance tension in steel, the maximum compressive stain in concrete reaches the ultimate crushing value before the tensile strain in steel reaches the yield value. Since this failure is initiated by compression in concrete, it is known as primary compression failure. Such section does not give sufficient warning before failure and failure occurs suddenly by crushing of concrete. Due to this, IS code totally forbids this type of section.

VIII. Experimental Set-up



Strain Diagram for Balanced Section

IX. Resources required

Sr. No.	Particulars	Specification	Quantity	Remark
1	Limit State Theory and Design of Reinforced Concrete	Dr. S. R. Karve and Dr. V. L. Shah	1 No.	Per group of 5 students
2	A3 size sketchbook and Drawing tools (scale, pencil, eraser etc.)	--------	1set	Per student

X. Procedure

1. Teacher should guide the students about classification of sections based on position of neutral axis. (N.A.)
2. Student should discuss the reason of change in position of neutral axis.
3. They should discuss the effect of change in position of neutral axis.
4. Students should draw strain diagram for different classification of beams based on position of neutral axis in sketchbook by mentioning its properties. (Refer point no. VIII Experimental set-up.)

XI. Precautions to be followed

1. Draw block diagram for different sections showing variation in positions of neutral axis.
2. Sketches should be drawn with appropriate height/depth (h/d) ratio along with the font size used for labeling.

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. Over-reinforced section is not permitted as per IS 456:2000. Justify answer.
2. Classify the section based on given position of neutral axis.
   Depth of critical neutral axis = _____ mm
   Depth of actual neutral axis = _____ mm
   Hence, type of section = _____ .
   (Teacher should provide values for depth neutral axis.)
3. If section is under-reinforced strain in _____ will reach to its maximum value first before strain in _____.
4. If section is over-reinforced strain in _____ will reach to its maximum value first before strain in _____.
5. If section is balanced, strain in concrete and strain in steel will reach to its maximum value _____.
6. For balanced section state values of strain in concrete and strain in steel.
7. Explain primary tension failure.

8. Explain primary compression failure.
9. In over-reinforced section percentage of steel provided is _____ than critical section.

Space to Write Answers

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XIII. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related:15 Marks		**60%**
1	Understanding position of N.A. in sketches.	25%
2	Precision in sketchbook, neatness, cleanliness.	30 %
3	Working in team.	5 %
Product related:10 Marks		**40%**
3	Interpretation of given data.	10%
4	Answers to practical related questions.	20%
5	Submission of report in time.	10%
Total: 25 Marks		**100%**

List of Student Team Members (Roll No.)

1. ……
2. ……
3. ……
4. ……

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

Practical No. 12: 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. Relevant Program Outcomes

PO. 1 ***Basic knowledge:*** *An ability to apply knowledge of basic mathematics, science and engineering to solve the engineering problems.*

PO. 2 ***Discipline knowledge****: An ability to apply Civil engineering knowledge to solve broad-based Civil engineering related problems.*

PO. 4 ***Engineering Tools:*** *An ability to apply relevant civil technologies and tools with an understanding of the limitations.*

PO. 7 ***Ethics:*** *Apply ethical principles for commitment to professional ethics, responsibilities and norms of the practice also in the field of Civil engineering.*

PO. 8 ***Individual and Team Work:*** *Function effectively as leader and team member in diverse /multidisciplinary team.*

III. Relevant Course Outcomes

a. Design of shear reinforcement and development length for beam and slabs.

IV. Practical Outcome

Write five IS clauses related to shear reinforcement in beams and slabs from IS 456:2000.

V. Competency and Practical Skills

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

a. Ability to understand necessity of shear reinforcement.
b. Ability to understand various forms of shear reinforcement.
c. Ability to refer IS code clauses related to shear reinforcement.

VI. Relevant Affective domain related

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

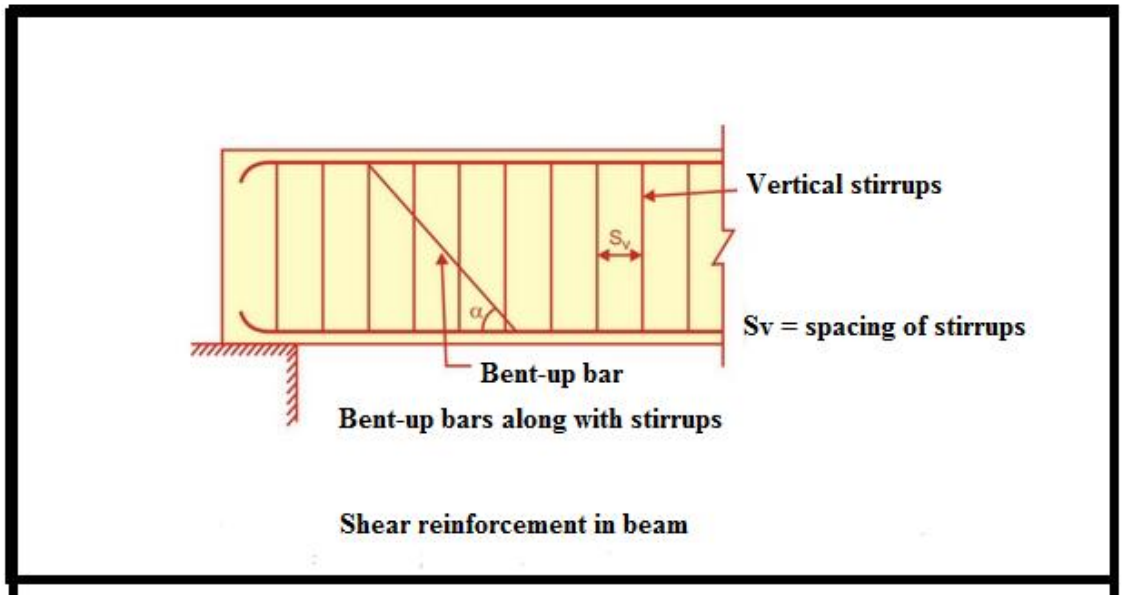
VII. Minimum Theoretical Background

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".

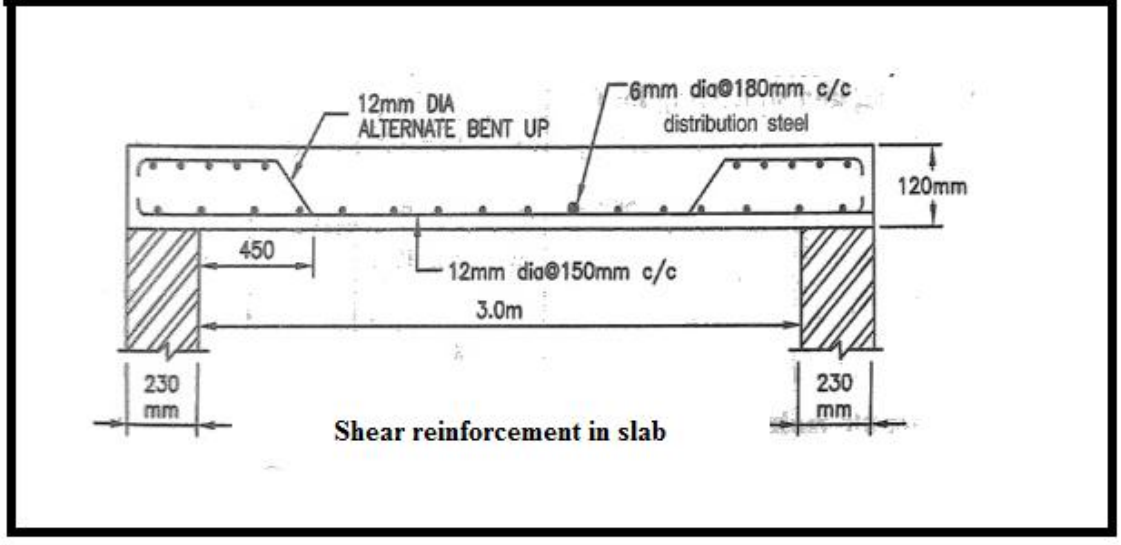
Various forms of shear reinforcement: It can be provided in various forms as mentioned below –

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

VIII. Experimental Set-up



Shear reinforcement in beam



Shear reinforcement in slab

IX. Resources required

Sr. No.	Particulars	Specification	Quantity	Remark
1	IS 456: 2000	--------	1 No.	Per group of 5 students

X. Procedure

1. Teacher should discuss with the students 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.

XI. Precautions to be followed

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

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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 need of shear reinforcement.
2. Explain diagonal cracks.
3. Write formulae to calculate spacing of vertical stirrups.
4. The cracks due to shear are _____. *(Vertical / Horizontal / Inclined at 45 °)*
5. Spacing of stirrups shall not exceed _____ whichever is less.
6. If nominal shear stress in beam is less than design shear strength of concrete then shear reinforcement is _____. *(required / not required)*
7. Minimum shear reinforcement should be provided. Justify answer.
8. Maximum shear stress for _____ grade of concrete is _____ MPa. *(Teacher should provide grade of concrete).*
9. Characteristic strength of stirrup reinforcement shall not exceed _____ *MPa. (250 / 415 / 500)*

Space to Write Answers

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XIII. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related:15 Marks		**60%**
1	Use of IS 456:2000	25%
2	Interpretation of given data and its presentation	30 %
3	Working in team.	5 %
Product related:10 Marks		**40%**
3	Interpretation of given data.	10%
4	Answers to practical related questions.	20%
5	Submission of report in time.	10%
Total: 25 Marks		**100%**

List of Student Team Members (Roll No.)

1..……

2.…….

3.…….

4.…….

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

Practical No. 13: Write the procedure to calculate development length of main reinforcement in slabs and beams

I. Practical Significance

Provision of appropriate development length is an important aspect of safe construction practices. Proper development length in reinforcement bars shall be provided as per the steel grade considered in design. Otherwise in scenarios where less development length against the required is provided the structures will be prone to encounter failure due to slippage of joints, bonds, anchors and laps, in such cases the bars will not yield first but the failure will happen at joints and laps prior to yielding of reinforcement bars. This practical will help the students to understand the importance of development length and its provision.

II. Relevant Program Outcomes

PO. 1 ***Basic knowledge:*** *An ability to apply knowledge of basic mathematics, science and engineering to solve the engineering problems.*

PO . 2 ***Discipline knowledge****: An ability to apply Civil engineering knowledge to solve broad-based Civil engineering related problems.*

PO. 4 ***Engineering Tools:*** *An ability to apply relevant civil technologies and tools with an understanding of the limitations.*

PO. 7 ***Ethics:*** *Apply ethical principles for commitment to professional ethics, responsibilities and norms of the practice also in the field of Civil engineering.*

PO . 8 ***Individual and Team Work:*** *Function effectively as leader and team member diverse /multidisciplinary team.*

III. Relevant Course Outcomes

a. Design of shear reinforcement and development length for beam and slabs.

IV. Practical Outcome

Write the procedure to calculate development length of main reinforcement in slabs and beams.

V. Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency, ***"Safe design of beam and slab by provision of development length."***

a. Ability to understand the importance of development length in RCC structures.
b. Ability to understand IS code provisions for development length for beam and slab.
c. Ability to understand the procedure to calculate development length.

VI. Relevant Affective domain related

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

VII. Minimum Theoretical Background

Development length: It is defined as the length of bar required on either side of the section to develop the required stress in steel at that section through bond.

It is calculated by using formula –

$$Ld_{required} = \frac{0.87 \times fy \times \emptyset}{4 \times \tau_{bd}}$$

Where, ϕ = Nominal bar diameter and ζ_{bd} = Design bond stress.

Purpose of providing development length: It is required to transfer the force from surrounding concrete to the bar.

Design bond stress (ζ_{bd}) for plain bars in tension i. e. for f_y = 250 N/mm^2.

Grade of concrete	M 15	M 20	M 25	M 30	M 35	M 40
ζ_{bd} in N/mm^2	1.0	1.2	1.4	1.5	1.7	1.9

Note :

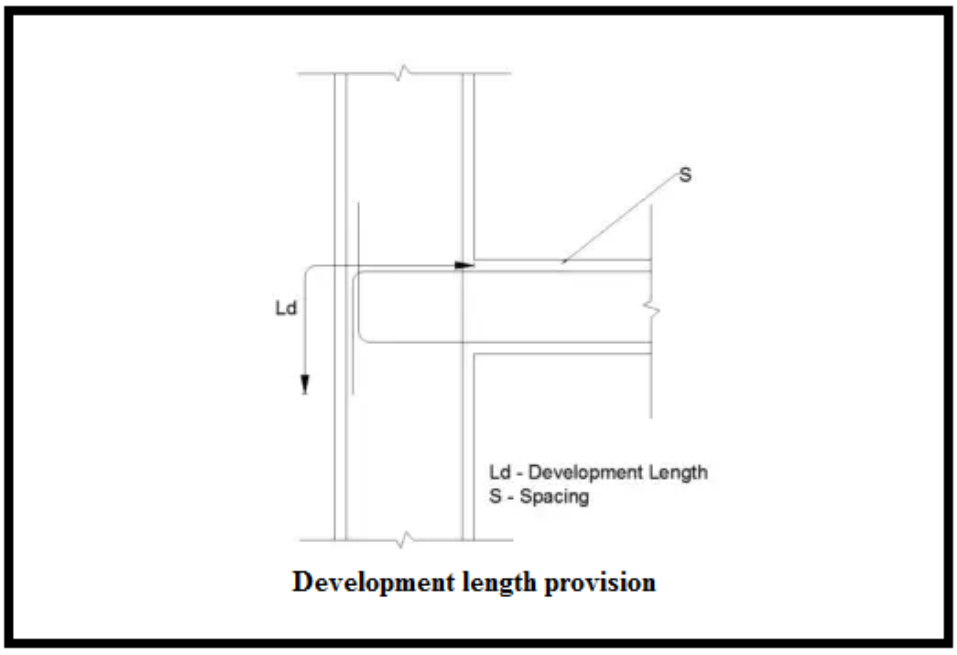
1) *For deformed bars, the values of ζ_{bd} given in above table shall be increased by 60%.*
2) *For bars in compression, the values of ζ_{bd} shall be increased by 25%.*

Available development length: As per clause 26.2.3.3 (Page no. 44) of IS 456:2000, available development length is calculated by using formula –

$$Ld_{available} = L_0 + \frac{1.3 \times M_1}{V_0}$$

Always $Ld_{available} > Ld_{required}$.

VIII. Experimental Set-up



Development length provision

IX. Resources required

Sr. No.	Particulars	Specification	Quantity	Remark
1	Limit state theory and design of Reinforced Concrete Structures	Shah and Karve	1 No.	Per group of 5 students
2	IS 456: 2000	--------	1 No.	Per group of 5 students

X. Procedure

1. Teacher should discuss with the students regarding importance of development length in RCC structures and IS code provisions related to it.
2. Students should write detailed procedure to calculate bond length of main reinforcement in beams and slabs.

XI. Precautions to be followed

1. Read carefully the IS code to extract the information related development length of main reinforcement in beam and slab.
2. Take precaution while considering values of ζ_{bd} considering grade of steel and nature of force in the bar.

Space to write procedure

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. Define development length.
2. Enlist different factors affecting development length.
3. Calculate design bond stress if _____ concrete and _____ steel is used which carries _____ type of force. *(Teacher should provide grade of concrete, grade of steel and nature of force in bar.)*
4. Calculate the development length for _____ mm diameter bar of grade _____ in compression. Take grade of concrete as _____. *(Teacher should provide diameter of bar, grade of steel and grade of concrete*.)
5. Calculate the development length for _____ mm diameter bar of grade _____ in tension. Take grade of concrete as _____. *(Teacher should provide diameter of bar, grade of steel and grade of concrete*.)
6. Write importance of development length.
7. Write formula to calculate development length along with terms used.
8. Calculate the development length of 12 mm diameter bar in tension and compression for Fe 250 and Fe 415 grade steel. Use M 25 grade concrete.
9. For deformed bars, the values of ζ_{bd} for plain bars in tesnsion shall be increased by = _____ %.

Space to Write Answers

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XIII. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related:15 Marks		**60%**
1	Use of IS 456:2000	25%
2	Interpretation of given data and its presentation	30 %
3	Working in team.	5 %
Product related:10 Marks		**40%**
3	Interpretation of given data.	10%
4	Answers to practical related questions.	20%
5	Submission of report in time.	10%
Total: 25 Marks		**100%**

List of Student Team Members (Roll No.)

1. ……
2. ……
3. ……
4. ……

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

Practical No. 14: Write four IS clauses related to each for slab, beam 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 turn transfer the load to the foundation system. This practical will help the students to understand the elements of framed structure with provisions of various clauses related to it using IS 456:2000.

II. Relevant Program Outcomes

PO. 1 ***Basic knowledge:*** *An ability to apply knowledge of basic mathematics, science and engineering to solve the engineering problems.*

PO. 2 ***Discipline knowledge****: An ability to apply Civil engineering knowledge to solve broad-based Civil engineering related problems.*

PO. 4 ***Engineering Tools:*** *An ability to apply relevant civil technologies and tools with an understanding of the limitations.*

PO. 7 ***Ethics:*** *Apply ethical principles for commitment to professional ethics, responsibilities and norms of the practice also in the field of Civil engineering.*

PO. 8 ***Individual and Team Work:*** *Function effectively as leader and team member diverse /multidisciplinary team.*

III. Relevant Course Outcomes

a. Analysis and design of singly reinforced rectangular beams.
b. Design various slabs for given edge condition.
c. Design of axially loaded short columns and footings.

IV. Practical Outcome

Write four IS clauses related to each for slab, beam and column from IS 456:2000.

V. Competency and Practical Skills

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

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

VI. Relevant Affective domain related

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

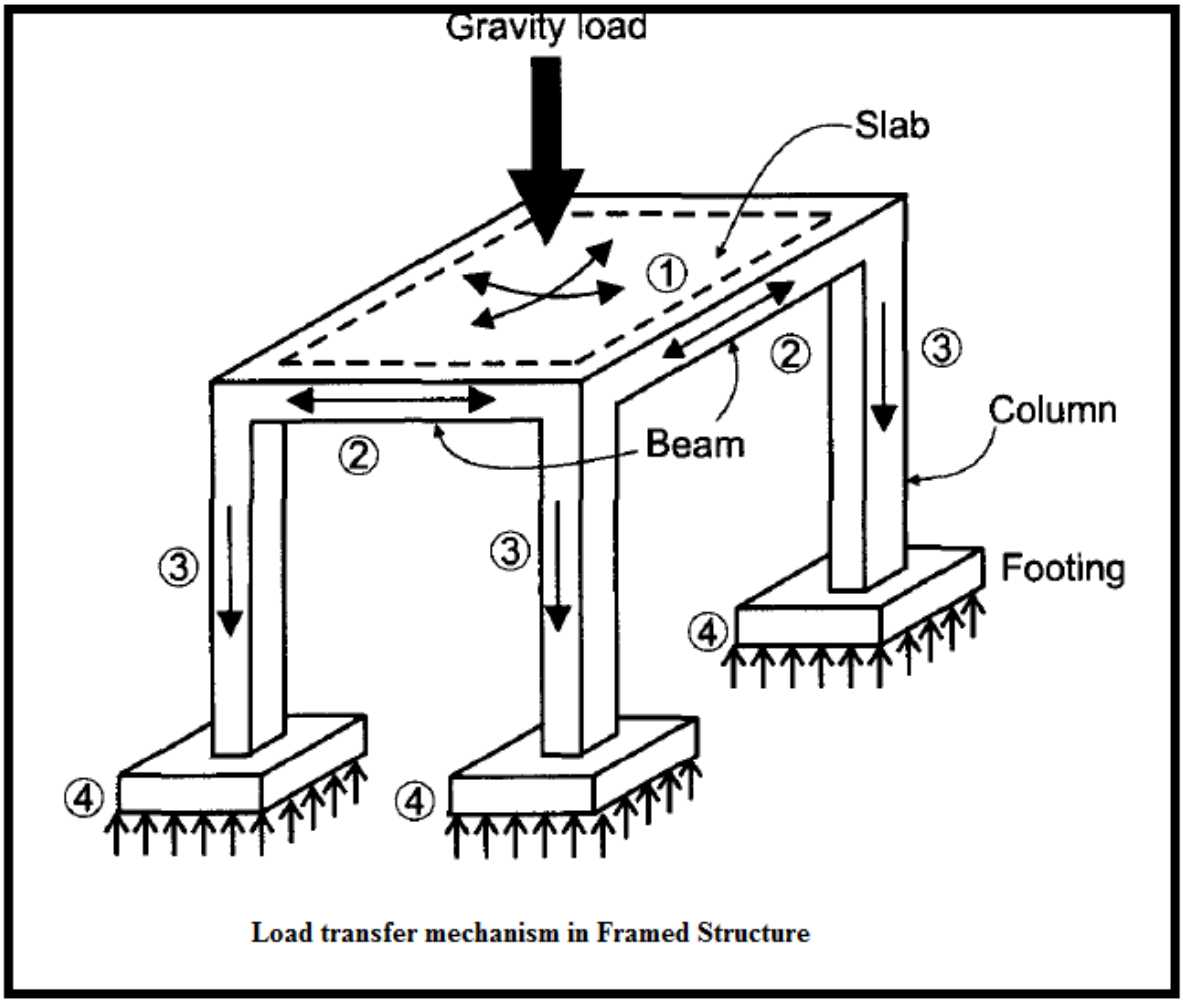
VII. Minimum Theoretical Background

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 direction.

Beam: A beam is a one dimensional (normally horizontal) member which provides support to the slab. Load transfer is affected by bending. They receive loads from slab and transfer it to the supporting column.

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.

VIII. Experimental Set-up



Load transfer mechanism in Framed Structure

IX. Resources required

Sr. No.	Particulars	Specification	Quantity	Remark
1	IS 456: 2000	--------	1 No.	Per group of 5 students

X. Procedure

1. Teacher should discuss with the students regarding structural elements of a RCC structure.
2. He / 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 beam:

1. Write clause 23 from IS 456: 2000 (Page no.36) related to effective depth of beam.
2. Write clause 23.2.1(a) from IS 456: 2000 (Page no. 37) related to basic values of span to effective depth ratio of beam.
3. Write clause 26.5.1.1 from IS 456: 2000 (Page no. 46) related to minimum and maximum tension reinforcement of beam.
4. Write clause 26.5.1.5 from IS 456: 2000 (Page no. 47) related to maximum spacing of shear reinforcement.
5. Write clause 26.5.1.6 from IS 456: 2000 (Page no. 48) related to minimum shear reinforcement.

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.

XI. Precautions to be followed

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

Space to write clauses

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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 maximum and minimum area of steel for given beam size.
   Beam size = _____.
   (Teacher should provide width, effective depth and overall depth of beam.)
2. Calculate minimum area of steel for depth of slab = _____ mm.
   (Teacher should provide overall depth of slab.)
3. Calculate effective length for given end condition and length of column.
   End condition = _____
   Length of column = _____ mm. *(Teacher should provide end condition and length of column.)*
4. Calculate effective span for a slab having span = _____ mm, effective depth = _____ mm and thickness of support = _____ mm.
   (Teacher should provide values.)

5. Calculate minimum and maximum area of steel for column size = _____ mm.. *(Teacher should provide size of column.)*
6. State the column is short or slender and justify answer also when effective length of column = _____ mm and size of column = _____ mm. *(Teacher should provide effective length and size of column.).*
7. Write formulae to calculate minimum and maximum eccentricity of column.
8. Write minimum and maximum percentage of steel that can be used as per IS 456:2000.
9. If 20 mm diameter bars are to be used as a longitudinal steel in column, calculate diameter of lateral ties of Fe 415 grade to be used.

Space to Write Answers

XIII. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related:15 Marks		**60%**
1	Use of IS 456:2000	25%
2	Interpretation of given data and its presentation	30 %
3	Working in team.	5 %
Product related:10 Marks		**40%**
4	Interpretation of given data.	10%
5	Answers to practical related questions.	20%
6	Submission of report in time.	10%
Total: 25 Marks		**100%**

List of Student Team Members (Roll No.)

1. ……
2. ……
3. ……
4. ……

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

Practical No. 15: Draw diagrams showing transfer of loads from one way simply supported slab and two way simply supported slab to the supporting beams as per IS 456:2000

I. Practical Significance

One-way slab, transfer of load takes place in one direction only. The total load is supported on two opposite long sides supporting the slab. For certain ratio of longer dimension to shorter dimension (aspect ratio), the rectangular slab bends in both directions. The slab bends into shape of saucer. It is convenient to think of such slabs as consisting of two sets of parallel strips, in each direction and intersecting each other. So part of the load is carried by supports provided in both directions. This practical will help to understand the load distribution diagram of beams for one way or two way slab as per IS 456: 2000.

II. Relevant Program Outcomes

PO. 2 Discipline knowledge*: An ability to apply Civil engineering knowledge to solve broad-based Civil engineering related problems.*

PO. 4 Engineering Tools: *An ability to apply relevant civil technologies and tools with an understanding of the limitations.*

PO. 8 Individual and Team Work: *Function effectively as leader and team member in diverse / multidisciplinary team.*

PO. 9 Communication: *An ability to communicate effectively in oral and written form.*

III. Relevant Course Outcomes

a. Design various slabs for the given edge condition.

IV. Practical Outcome

Draw diagrams showing transfer of loads from one way simply supported slab and two way simply supported slab to the supporting beams as per IS 456:2000.

V. Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency, ***"Design of simply supported slabs and precautions to be taken to avoid its failure."***

a. Observation skill.
b. To know and understand one way or two way slab load distribution.
c. Ability to draw load distribution diagram of beams for one way or two way slab as per IS 456: 2000.

VI. Relevant Affective domain related

a. Practice precision in drawing, neatness and cleanliness.
b. Demonstrate working as a leader / a team member.

VII. Minimum Theoretical Background

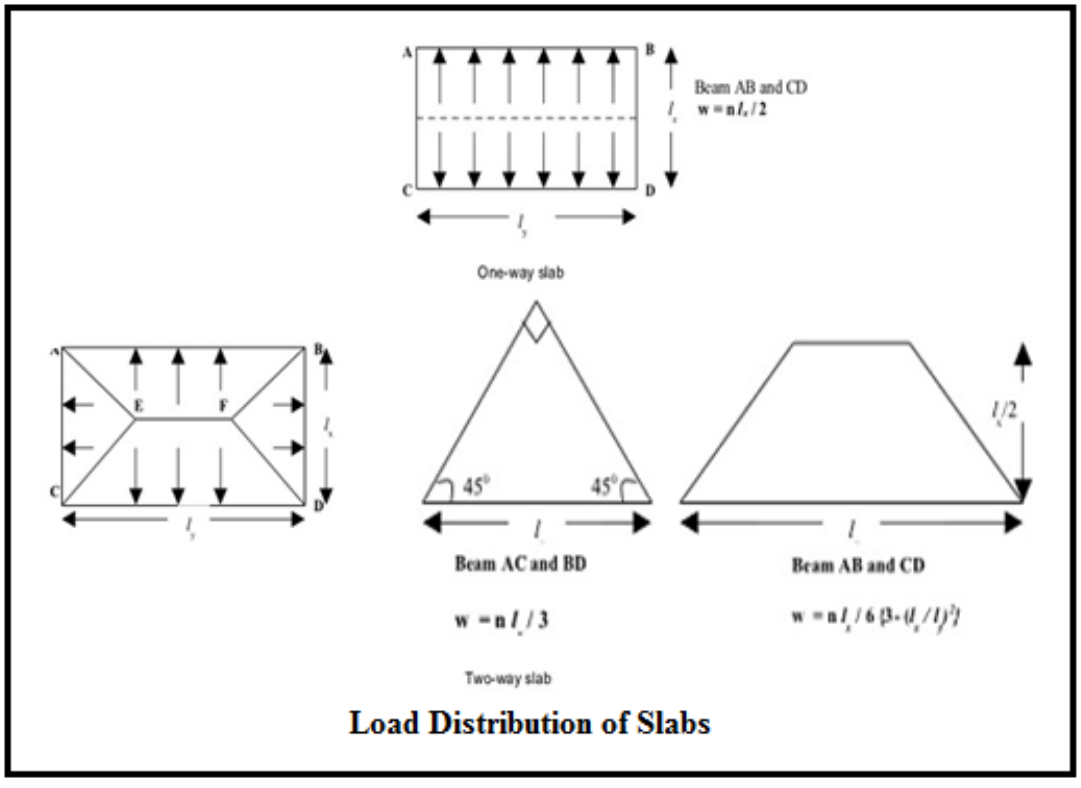
Loads on Supporting Beams: The load transferred to supporting beams depends upon the aspect ratio L_y/L_x and upon the support conditions.

a) In case of one way spanning slab, the half load of slab is distributed uniformly on the longer beam or wall supporting it.
In the slab ABCD, load of half area is distributed uniformly per unit meter length to the longer supporting beam AB and CD.

b) In case of two way spanning slab, load is transferred uniformly on all the four supporting walls as shown in fig.
In the two way spanning slab ABCD, in which load of trapezium AEFB and trapezium CEFD is transferred uniformly per meter length to the longer supporting beam AB and CD respectively.
The load of 45^0 isosceles triangle AEC and triangle BFD is transferred uniformly per unit meter length to shorter supporting beam AC and BD respectively.

c) In case of cantilever slab full load is transferred uniformly per unit meter length to the beam at the supporting end.

VIII. Experimental Set-up



Load Distribution of Slabs

For bending moment: The equivalent udl for

i) Trapezoidal load on long span, i.e. on beam AB & CD = $W_d \times \frac{Lx}{2} [\ 1 - \frac{1}{3\beta^2}\ ]$

ii) Traingular load on short span, i.e. on beam AC & BD = $W_d \times \frac{Lx}{2} [\ 1 - \frac{1}{2\beta}\ ]$

where W_d = Design load

β = Span ratio (aspect ratio) L_y/L_x

For Shear force : The equivalent udl for

i) Trapezoidal load on long span, i.e. on beam AB & CD = $W_d \times \frac{Lx}{2}$

ii) Traingular load on short span, i.e. on beam AC & BD = $W_d \times \frac{Lx}{2}$

IX. Resources required

Sr. No.	Particulars	Specification	Quantity	Remark
1	Limit State Theory and Design of Reinforced Concrete	Dr. S. R. Karve and Dr. V. L. Shah	1 No.	Per group of 5 students
2	A3 size sketchbook and Drawing tools (scale, pencil, eraser etc.)	--------	1set	Per student

X. Procedure

1. Teacher should guide the students about load distribution diagram of beams for one way or two way slab as per IS 456: 2000.
2. Student should understand it's importance in designing the beams.
3. Students should draw load distribution of all types of slabs in sketchbook. (Refer point no. VIII Experimental set-up.)

XI. Precautions to be followed

1. Proper care to be taken to draw diagram for load transfer from slab to supporting beam is necessary.
2. Use IS 456: 2000 to understand it.

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 load transferred by a 3 m x 4 m slab to the supporting beams on its all sides. Ultimate design load on the slab is 18 kN/m^2.

2. Calculate load transferred by a 7 m x 2.5 m slab to the supporting longer beams. Ultimate design load on the slab is 14 kN/m^2.
3. Calculate load transferred by a cantilever slab projecting 1.2 m, to the supporting longer beams. Ultimate design load on the slab is 8 kN/m^2.
4. Why width of beam is generally 230 mm?
5. State formula for equivalent uniformly distributed load on longer beams; for beams supporting two way slab.
6. State formula for equivalent uniformly distributed load on shorter beams; for beams supporting two way slab.
7. State formula for equivalent uniformly distributed load on longer beams; for beams supporting one way slab.
8. State formula for equivalent uniformly distributed load on supporting beam; for beams supporting cantilever slab.
9. In case of two way slab, load transferred on all four supporting beams is _____. (Same / different)

Space to Write Answers

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XIII. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related:15 Marks		**60%**
1	Understanding and drawing diagram	20%
2	Precision in sketchbook, neatness, cleanliness.	30%
3	Working in team.	10 %
Product related:10 Marks		**40%**
3	Interpretation of given data.	10%
4	Answers to practical related questions.	20%
5	Submission of report in time.	10%
Total: 25 Marks		**100%**

List of Student Team Members (Roll No.)

1. ……
2. ……
3. ……
4. ……

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

Practical No. 16: Draw the table showing details of deflected shape along with effective length of column as per IS 456:2000

I. Practical Significance

There are basically two types of column which are short column and long column. These are classified on the basis of type of failure, i.e. crushing failure and buckling failure. Buckling is the phenomenon related to lateral displacement of column axis due axial load applied to column. The buckling of column depends on the column end conditions, eccentricity of loading and its initial curvature. These end restraints of column affects effective length of column and ultimately deciding type of column as short and long column. This practical will help to understand the deflected shape and effective length of column for various end constraints.

II. Relevant Program Outcomes

PO. 2 ***Discipline knowledge****: An ability to apply Civil engineering knowledge to solve broad-based Civil engineering related problems.*

PO. 4 ***Engineering Tools:*** *An ability to apply relevant civil technologies and tools with an understanding of the limitations.*

PO. 8 ***Individual and Team Work:*** *Function effectively as leader and team member in diverse /multidisciplinary team.*

PO. 9 ***Communication:*** *An ability to communicate effectively in oral and written form.*

III. Relevant Course Outcomes

a. Design of axially loaded short columns and footings.

IV. Practical Outcome

Draw the table showing details of deflected shape along with effective length of column as per IS 456:2000.

V. Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency, ***"Effect of end constraints on effective length of column."***

a. Observation skill.
b. Ability to identify the different end constraints and to understand their effect on effective length of column.
c. Ability to understand the effect of end constraints on critical load carrying of column.

VI. Relevant Affective domain related

a. Practice precision in drawing, neatness and cleanliness.
b. Demonstrate working as a leader / a team member.

VII. Minimum Theoretical Background

Column: A vertical member of a structure which is used to support axial compressive load is called as column.

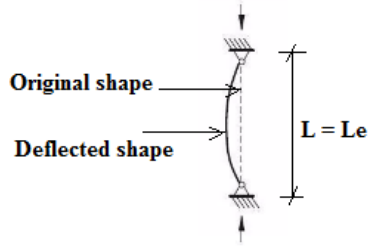
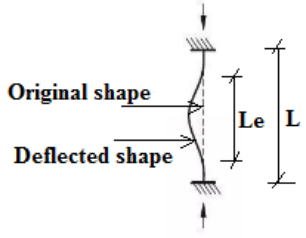
Buckling: It is phenomenon in which lateral displacement of axial compression member takes place due to increase of height or length of axial member.

Effective length: It is a length between points of zero bending moments, i.e. length between two points of contraflexure of a buckled column. It depends upon the end constraints as regards restraint against rotation and that against transverse displacement.

VIII. Experimental Set-up

Symbols for end restraint conditions	
	Rotation fixed, translation fixed
	Rotation free, translation fixed
	Rotation fixed, translation free
	Rotation free, translation free

Table showing Effectivel length of column for various end conditions as per IS 456:2000

End condition	Sketch	Recommended value of Effective length
Effectively held in position but not restrained against rotation at both ends		1.00 L
Effectively held in position and restrained against rotation at both ends		0.65 L

IX. Resources required

Sr. No.	Particulars	Specification	Quantity	Remark
1	IS 456:2000	--------	1 No.	Per group of 5 students
2	A3 size sketchbook and Drawing tools (scale, pencil, eraser etc.)	--------	1set	Per student

X. Procedure

1. Teacher should guide the students about various end constraints of column and its effect on effective length of column.
2. Student should discuss about the deflected shape of column.
3. Students should draw table showing various end conditions of column, sketch showing deflected shape of column and recommended values of effective length of column in sketchbook. (Refer VIII Experimental set-up.)

XI. Precautions to be followed

1. Draw carefully the deflected shape of column considering rotation and translation for various end restraints.
2. Sketches should be drawn appropriately along with the font size used for labeling.

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. For end restraint condition = _____
   Rotation is (free / restrained) and transverse displacement is (free / restrained).
   (Teacher should provide different end restraint condition.)
2. Draw symbol to be used to show following end restraints.
   End restraint 1 : _____
   End restraint 2 : _____
   (Teacher should provide two end restraints.)
3. State effective length of column for given end conditions of column.
   End condition 1 : _____
   End condition 1 : _____
   (Teacher should give two end conditions of column.)
4. Define buckling of column.
5. Buckling is most important in case of _____ column. (short / long)

6. Effective length for column having both ends fixed is _____ than column having both ends hinged. (less / more)
7. Calculate effective length for given end conditions and given length of column.
   End condition of column = _____
   And effective length of column = _____ mm. *(Teacher should provide end condition and length of column.)*
8. Define effective length.
9. Define buckling phenomenon.

Space to Write Answers

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XIII. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related:15 Marks		**60%**
1	Understanding end restraints and deflected shape of column	25%
2	Precision in sketchbook, neatness, cleanliness.	30 %
3	Working in team.	5 %
Product related:10 Marks		**40%**
4	Interpretation of given data.	10%
5	Answers to practical related questions.	20%
6	Submission of report in time.	10%
Total: 25 Marks		**100%**

List of Student Team Members (Roll No.)

1. ……
2. ……
3. ……
4. ……

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

Practical No. 17: Design of a welded connection for the given data and compare it using open software / IS code

I. Practical Significance

Many steel structures are made-up of various components which are connected together by means of rivets, bolts or by welds. With the progress made in welding equipment and electrodes, the advancing art and science of designing for welding and the increasing trust and acceptance of welding have combined to make it powerful implement for the expanding construction industry. In addition, the shortened production cycles made possible by welding, have helped effect a quickening in the pace of new construction. Welding will become increasingly important as more people acquire a greater depth of knowledge and experience that goes with it. This practical will help to understand the design process of welded connection.

II. Relevant Program Outcomes

PO. 1 ***Basic knowledge:*** *An ability to apply knowledge of basic mathematics, science and engineering to solve the engineering problems.*

PO. 2 ***Discipline knowledge****: An ability to apply Civil engineering knowledge to solve broad-based Civil engineering related problems.*

PO. 4 ***Engineering Tools:*** *An ability to apply relevant civil technologies and tools with an understanding of the limitations.*

PO. 7 ***Ethics:*** *Apply ethical principles for commitment to professional ethics, responsibilities and norms of the practice also in the field of Civil engineering.*

PO. 8 ***Individual and Team Work:*** *Function effectively as leader and team member in diverse /multidisciplinary team.*

III. Relevant Course Outcomes

a. Design the connections for the given steel joints.

IV. Practical Outcome

Design of a welded connection for the given data and compare it using open software / IS code.

V. Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency, ***"Designing the welded connection for the given condition."***

a. Ability to design the welded connection for the given condition.
b. Ability of using IS 800:2007 for design of welded connection.

VI. Relevant Affective domain related

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

VII. Minimum 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.)

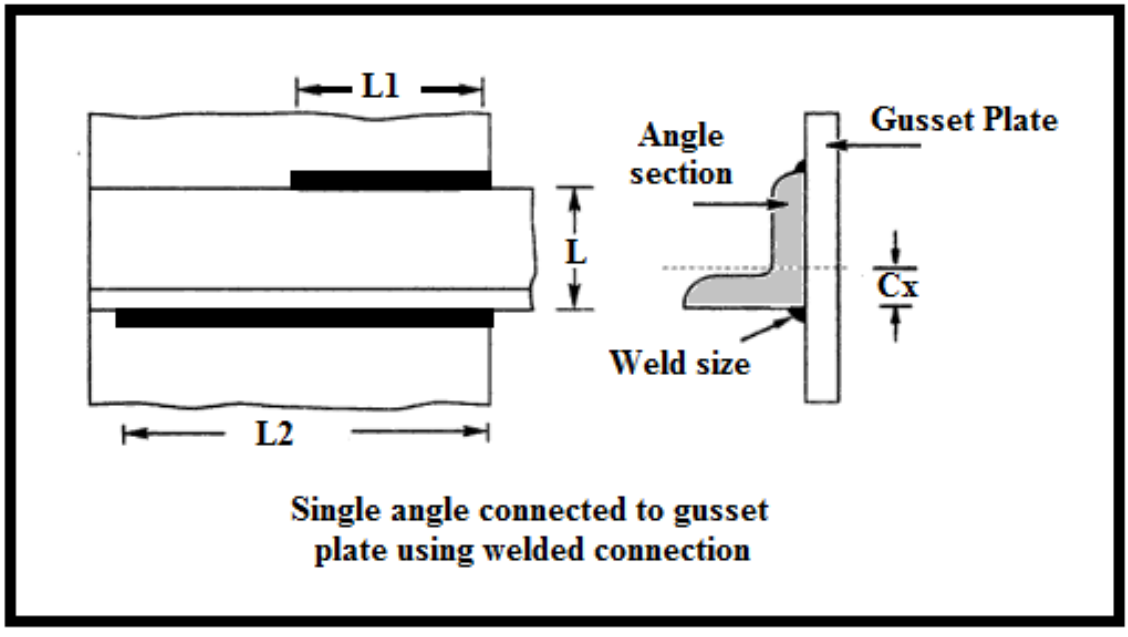
Permissible stresses in weld: The permissible stresses in weld for tension or compression section through throat of butt weld is taken as 150 N/mm^2.

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	¾ 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.

VIII. Experimental Set-up



Single angle connected to gusset plate using welded connection

IX. Resources required

Sr. No.	Particulars	Specification	Quantity	Remark
1	IS 800:2007	--------	1 No.	Per group of 5 students
2	Limit state design of steel structures	Shah, Gore, Veena	1 No.	Per group of 5 students

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} = ¾ 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 L_1 or L_2 accordingly.
6. Draw sketch showing connection details.

XI. Precautions to be followed

1. While designing the connection IS code provisions should be considered.
2. Precaution should be taken while taking moment to calculate weld length.
3. Calculations should be made accurately.

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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 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.
3. Write the formula to calculate full strength of section.
4. Enlist two advantages and two disadvantages of welded connection over bolted connection.
5. Write formula to calculate effective length of weld.
6. Write the relation between size of fillet weld and throat thickness.
7. 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.

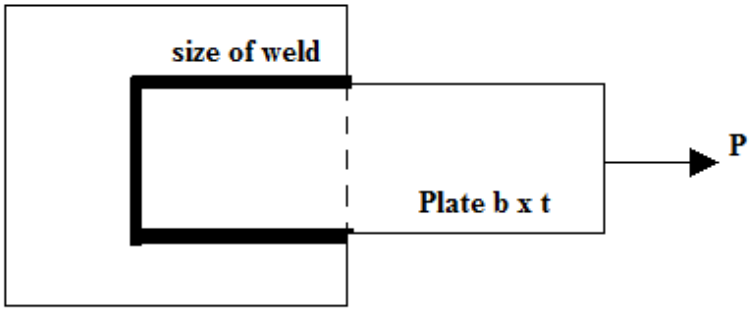

Fig. 1

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

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XIII. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related:15 Marks		**60%**
1	Use of steel table.	20%
2	Process of designing the given structural component	35%
3	Working in team.	5 %
Product related:10 Marks		**40%**
3	Interpretation of given data.	10%
4	Answers to practical related questions.	20%
5	Submission of report in time.	10%
Total: 25 Marks		**100%**

List of Student Team Members (Roll No.)

1. ……
2. ……
3. ……
4. ……

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

Practical No. 18: Draw reinforcement detailing of dog legged stair

I. Practical Significance

In multistory buildings, for vertical communication between two floors staircases are used. One of the type of staircase is dog legged staircase. It has two flights out of which one flight goes up to mid-landing and after that second flight continues through 180 degree turn. This practical will help to understand the reinforcement detailing of dog legged staircase.

II. Relevant Program Outcomes

PO. 2 Discipline knowledge*: An ability to apply Civil engineering knowledge to solve broad-based Civil engineering related problems.*

PO. 4 Engineering Tools: *An ability to apply relevant civil technologies and tools with an understanding of the limitations.*

PO. 8 Individual and Team Work: *Function effectively as leader and team member in diverse /multidisciplinary team*

PO. 9 Communication: *An ability to communicate effectively in oral and written form.*

III. Relevant Course Outcomes

a. Design of shear reinforcement and development length for beam and slabs.
b. Design various slabs for the given edge condition.

IV. Practical Outcome

Draw reinforcement detailing of dog legged stair.

V. Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency, ***"Reinforcement details in stairs."***

a. Observation skill.
b. Ability to understand provision of main steel and distribution steel in waist slab and mid-landing slab.
c. Ability to understand provision of development length in the form of extra bar.

VI. Relevant Affective domain related

a. Practice precision in drawing, neatness and cleanliness.
b. Demonstrate working as a leader / a team member.

VII. Minimum Theoretical Background

Stair: It is one of the vertical mean of circulation which joins two different floors.

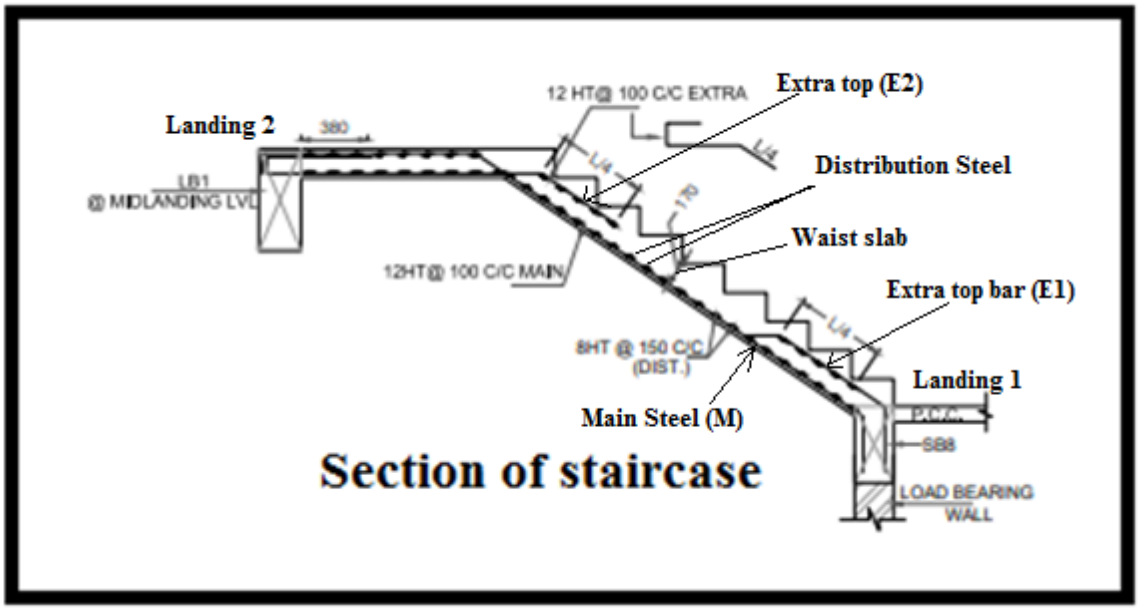
Dog legged staircase: Doglegged stair case is the most economical staircase. It is the most common type of stairs arranged with two adjacent flights running parallel with a mid landing. Where space is less, doglegged staircase is generally provided resulting

in economical utilization of available space. In this type of staircase landing is provided corresponding to the level at which the direction of the flight changes.

Some of the important parts of stairs are as follows -

- **1st landing (Landing 1):** From where step will start.
- **2nd Landing (Landing 2):** where step will over or will start new steps.
- **Waist slab:** The inclined slab between 1st and 2nd landing.
- **Main Steel:** Main reinforcement will start from the bottom of 1st landing and go through the inclined slab and will stay on top of 2nd landing. Spacing of bar depends on structural design. Another main reinforcement starts from the top of 1st landing and goes through the waist slab and will stay on the bottom of 2nd landing.
- **Distribution Steel:** These bars are provided perpendicular to main steel or parallel to width of stair.
- **Extra Top Bar (E1):** E1 is extra top at 1st landing. It is extended up to one-third to one-fourth length (L) of waist slab from the 1st landing edge.
- **Extra Top (E2):** E2 is also extra top bar same as E1. But it is placed at 2nd landing and extended up to one-third to one-fourth length of waist slab into the waist slab.

VIII. Experimental Set-up



IX. Resources required

Sr. No.	Particulars	Specification	Quantity	Remark
1	Limit State Theory and Design of Reinforced Concrete	Dr. S. R. Karve and Dr. V. L. Shah	1 No.	Per group of 5 students
2	A3 size sketchbook and Drawing tools (scale, pencil, eraser etc.)	--------	1 set	Per student

X. Procedure

1. Teacher should guide the students about structural components of staircase which are required to be designed.
2. Teacher should also discuss the position of main steel, distribution steel, development length of bar, extra bar and their functions in stairs.
3. Students should draw cross section of staircase showing reinforcement detailing in sketchbook. (Refer point no. VIII Experimental set-up.)

XI. Precautions to be followed

1. Draw carefully the extra bar, development length of bar.
2. Sketch should be drawn appropriately along with the font size used for labeling.

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. Define waist slab.
2. State need of extra bar to be provided in stairs.
3. State need of development length to be provided in stairs.
4. State the position of extra bar in stairs.
5. State the position of development length of bar in stairs.
6. Mention value of cover to be provided for waist slab.
7. Write the position where scissor cut is provided in case of stairs.
8. Main steel in case stairs is provided _____ *(parallel / perpendicular)* to span of stair.
9. Write the formulae to calculate span of stair.

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XIII. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related:15 Marks		**60%**
1	Understanding steel detailing in stairs	25 %
2	Precision in sketchbook, neatness, cleanliness.	30 %
3	Working in team.	5 %
Product related:10 Marks		**40%**
4	Interpretation of given data.	10%
5	Answers to practical related questions.	20%
6	Submission of report in time.	10%
Total: 25 Marks		**100%**

List of Student Team Members (Roll No.)

1. ……
2. ……
3. ……
4. ……

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

Practical No. 19: Check the given drawing as per IS 456:2000 specifications with respect to reinforcement detailing (Working drawing / Blue print should be collected from the suitable site)

I. Practical Significance

The *structural engineer* plays a key *role* in the construction process at site. S*tructural engineering* is part of civil *engineering* concerned with the design and physical integrity of buildings and other *structures.* Structural design engineer performs various roles and responsibilities in a construction project providing technical details for the activities to be performed at construction site related to reinforcement and dimensions of the members of structure. This practical will help the students to correlate the obtained structural drawing with IS specifications regarding reinforcement detailing.

II. Relevant Program Outcomes

PO. 2 Discipline knowledge*: An ability to apply Civil engineering knowledge to solve broad-based Civil engineering related problems.*

PO. 4 Engineering Tools: *An ability to apply relevant civil technologies and tools with an understanding of the limitations.*

PO. 8 Individual and Team Work: *Function effectively as leader and team member in diverse /multidisciplinary team.*

PO. 9 Communication: *An ability to communicate effectively in oral and written form.*

III. Relevant Course Outcomes

a. Analysis and design of singly reinforced rectangular beams.
b. Design of shear reinforcement and development length for beam and slabs.
c. Design various slabs for the given edge condition.
d. Design of axially loaded short columns and footings.

IV. Practical Outcome

Check the given drawing as per IS 456:2000 specifications with respect to reinforcement detailing. (Working drawing / Blue print should be collected from the suitable site)

V. Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency, ***"Proper execution of the activities on the site with desired performance."***

a. Observation skill.
b. Ability to understand the structural drawing.
c. Ability to correlate the collected structural drawing as per IS specifications with respect to reinforcement detailing.

VI. Relevant Affective domain related

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

VII. Minimum Theoretical Background

Site Inspection: The structural designer/technician at site inspects the actual laying of reinforcement, checking dimensions of the members and other quality aspect with respect to concrete works. These activities are done prior to beginning of concreting operation. These activities are checked by technician from the structural drawing provided at site.

Role of Site Engineer: A site engineer has to perform a lot of activities on the site. His/her role involves a lot of responsibility which includes giving sufficient advice and supervision when there are any technical issues, or for proper management. The site engineer should possess basic knowledge about the practical construction procedures in site, along with the details of how they are planned, how reinforcement is placed and what precautions should be taken for placement of steel. This idea of planning and coordination will help him to have proper execution of the activities in the site with desired performance.

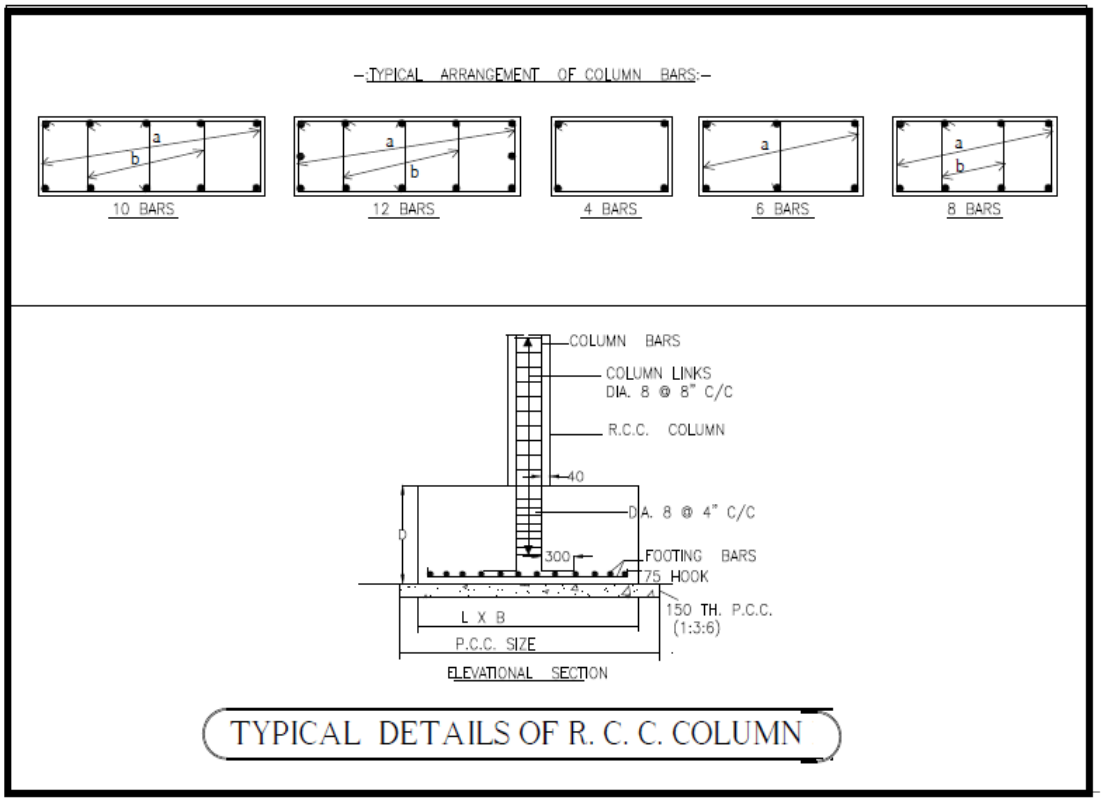
IS Specifications: IS code provides some specifications regarding cover used for reinforcement, bar diameter, number of bars to be used, minimum and maximum percentage of steel, spacing of bars etc.

e.g. As per IS 456:2000 – Clause no. 26.5.3.1 (Page 48)

For longitudinal steel of column –

(1) Minimum percentage of steel = 0.8 % of gross area of column
(2) Maximum percentage of steel = 6 % of gross area of column
(3) Minimum number of bars = 4 for rectangular column and 6 for circular column
(4) Minimum diameter of bar for column = 12 mm
(5) Maximum spacing of longitudinal bars in column = 300 mm measured along the periphery of the column.

VIII. Experimental Set-up



IX. Resources required

Sr. No.	Particulars	Specification	Quantity	Remark
1	IS 456:2000	-------	1 No.	Per group of 5 students

X. Procedure

1. Teacher should guide the students regarding reading of structural drawing and IS 456:2000 provisions of reinforcement detailing.
2. Student should discuss with batch mates to correlate the obtained structural drawing with IS 456:2000 specifications.

XI. Precautions to be followed

1. Take care while finding accurate clause related to the structural component (e.g. beam, column, slab etc) from IS 456:2000.

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 minimum and maximum bar diameter used for _____ in given structural drawing. *(Teacher should provide different structural components.)*
2. State the type of slab shown on given structural drawing.
3. State the spacing between bars for _____. *(Teacher should provide different structural components.)*
4. State the cover used for – _____.
   (Teacher should provide different structural components.)
5. Compare IS specification with actual provision of reinforcement for – _____.
   (Teacher should provide different structural components.)
6. State the number of bars used for _____. *(Teacher should provide the beam or column shown on drawing.)*
7. For column _____ *(two legged / three legged)* links are used on provided drawing.
8. For beam _____ *(two legged / three legged)* stirrups are used on provided drawing.
9. Write any two notes form provided structural drawing.

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XIII. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related:15 Marks		**60%**
1	Interpretation of given data	25%
2	Use of IS 456:2000	30 %
3	Working in team.	5 %
Product related:10 Marks		**40%**
3	Interpretation of given data.	10%
4	Answers to practical related questions.	20%
5	Submission of report in time.	10%
Total: 25 Marks		**100%**

List of Student Team Members (Roll No.)

1. ……
2. ……
3. ……
4. ……

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

Practical No. 20: Design one cantilever slab from the given data

I. Practical Significance

Cantilever Slab is a slab panel supported on only one edge. The edge may be wall or beam. In case of RCC framed buildings cantilever slab is provided for projected balconies, projected landing of staircase or chajja over windows. 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. Relevant Program Outcomes

PO. 1 Basic knowledge: *An ability to apply knowledge of basic mathematics, science and engineering to solve the engineering problems.*

PO. 2 Discipline knowledge*: An ability to apply discipline - specific knowledge to solve core and/or applied engineering problems.*

PO. 4 Engineering tools: *Apply relevant Civil technologies and tools with an understanding of the limitations.*

PO. 7 Ethics: *Apply ethical principles for commitment to professional ethics, responsibilities and norms of the practice also in the field of Civil engineering.*

PO. 8 Individual and Team Work: *Function effectively as leader and team member in Diverse / multidisciplinary team.*

III. Relevant Course Outcomes

a. Design of shear reinforcement and development length for beam and slabs.
b. Design various slabs for the given edge condition.

IV. Practical Outcome

Design one cantilever slab from the given data.

V. Competency and Practical Skills

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.

VI. Relevant Affective domain related

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

VII. Minimum Theoretical Background

Cantilever slab is designed for maximum bending moment at fixed support. 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 distribution steel is calculated to resist temperature and shrinkage stresses. The reinforcement of cantilever slab consists of mesh of main steel and distribution steel. In this mesh, main steel is laid perpendicular to supporting beam and at the top position in slab (Due to tension developed at top of cantilever). The distribution steel is laid perpendicular to main reinforcement and below it. The reinforcement is laid up to the free end of cantilever with each alternate bar bent in to spring shape (Chimta**).**

VIII. Resources required

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

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
M_u	- Ultimate moment of resistance	t	- Thickness of support	W_u	- Factored Load

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 cantilever type of slab and design the same as per IS 456: 2000.
6. Use following steps to design:
   a. Take span of slab as projection beyond face of wall / beam (L).
   b. Determine effective depth required for deflection control [Clause 23.2.1.a]
      (L/d) ≤ (M.F. x basic value of span-depth ratio)
      i.e. $d_{reqd} \geq L /(M.F. \times 7)$
      $D_{reqd} \geq d_{reqd}$ + 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) l = L+ d/2 and ii) l = L+ t/2

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

W = DL + LL + FF

Wu = γ_f [(density of rcc X D)+ LLi + FFi] X 1X 1, γ_f = 1.5

= 1.5[(25 X D) + LLi + FFi] X 1X 1

e. Determine designed or factored bending moment using

$M_u = w_u (l^2) / 2$

Determine and Check the required effective depth using, $M_u = M_{ur} = R_{ulim}(bd^2)$

If provided 'd' is > required 'd', then ok.

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

f. Determination of tensile steel area (for TOR steel) –

a) Min. steel area in any direction = 0.12% of A_g.

b) A_{st} reqd to resist M_u with provided'd' is given by

$$A_{st} \text{ reqd} = 0.5 \frac{fck}{fy} \left[1-\sqrt{1 - \frac{4.6Mu}{fck\, bd2}}\right] bd$$

c) Assuming suitable bar diameter calculate required spacing using,

$$S_P \text{ reqd} = \frac{1000\ xA1}{Ast\ reqd}$$

d) Apply check for maximum spacing 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

a) Calculate area of Distribution steel – as per clause

A_{DS} = 0.15% of A_g

= 0.15/100 X b X D

b) Calculate spacing of distribution steel

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

c) Give check for spacing of distribution steel as per clause…..

It should not be more than minimum of the following two

i) 5d =

ii) 450 mm

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

Hence O.K.

h. Check for development length $L_{d.}$

$$L_d = \frac{0.87\ fy\ \Phi}{4\tau bd}$$

As per Clause 26.2.1.1, page no. 43,

τbd = ___ for ____grade concrete

$$M_O = 0.87 f_y A_{st} \frac{(d - fy.Ast)}{fckXb}$$

Factored shear force,

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

L_0 = d or 12Φ or can be considered as zero.

Hence -

$$L_d \text{ calculated} = 1.3[\frac{1.3MO}{Vu} + L_0]$$

Thus provide development length = $L_d/3$ from the face of wall.

X. 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.

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XI. Resources used

Sr. No.	Name of Resource	Broad Specifications		Quantity	Remark
		Make	Details		
1					
2					

XII. Results (Summary of Design)

1. Overall depth (D) = _____ mm.
2. Effective depth (d) = _____ mm.
3. Main steel ____mm ϕ bars of _____ grade at _____mm c/c.
4. Dist. steel ____mm ϕ bars of grade at _____mm c/c.

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. The basic value of span to effective depth ratio for cantilever slab is ____.
2. Calculate the intensity of self-weight of _____ mm thick slab per unit area? *(Teacher should provide thickness of slab.)*
3. Write the functions of distribution steel.
4. State intensity of live load to be considered for passage slab in a school building.
5. Alternate bars are bent up in spring (chimta) shape in a cantilever slab. Justify your answer.
6. Write situations where design of cantilever slab is must.
7. State the position of main reinforcement in case of cantilever slab and give reason?
8. State the reason for not taking checks for shear and development length in case of design of cantilever slab? Justify your answer.
9. Write different standard steel bar diameters available in the market to be provided as reinforcement.

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XIV. References / Suggestions for further Reading

Sr. No.	Title of Book/ Website Links	Author	Publication
1.	Limit State Theory and Design of Reinforced Concrete Structures	Dr. V. L. Shah and Dr. S. R. Karve	Structures Publications, Pune. ISBN-13:9788190371711
2.	Fundamentals of Reinforced Concrete	N. C. Sinha and S. K. Roy	S. Chand & Co., New Delhi ISBN-13:978-8121901277
3.	Reinforced Concrete Design Principles and Practice	N. Krishna Raju and R. N. Pranesh	New Age International, Mumbai ISBN-13:9788122414608
4.	Reinforced Concrete Design	S. U. Pillai and DevdasMenon	Tata McGraw Hill Publications, New Delhi ISBN-13: 978-0070141100

XV. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related:15 Marks		**60%**
1	Design of slab panel	30 %
2	Proper calculation	30 %
Product related:10 Marks		**40%**
3	Design details	5%
4	Answers to practical related questions.	25%
5	Submission of report in time.	10%
Total: 25 Marks		**100%**

List of Student Team Members (Roll No.)

1. ……
2. ……
3. ……
4. ……

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

Practical No. 21: Design a One Way Simply Supported Slab from the given data

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. Relevant Program Outcomes

PO. 1 Basic knowledge: *An ability to apply knowledge of basic mathematics, science and engineering to solve the engineering problems.*

PO. 2 Discipline knowledge*: An ability to apply discipline – specific knowledge to solve core and/or applied engineering problems.*

PO. 4 Engineering tools: *Apply relevant Civil technologies and tools with an understanding of the limitations.*

PO. 7 Ethics: *Apply ethical principles for commitment to professional ethics, responsibilities and norms of the practice also in the field of Civil engineering.*

PO. 8 Individual and Team Work: *Function effectively as leader and team member in diverse / multidisciplinary team.*

III. Relevant Course Outcomes

a. Design of shear reinforcement and development length for beam and slabs.
b. Design various slabs for the given edge condition.

IV. Practical Outcome

Design a one way simply supported slab from the given data.

V. Competency and Practical Skills

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.

VI. Relevant Affective domain related

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

VII. Minimum 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.

VIII. Resources required

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

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
M_u	- Ultimate moment of resistance	t	- Thickness of support	W_u	– Factored Load

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. $L = L_X$
   b. Determine effective depth required from deflection control [Clause 23.2.1.a]
      (L/d) ≤ (M.F. x basic value of span-depth ratio)
      i.e. $d_{reqd} \geq L_X$ /(M.F. x 20)
      $D_{reqd} \geq d_{reqd}$ + 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 = γ_f[(density of rcc X D) + LLi + FFi] X 1X 1, γ_f = 1.5
      = 1.5[(25 X D) + LLi + FFi] X 1X 1
   e. Determine designed or factored bending moment using
      $M_u = w_u (l^2) / 8$
      Determine and Check the required effective depth using, $M_u = M_{ur} = R_{ulim}(bd^2)$
      If provided 'd' is > required 'd' ,then ok
      If 'd' is < required 'd', then repeat design step atSr.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 A_g

      ii) A_{st} reqd to resist M_u with provided 'd' is given by

$$A_{st}\text{ reqd} = 0.5 \frac{fck}{fy} \left[1-\sqrt{1 - \frac{4.6Mu}{fck\, bd2}}\right] bd$$

      iii) Assuming suitable bar diameter calculate required spacing using,

$$S_P\text{ reqd} = \frac{1000\ xA1}{Ast\ reqd}$$

      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 A_g
   = 0.15/100 X b X D

i) Calculate spacing of distribution steel

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

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

$$L_d = \frac{0.87\ fy\ \Phi}{4\tau bd}$$

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

τbd = ___for ____grade concrete

$$M_O = 0.87 f_y A_{st} \frac{(d - fy.Ast)}{fck.b}$$

Factored shear force,

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

L_0 = d or 12 Φ or can be considered as zero

Hence -

$$L_d \text{ calculated} = 1.3[\frac{1.3MO}{Vu} + L_0]$$

Thus provide development length = $L_d/3$ from the face of wall.

X. 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.

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

Sr. No.	Slab Notation	Span

Space to Write Design

Design of slab at Sr. No.____

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XI. Resources used

Sr. No.	Name of Resource	Broad Specifications		Quantity	Remark
		Make	Details		
1					
2					

XII. 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.

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. The basic value of span to effective depth ratio for One-Way slab is ____.
2. Stair slab is designed as _____ slab.
3. Write the functions of main steel.
4. Write the available grades of reinforcing steel in the market.
5. Explain the terms overall depth, effective depth with sketch.
6. State the de-shuttering time for slab as per IS 456:2000 and compare with site practice.
7. Draw reinforcement details for sloping slab. Indicate main and distribution bars.

8. Modification factor depends upon _____.
9. Write the lowest grade of concrete used for RCC.

Space to Write Answers

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XIV. References / Suggestions for further Reading

Sr. No.	Title of Book/ Website Links	Author	Publication
1.	Limit State Theory and Design of Reinforced Concrete Structures	Dr. V. L. Shah and Dr. S. R. Karve	Structures Publications, Pune. ISBN-13:9788190371711
2.	Fundamentals of Reinforced Concrete	N. C. Sinha and S. K. Roy	S. Chand & Co., New Delhi ISBN-13:978-8121901277
3.	Reinforced Concrete Design Principles and Practice	N. Krishna Raju and R. N. Pranesh	New Age International, Mumbai ISBN-13:9788122414608
4.	Reinforced Concrete Design	S. U. Pillai and DevdasMenon	Tata McGraw Hill Publications, New Delhi ISBN-13: 978-0070141100

XV. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related:15 Marks		**60%**
1	Design of slab panel	30 %
2	Proper calculation	30 %
Product related:10 Marks		**40%**
3	Design details	5%
4	Answers to practical related questions.	25%
5	Submission of report in time.	10%
Total: 25 Marks		**100%**

List of Student Team Members (Roll No.)

1. ……
2. ……
3. ……
4. ……

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

Practical No. 22: Design a two way simply supported slab from the given data

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 usingLimit State Method along with the knowledge of placing of reinforcement in actual practice.

II. Relevant Program Outcomes

PO. 1 Basic knowledge: *An ability to apply knowledge of basic mathematics, science and engineering to solve the engineering problems.*

PO. 2 Discipline knowledge*: An ability to apply discipline - specific knowledge to solve core and/or applied engineering problems.*

PO. 4 Engineering tools: *Apply relevant Civil technologies and tools with an understanding of the limitations.*

PO. 7 Ethics: *Apply ethical principles for commitment to professional ethics, responsibilities and norms of the practice also in the field of Civil engineering.*

PO. 8 Individual and Team Work: *Function effectively as leader and team member in diverse / multidisciplinary team.*

III. Relevant Course Outcomes

a. Design of shear reinforcement and development length for beam and slabs.
b. Design various slabs for the given edge condition.

IV. Practical Outcome

Design a two way simply supported slab from the given data.

V. Competency and Practical Skills

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.

VI. Relevant Affective domain related

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

VII. Minimum 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 it 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.

VIII. Resources required

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

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
M_u	- Ultimate moment of resistance	t	- Thickness of support	W_u	- Factored Load

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 on the basis of aspect ratio of longer span and shorter span.
3. Teacher shall prepare four groups for a batch of 20 students.
4. Each group shall design at least one slab.
5. Students should observe the slab type and design the same as per IS 456: 2000.
6. Use following steps to design:
   a. Write down both shorter span (Lx) and longer span (L_y).
   b. Using short span, determine overall depth required for deflection control. [Clause 23.2.1.a]
   (L_x/D) ≤ (M.F. x basic value of span-depth ratio)
   For two-way slab of shorter span upto 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
   i.e. $D_{reqd} \geq L_X$ /(M.F. x 35) or $D_{reqd} \geq L_X$ /(M.F. x 28)

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

Select overall depth in multiples of 10 mm; say D

Hence provided effective depth d = D - effective cover

c. Calculate effective span

l_x as lesser of i) centre to centre dist. between supports and ii)$L_x + d_x$

$l_y$as lesser of i) centre to centre dist. between supports and ii)$L_y + d_y$

d. Determine intensity of ultimate ud.load per m run of slab of strip of width 1m, as
W = W = DL + LL + FF
Wu = γ_f[(density of rcc X D) + LLi + FFi] X 1X 1, γ_f = 1.5
= 1.5[(25 X D) + LLi + FFi] X 1 X 1
Determine aspect ratio i.e. ratio of l_y to l_x
Referring IS 456-2000, Table 27, Appendix D, obtain values of B.M. coefficients
α_x = _____and α_y = _____

e. Determine design or factored moment using
$M_{ux} = \alpha_x (w_u l_x^2)$ and $M_{uy} = \alpha_y (w_u l_x^2)$
Check the required effective depth using, $M_u = M_{ur} = R_{ulim}(bd^2)$
If provided 'd_x' 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) –
a) Min. steel area in any direction = 0.12% of A_g

b) A_{stx} reqd to resist M_{ux} with provided 'd_x' is given by

$$A_{stx} \text{ reqd} = 0.5 \frac{fck}{fy} [1-\sqrt{1 - \frac{4.6Mux}{fck\, bdx2}}] bd_x$$

Similarly calculate, A_{sty} reqd to resist M_{uy} with 'd_y'

$$A_{sty} \text{ reqd} = 0.5 \frac{fck}{fy} [1-\sqrt{1 - \frac{4.6Muy}{fck\, bdy2}}] bd_y$$

c) Assuming suitable bar diameter calculate required spacing using,

$$S_P \text{reqd} = \frac{1000\ xA1}{Ast\ reqd}$$

d) Apply check for maximum spacingin 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.

X. 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

Sr. No.	Slab Notation	Span

Space to Write Design

Design of slab at Sr. No.____

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XI. Resources used

Sr. No.	Name of Resource	Broad Specifications		Quantity	Remark
		Make	Details		
1					
2					

XII. Results (Summery of Design)

1. Overall depth (D) = _____ mm.
2. Effective depth (d) = _____ mm.
3. Main steel:
   i) Along shorter span ____mm ϕ bars ____mm c/c.
   ii) Along longer span ____mm ϕ bars ____mm c/c.

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. 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.
7. Alternate bars are bent up in two way slab. Give reason.
8. In two way slab, along longer span _____steel and along shorter span _____steel is provided. *(Main / distribution)*
9. State the criteria to decide thickness of two way slab in accordance with span, live load and grade of steel.

Space to Write Answers

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XIV. References / Suggestions for further Reading

Sr. No.	Title of Book/ Website Links	Author	Publication
1.	Limit State Theory and Design of Reinforced Concrete Structures	Dr. V. L. Shah and Dr. S. R. Karve	Structures Publications, Pune. ISBN-13:9788190371711
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3.	Reinforced Concrete Design Principles and Practice	N. Krishna Raju and R. N. Pranesh	New Age International, Mumbai ISBN-13:9788122414608
4.	Reinforced Concrete Design	S. U. Pillai and DevdasMenon	Tata McGraw Hill Publications, New Delhi ISBN-13: 978-0070141100

XV. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related:15 Marks		**60%**
1	Design of slab panel	30 %
2	Proper calculation	30 %
Product related:10 Marks		**40%**
3	Design details	5%
4	Answers to practical related questions.	25%
5	Submission of report in time.	10%
Total: 25 Marks		**100%**

List of Student Team Members (Roll No.)

1. ……
2. ……
3. ……
4. …….

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

Practical No. 23: Design the beam/s each supporting cantilever slab, one way simply supported slab and two way simply supported slab from the given data

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. Relevant Program Outcomes

PO. 1 ***Basic knowledge:*** *Apply knowledge of basic mathematics, science and basic engineering to solve the broad-based Civil engineering problems.*

PO. 2 ***Discipline knowledge****: An ability to apply Civil engineering knowledge to solve broad-based Civil engineering related problems.*

PO. 3 ***Experiments and practice:*** *Plan to perform experiments and practices to use the results to solve the broad-based Civil engineering problems.*

PO. 4 ***Engineering Tools:*** *An ability to apply relevant civil technologies and tools with an understanding of the limitations.*

PO 8. ***Individual and Team Work:*** *Function effectively as leader and team member in diverse /multidisciplinary team.*

PO. 9 ***Communication:*** *An ability to communicate effectively in oral and written form.*

III. Relevant Course Outcomes

a. Analysis and design of singly reinforced rectangular beams.

IV. Practical Outcome

Design the beam/s each supporting cantilever slab, one way simply supported slab and two way simply supported slab from the given data.

V. Competency and Practical Skills

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.

VI. Relevant Affective domain related

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

VII. Minimum 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.

VIII. Resources required

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

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
Vuc	= Factored shear force resisted by concrete	Vus	= Factored shear force resisted by stirrups
Vus	= Factored shear force resisted by bent up bar		
v			
Wu	= Factored udl	Xu	= Actual depth of Neutral axis

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 –

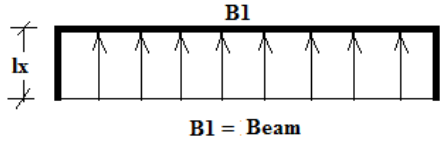
(A) Flexural design of beam:

- **Designation, type and support condition:** From the blue print / working drawing, write the designation of the beam as B1, B2, ….. 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 = $Wu_{-self} = 1.5 * \rho_{RCC} * b * D$
(Unit weight of RCC (ρ_{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 – q_u = Total ultimate slab load in kN/m^2.

- Load transfer from cantilever slab

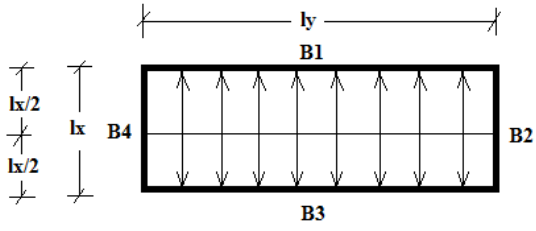


Equivalent udl on beam

$$w_{u\,slab} = q_u \times l_x$$

Transfer of load from Cantilever slab

- Load transfer from one way simply supported slab

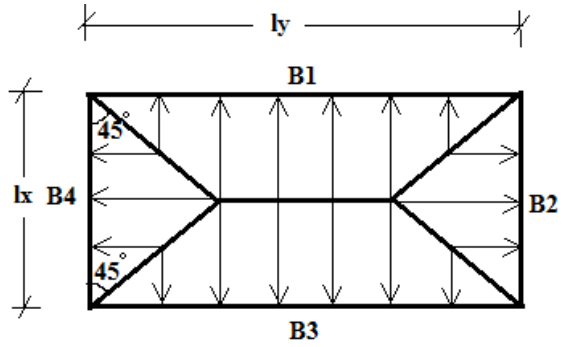


Equivalent udl on longer beam

$$w_{u\,slab} = \frac{q_u \times l_x}{2}$$

Transfer of load from one way simply supported slab

- Load transfer fromtwo way simply supported slab



B1 = B3 = Longer Beam
B2 = B4 = Shorter Beam

Transfer of load from two way simply supported slab

Equivalent udl on longer beam

$$w_{u\,slab} = \frac{q_u \times l_x}{2}\left[1 - \frac{1}{3 \times \beta^2}\right]$$

Equivalent udl on shorter beam

$$w_{u\,slab} = \frac{q_u \times l_x}{2}\left[1 - \frac{1}{2 \times \beta}\right]$$

Where,

$$\beta = \frac{ly}{lx}$$

(c) Ultimate wall load: $Wu_{wall} = 1.5 * \rho_{masonry} * b * H$

($\rho_{masonry}$ = Unit weight of masonry, b = Width of wall, H = Clear height of wall)

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

$Wu = Wu_{-self} + Wu_{-slab\,1} + Wu_{-slab\,2} + Wu_{wall}$

(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 –

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

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

$$d_{bal} = \sqrt{\frac{M_u}{q_{max} \times f_{ck} \times b}}$$

- **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:**
  Calculate area of main steel as –

$$Ast_{reqd} = \frac{0.5 \times f_{ck}}{f_y} \times \left[1 - \sqrt{1 - \frac{4.6 \times M_u}{f_{ck} \times b \times d^2}}\right] \times b \times d$$

Check $Ast_{min.}$

$$Ast_{min} = \frac{0.85 \times b \times d}{f_y}$$

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

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

$$No.\ of\ bars = \frac{Ast}{A_\phi} = \frac{Ast}{\left(\frac{\pi}{4} \times \phi^2\right)}$$

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

$$Ast_{provided} = No.of\ bars \times A_\phi$$

(If bars cannot be accommodated in one layer, provide bars in two layers.)

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

- **Ultimate design shear force (Vu)**

$$V_u = \frac{w_u \times l}{2}$$

- **Nominal shear force (τ_v)**

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

- **Ultimate shear force resisted by concrete**

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

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

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

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

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

- **Bent-up bars used:**

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

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 τ_c.

Determine ultimate shear force resisted by concrete.

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

- **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}):**

$$V_{usb} = 0.87 \times fy \times A_{sb} \times \sin \alpha > \frac{V_{us}}{2}$$

Where, A_{sb} = Area of one bent up bar.

- **Ultimate shear to be resisted by vertical stirrups (V_{usv}):**

$$V_{usv} = V_{us} - V_{usb}$$

- **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 –

$$S = \frac{0.87 \times fy \times A_{sv} \times d}{0.4 \times b}$$

Where, $A_{sv} = (2 \times \pi \times Ø^2) / 4$ 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 -

$$S = \frac{0.87 \times fy \times A_{sv} \times d}{V_{usv}}$$

Where, $A_{sv} = (2 \times \pi \times Ø^2) / 4$ 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.

(C) Check for development length: Calculate development length –

$$L_d = \frac{0.87 \times f_y \times \phi}{4 \times \tau_{bd}}$$

Take values of τ_{bd} from Clause 26.2.1.1, page 43 of IS 456:2000.

Check whether,

$$\frac{1.3 \times M_u}{V_u} > L_d$$

X. Precautions to be followed

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

Space to Write Design

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XI. Resources used

Sr. No.	Name of Resource	Broad Specifications		Quantity	Remark
		Make	Details		
1					
2					

XII. Results (Summery of Design)

1. Size of beam –
   b = _____ mm and
   D = _____ mm
   d = _____ mm.
2. Main steel
   Dia. of bar (Ø) = _____ mm and
   No. of bars = _____.
3. Stirrups
   Dia. of stirrup= _____ mm and
   Spacing of stirrup = _____ mm c/c.

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. 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 (l) = _____ mm, effective depth (d) = _____ mm and supporting wall thickness = _____ mm. *(Teacher should provide values of l, 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.
6. State IS 456:2000 specifications regarding spacing of vertical stirrups.
7. Calculate load transferred by a slab to supporting beam having dimensions (lx) = _____ m and (ly) = _____ m. Take ultimate design load on the slab (w_{ud}) = _____ kN/m^2.*(Teacher should provide values of lx, ly and w_{ud}.)*
8. Calculate load transferred by a cantilever slab to the supporting beam projecting (l) = _____ m. Take ultimate design load on the slab (w_{ud}) = _____ kN/m^2. *(Teacher should provide values of l and w_{ud}.)*
9. The main design criteria under limit state of collapse for design of beams are _____ and _____. The design is required to be checked for _____ and _____.

Space to Write Answers

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XIV. References / Suggestions for further Reading

Sr. No.	Title of Book/ Website Links	Author	Publication
1.	Limit State Theory and Design of Reinforced Concrete Structures	Dr. V. L. Shah and Dr. S. R. Karve	Structures Publications, Pune. ISBN-13:9788190371711
2.	Fundamentals of Reinforced Concrete	N. C. Sinha and S. K. Roy	S. Chand & Co., New Delhi ISBN-13:978-8121901277
3.	Reinforced Concrete Design Principles and Practice	N. Krishna Raju and R. N. Pranesh	New Age International, Mumbai ISBN-13:9788122414608
4.	Reinforced Concrete Design	S. U. Pillai and Devdas Menon	Tata McGraw Hill Publications, New Delhi ISBN-13: 978-0070141100

XV. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related:15 Marks		**60%**
1	Design of beam	30 %
2	Calculations	25 %
3	Use of IS 456:2000	5 %
Product related:10 Marks		**40%**
4	Design details	5%
5	Answers to practical related questions.	25%
6	Submission of report in time.	10%
Total: 25 Marks		**100%**

List of Student Team Members (Roll No.)

1. ……
2. ……
3. ……
4. …….

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

Practical No. 24: Design one axially loaded short column each supporting two given beams (corner column), three beams and four beams from the given field situation from the given data

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. Relevant Program Outcomes

PO. 1 ***Basic knowledge:*** *Apply knowledge of basic mathematics, science and basic engineering to solve the broad-based Civil engineering problems.*

PO. 2 ***Discipline knowledge****: An ability to apply Civil engineering knowledge to solve broad-based Civil engineering related problems.*

PO. 3 ***Experiments and practice:*** *Plan to perform experiments and practices to use the results to solve the broad-based Civil engineering problems.*

PO. 4 ***Engineering Tools:*** *An ability to apply relevant civil technologies and tools with an understanding of the limitations.*

PO 8. ***Individual and Team Work:*** *Function effectively as leader and team member in diverse /multidisciplinary team.*

PO. 9 ***Communication:*** *An ability to communicate effectively in oral and written form.*

III. Relevant Course Outcomes

a. Design of axially loaded short columns and footings.

IV. Practical Outcome

Design one axially loaded short column each supporting two given beams (corner column), three beams and four beams from the given field situation from the given data.

V. Competency and Practical Skills

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.

VI. Relevant Affective domain related

a. Demonstrate working as a leader / a team member.

b. Follow ethical practices.

VII. Minimum 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/b are 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.

VIII. Resources required

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

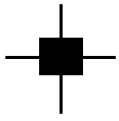
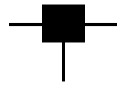
Abbreviations used:

Ag	= Gross area of column	Ac	= Area of concrete
Asc	= 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

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 (corner 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	Corner 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 (Pu) = _____ kN
- Unsupported height / length of column (L) = _____ m
- Assumed % of Asc (Asc) = 1% of Ag = _____ Ag
- Area of concrete (Ac) = Ag – Asc = Ag – (____Ag) = ____ Ag

(C) Calculation of Area, Ag and Asc

- Size of column

- Assuming column is subjected to minimum eccentricity.
- Using, Pu = {(0.4* fck * Ac) + (0.67 * fy * Asc)}

- Determine Ag required.
- Let, one side of column = b = width of wall
- Therefore, obtain other side required using, d = $\frac{\text{Ag required}}{\text{b}}$
- 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
- 300 mm

Hence, suggest pitch and diameter of lateral ties.

(D) Check for minimum eccentricity

Every column is designed for certain minimum eccentricity.

1) Actual e_{min} is taken as

- $\frac{L}{500} + \frac{D}{30}$ but subjected to minimum 20 mm

2) Permissible minimum eccentricity is 5 % of least lateral dimension of column

i.e. permissible e_{min} = 5 %

if actual $e_{min} \leq$ Permissible e_{min}. Then ok.

(E) Check the column for being short

Column will be short if $\frac{Le}{D} \leq 12$.

X. 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.

Space to Write Design

XI. Resources used

Sr. No.	Name of Resource	Broad Specifications		Quantity	Remark
		Make	Details		
1					
2					

XII. Results (Summery of Design)

1. Size of column –
   b = _____ mm and
   D = _____ mm.

2. Longitudinal / Main steel
   Dia. of bar (Ø) = _____ mm and
   No. of bars = _____.

3. Transverse steel
   Dia. of links = _____ mm and
   Spacing of links = _____ mm c/c.

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. 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.
6. Write IS 456:2000 specifications for longitudinal reinforcement in column.
7. Write IS 456:2000 specifications for transverse reinforcement in column.
8. Calculate working load carrying capacity of a square column having side (b) = _____ mm provided with _____ number of bars having diameter (Ø) = _____ mm. Use M20 concrete and Fe 415 steel.
   (Teacher should provide side of column, number of bars and diameter of bar.)

9. Calculate area of steel in compression for a square column of side (b) = _____ mm carrying an axial load of _____ kN. Use M20 concrete and Fe 415 steel. *(Teacher should provide side of column and axial load.)*

Space to Write Answers

XIV. References / Suggestions for further Reading

Sr. No.	Title of Book/ Website Links	Author	Publication
1.	Limit State Theory and Design of Reinforced Concrete Structures	Dr. V. L. Shah and Dr. S. R. Karve	Structures Publications, Pune. ISBN-13:9788190371711
2.	Fundamentals of Reinforced Concrete	N. C. Sinha and S. K. Roy	S. Chand & Co., New Delhi ISBN-13:978-8121901277
3.	Reinforced Concrete Design Principles and Practice	N. Krishna Raju and R. N. Pranesh	New Age International, Mumbai ISBN-13:9788122414608
4.	Reinforced Concrete Design	S. U. Pillai and DevdasMenon	Tata McGraw Hill Publications, New Delhi ISBN-13: 978-0070141100

XV. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related:15 Marks		**60%**
1	Design of column	30 %
2	Calculations	25 %
3	Use of IS 456:2000	5 %
Product related:10 Marks		**40%**
3	Design details	5%
4	Answers to practical related questions.	25%
5	Submission of report in time.	10%
Total: 25 Marks		**100%**

List of Student Team Members (Roll No.)

1. ……
2. ……
3. ……
4. …….

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

Practical No. 25: Design footing for axially loaded short column designed in Sr. No. 24

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. Relevant Program Outcomes

PO. 1 Basic knowledge: *An ability to apply knowledge of basic mathematics, science and engineering to solve the engineering problems.*

PO. 2 Discipline knowledge*: An ability to apply discipline - specific knowledge to solve core and / or applied engineering problems.*

PO. 4 Engineering tools: *Apply relevant Civil technologies and tools with an understanding of the limitations.*

PO. 7 Ethics: *Apply ethical principles for commitment to professional ethics, responsibilities and norms of the practice also in the field of Civil engineering.*

PO . 8 Individual and Team Work: *Function effectively as leader and team member in diverse /multidisciplinary team.*

III. Relevant Course Outcomes

a. Design of axially loaded short columns and footings.

IV. Practical Outcome

Design footing for axially loaded short column designed in Sr. no. 24.

V. Competency and Practical Skills

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.

VI. Relevant Affective domain related

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

VII. Minimum 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).

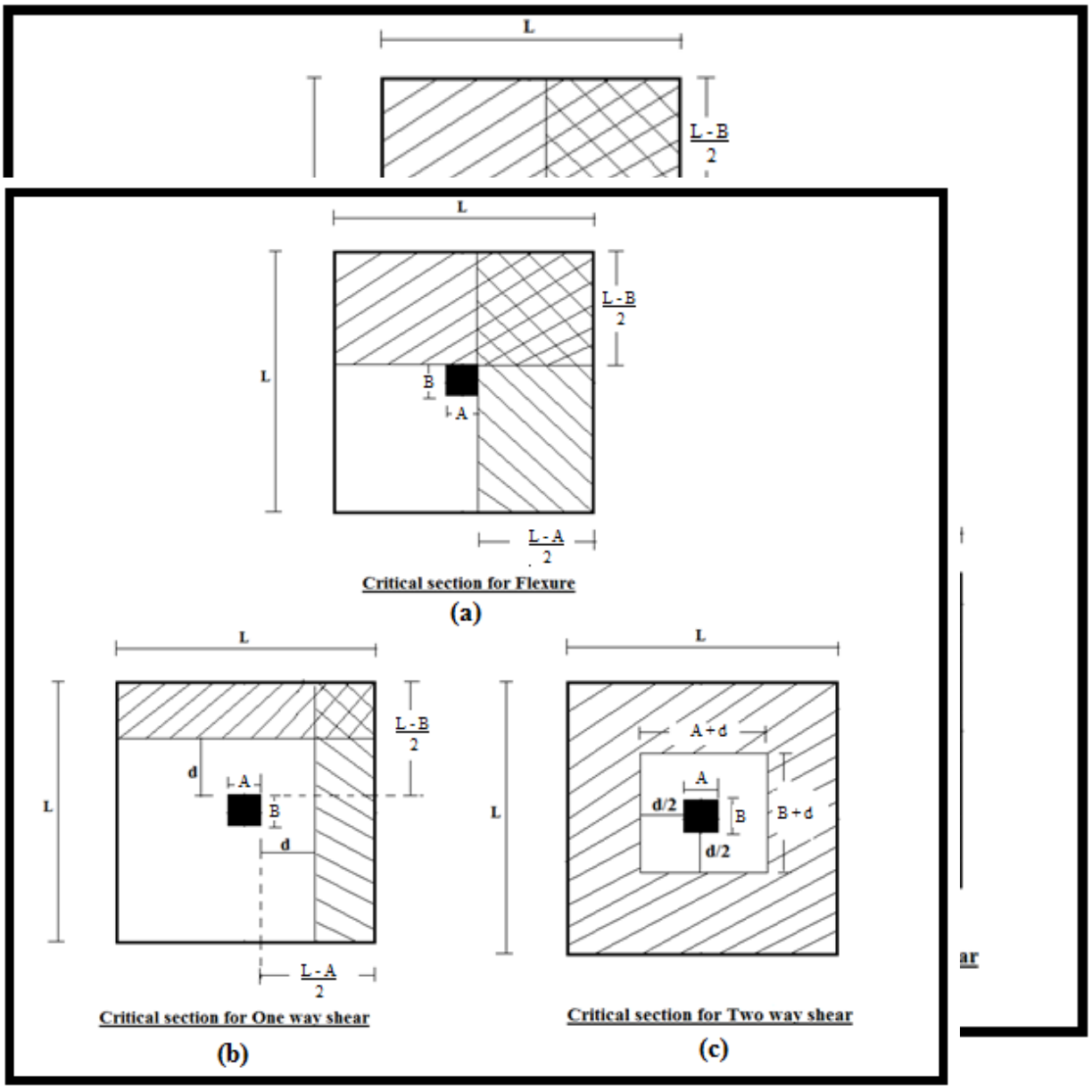
- **Different criterion used in design of Column Footing**

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 shall 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 portion 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)



VIII. Resources required

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

Abbreviations used:

Af - Area of footing	d - Effective depth
D - Overall depth	L - Side of footing
M_u - Ultimate moment of resistance	p - Upward soil pressure
P_u - Design axial load	W - Working load

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 P_u = ----

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

Assumed SBC of strata = ----

b. Calculation of size of footing

- Factored load (kN) on column,
  $P_u = P \times \gamma f$
- Determine required area of footing
  (Considering self-weight of footing as 5% or 10% of the factored load on column)
  Af required $= \frac{(1.05\ Pu)}{qu}$ or $\frac{(1.1\ Pu)}{qu}$
  Where, q_u = 2x SBC.
- Assuming square footing, calculate side required as -
  Length of one side = √Af required
  Round off value of Lengthto 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.
  M_{ux} = 1 x shaded area x upward soil pressure x c.g. of shaded area
  = 1 x [(L-B)/2] x p x [(L-B)/2]/2.

M_{uy} = 1 x shaded area x upward soil pressure x c.g. of shaded area

= 1 x [(L-A)/2] x p x [(L-A)/2]/2

Consider maximum bending moment value of above (Mu).

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

$$dreqd = \sqrt{\frac{Mu}{Rulim * b}}$$

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, $k_s = 0.5 + \beta_c$ but $\not> 1$

  β_c = Longer side of column / Shorter side of column

  $\tau_c = 0.25 \sqrt{fck}$

  $\tau_v = \tau_c$

  Convert τ_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[(L-B)/2 –d] xp ---------- (i)
- Shear resisted by concrete
  Vu= τ_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 = τ_c(b *d) --------- (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.

A_{st} reqd to resist M_u with provided'd' is given by

A_{st} reqd = $0.5 \frac{fck}{fy} [1-\sqrt{1 - \frac{4.6Mu}{fck\ bd2}}]$ bd

Assuming suitable bar diameter calculate required spacing using,

S_P reqd = $\frac{1000\ xA1}{Ast\ reqd}$

g. Development length L_d

$L_d = \frac{0.87\ fy\ \phi}{4\tau bd}$

X. Precautions to be followed

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

Space to Write Design

Design of footing at Sr. No.____

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XI. Resources used

Sr. No.	Name of Resource	Broad Specifications		Quantity	Remark
		Make	Details		
1					
2					

XII. 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

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

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XIV. References / Suggestions for further Reading

Sr. No.	Title of Book/ Website Links	Author	Publication
1.	Limit State Theory and Design of Reinforced Concrete Structures	Dr. V. L. Shah and Dr. S. R. Karve	Structures Publications, Pune. ISBN-13:9788190371711
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4.	Reinforced Concrete Design	S. U. Pillai and DevdasMenon	Tata McGraw Hill Publications, New Delhi ISBN-13: 978-0070141100

XV. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related:15 Marks		**60%**
1	Design of footing	30 %
2	Proper calculation	30 %
Product related:10 Marks		**40%**
3	Design details	5%
4	Answers to practical related questions.	25%
5	Submission of report in time.	10%
Total: 25 Marks		**100%**

List of Student Team Members (Roll No.)

1. ……
2. ……
3. ……
4. …….

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

Practical No. 26: Draw the reinforcement details for cantilever slab, one way simply supported slab and two way simply supported slab designed in Sr. no. 20 to 22

I. Practical Significance

In actual practice for constructing the building, it is necessary to understand and execute work according to details mentioned in the structural drawing. Details of structural drawing are essential to implement the provision of size of each RCC section and reinforcement in each RCC section. This practical will help to read and interpret structural drawing with reference to design.

II. Relevant Program Outcomes

PO. 2 Discipline knowledge*: An ability to apply Civil engineering knowledge to solve broad-based Civil engineering related problems.*

PO. 4 Engineering Tools: *An ability to apply relevant civil technologies and tools with an understanding of the limitations.*

PO. 8 Individual and Team Work: *Function effectively as leader and team member in diverse / multidisciplinary team.*

PO. 9 Communication: *An ability to communicate effectively in oral and written form.*

III. Relevant Course Outcomes

a. Design various slabs for the given edge condition.

IV. Practical Outcome

Draw the reinforcement details for cantilever slab, one way simply supported slab and two way simply supported slab designed in Sr. no. 20 to 22.

V. Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency, ***"Achieve absolute accuracy of dimensions and materials required on site."***

a. Observation skill.
b. Ability to suggest the different types of sections for various end conditions.
c. Ability to select sections based on the situation.

VI. Relevant Affective domain related

a. Practice precision in drawing, neatness and cleanliness.
b. Demonstrate working as a leader / a team member.

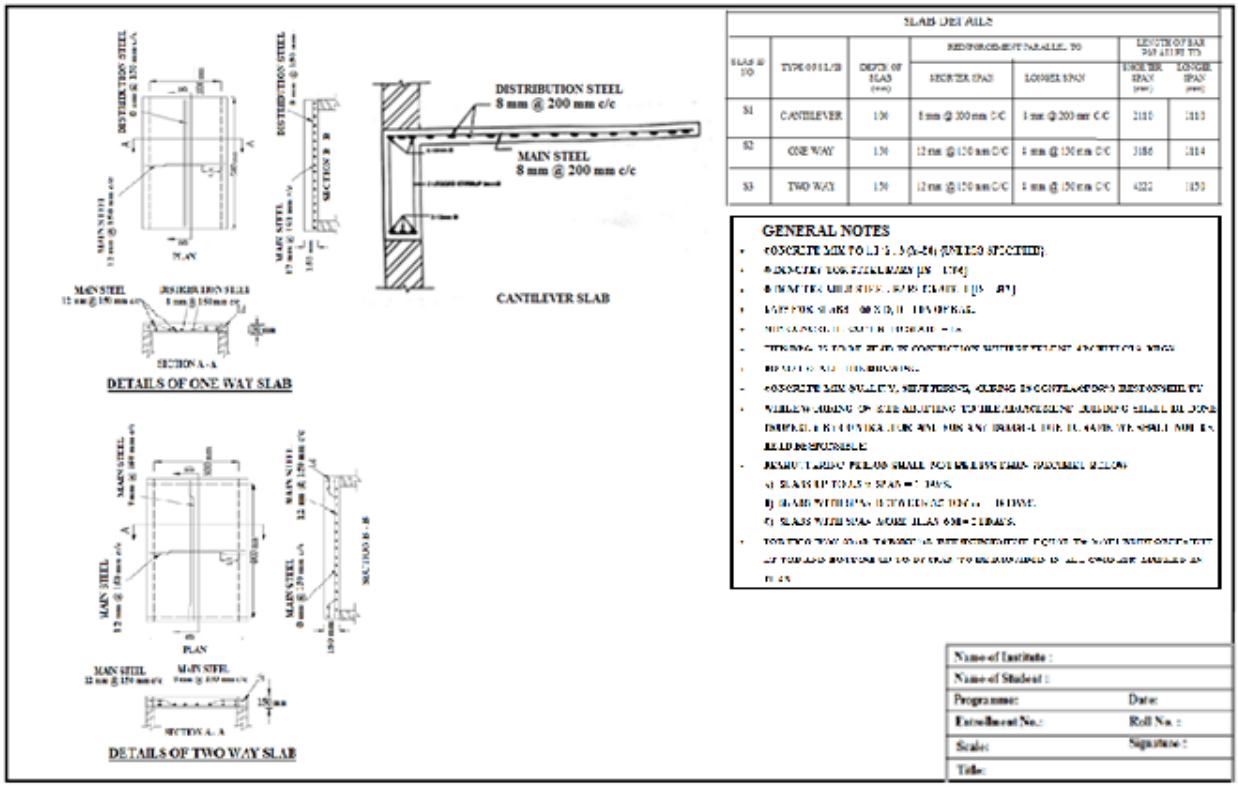
VII. Minimum Theoretical Background

Details of structural drawing are essential to implement the provision of size of each RCC section and reinforcement in each RCC section. Reinforcement detailing of a slab is done based on its support conditions. Slab may be supported on walls or beams or columns.

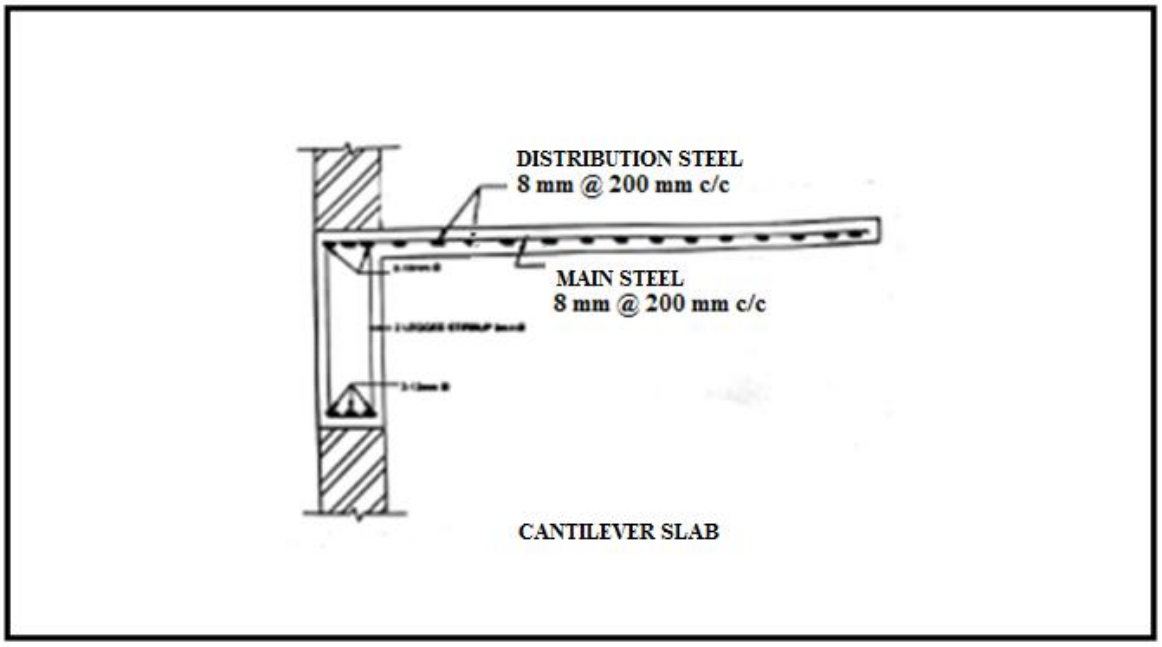
In cantilever slab main reinforcement is to be placed at support at top parallel to span. All bars are to be extended to free end with alternate bar having spring.

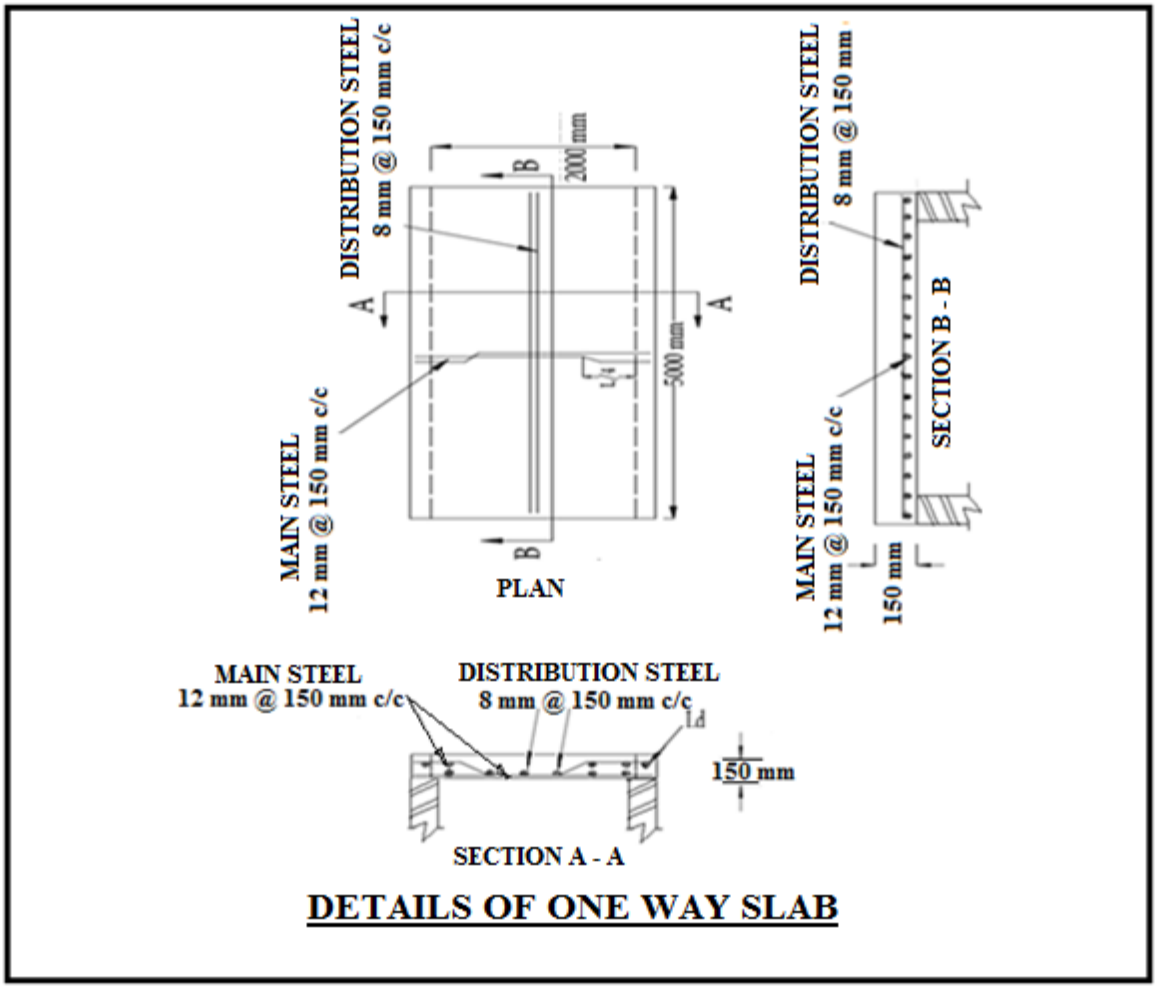
In one way slab main reinforcement is parallel to shorter direction and distribution steel is provided parallel to longer direction. In two way slab main reinforcement is provided along both direction.

VIII. Experimental Set-up

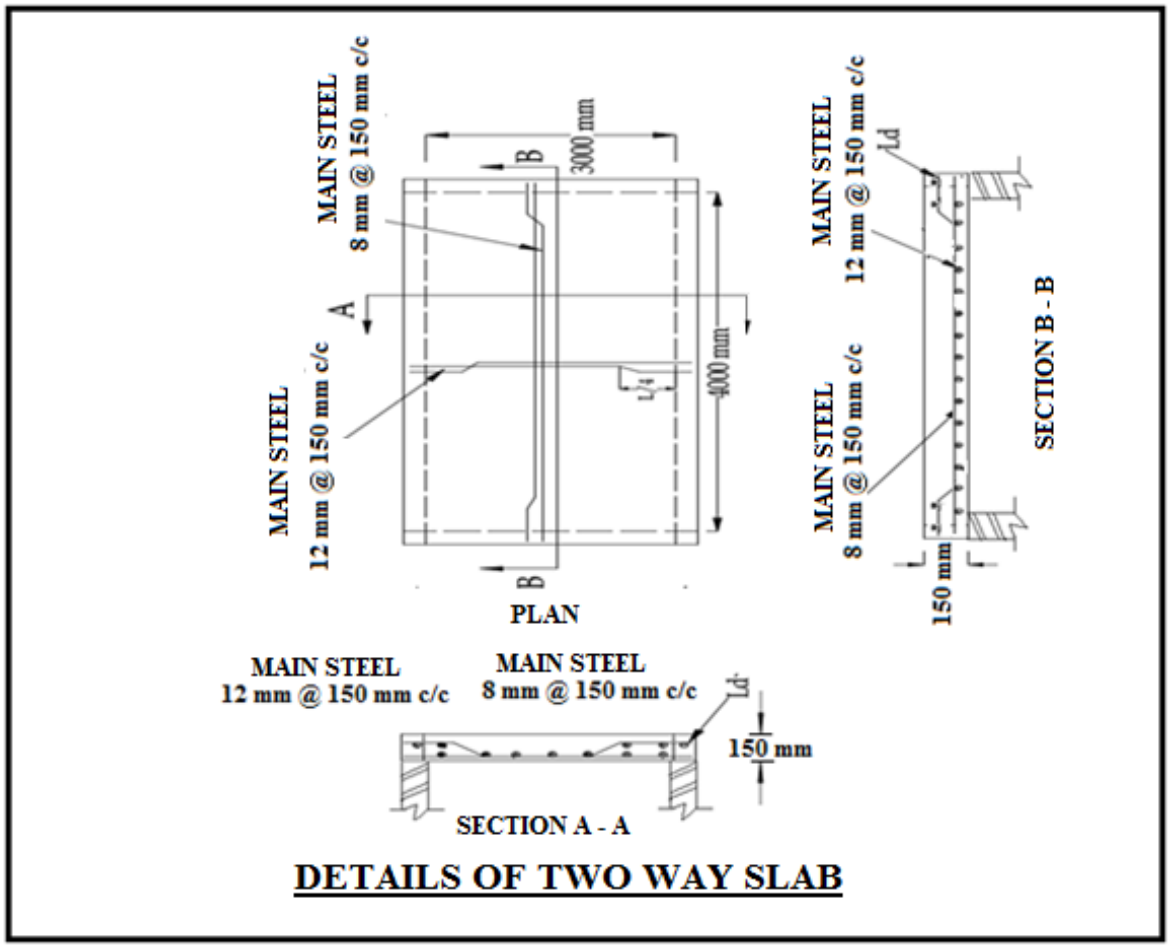


Sample layout of drawing sheet





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.

IX. Resources required

Sr. No.	Particulars	Specification	Quantity	Remark
1	Limit State Theory and Design of Reinforced Concrete Structures	Dr.Shah V. L. & Dr. S. R. Karve	1 No.	Per 5 students
2	A3 size sketchbook and Drawing tools (scale, pencil, eraser etc.)	--------	1set	Per student

X. Procedure

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

XI. Precautions to be followed

1. Carefully identify suitable slab.
2. Sketches should be drawn with appropriate scale along with the font size used for labeling.

XII. Resources used

Sr. No.	Name of Resource	Broad Specifications		Quantity	Remark
		Make	Details		

XIII. Conclusions

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XIV. 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 bar diameter of distribution steel with its spacing.
2. State the formula for calculation of main steel.
3. State cover used for two way slab.
4. Write thickness of cantilever slab.
5. Write necessity of providing schedule of slabs on drawing sheet.
6. State de-shuttering time for slab as per IS 456-2000.
7. Write thickness of one way slab.
8. Write the distance from support at which bars are bent up.
9. Write span of cantilever slab.

Space to Write Answers

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XV. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related:15 Marks		**60%**
1	Identify and draw slab details	25%
2	Precision in sketchbook, neatness, cleanliness.	30 %
3	Working in team.	5 %
Product related:10 Marks		**40%**
3	Interpretation of given data.	10%
4	Answers to practical related questions.	20%
5	Submission of report in time.	10%
Total: 25 Marks		**100%**

List of Student Team Members (Roll No.)

1. ……
2. ……
3. ……
4. …….

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

Practical No. 27: Draw the reinforcement details for the beam, column and footing designed in Sr. no. 23 to 25

I. Practical Significance

In actual practice for constructing the building, it is necessary to understand and execute work according to details mentioned in the structural drawing. Detailing is very important not only for the proper execution of the structures but for the safety of the structures. Details of structural drawing are essential to implement the provision of size of each RCC section and reinforcement in each RCC section. This practical will help to read and interpret structural drawing with reference to design.

II. Relevant Program Outcomes

PO. 2 Discipline knowledge*: An ability to apply Civil engineering knowledge to solve broad-based Civil engineering related problems.*

PO. 4 Engineering Tools: *An ability to apply relevant civil technologies and tools with an understanding of the limitations.*

PO. 8 Individual and Team Work: *Function effectively as leader and team member in diverse / multidisciplinary team.*

PO. 9 Communication: *An ability to communicate effectively in oral and written form.*

III. Relevant Course Outcomes

a. Analysis and design of singly reinforced rectangular beams.
b. Design of shear reinforcement and development length for beam and slabs.
c. Design of axially loaded short columns and footings.

IV. Practical Outcome

Draw the reinforcement details for the beam, column and footing designed in Sr. no. 23 to 25.

V. Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency, ***"Achieve absolute accuracy of dimensions and materials required on site"***

a. Observation skill.
b. Ability to suggest the different types of sections for various end conditions.
c. Ability to select sections based on the situation.

VI. Relevant Affective domain related

a. Practice precision in drawing, neatness and cleanliness.
b. Demonstrate working as a leader / a team member.

VII. Minimum Theoretical Background

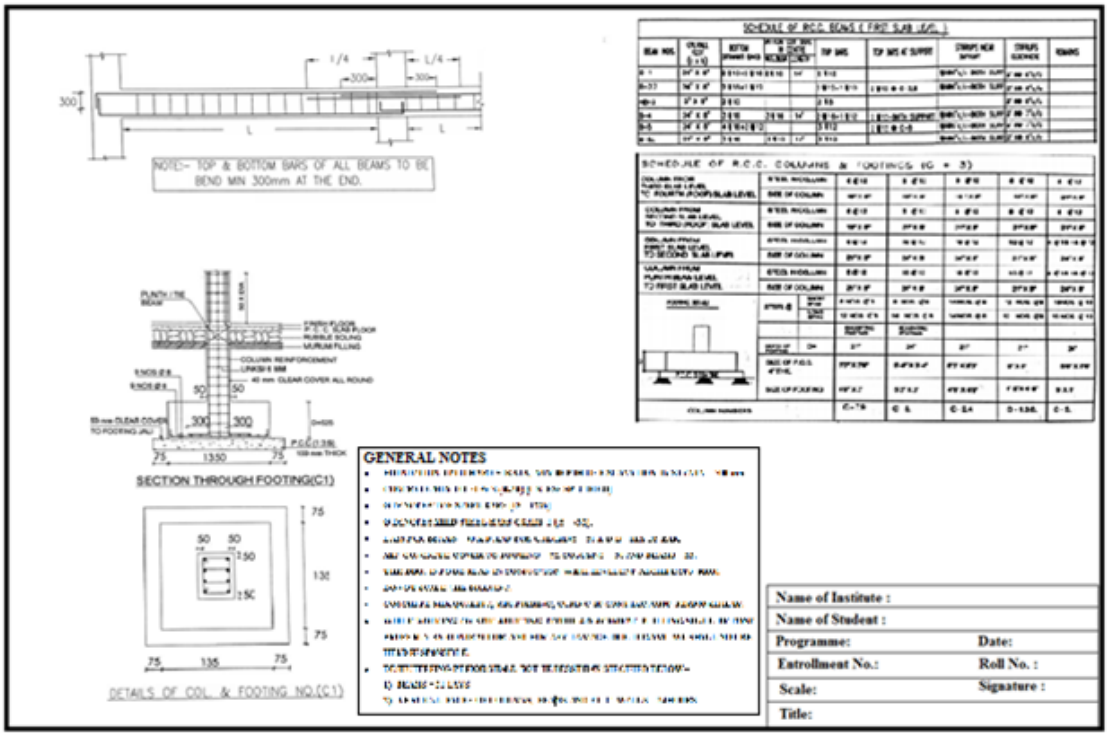
- Detailing of reinforcements in beams and slabs plays an important role in providing strength, durability and cost optimization. Reinforcement details of concrete beams and slabs should specify clearly about cover to reinforcement, length of reinforcement, curtailment of reinforcement, number and diameter of reinforcement to be provided.

- In column main bars and lateral ties are to be drawn neatly in plan and section.
- In footing, reinforcement in both directions is to be placed in the form of mesh at bottom. Bars parallel to larger projection shall be placed below over other bars.

(Generally every bar is provided with bend of minimum 100 mm length at either ends.)

It is desirable foundation should be detailed in both plan and elevation in drawings.

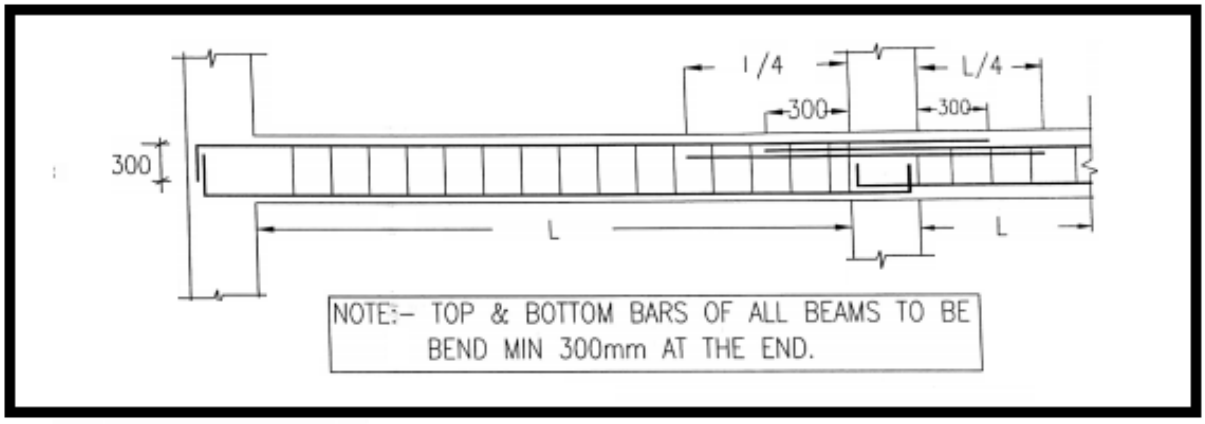
VIII. Experimental Set-up



Sample layout of drawing sheet

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.


l/4
L/4
300
300
300
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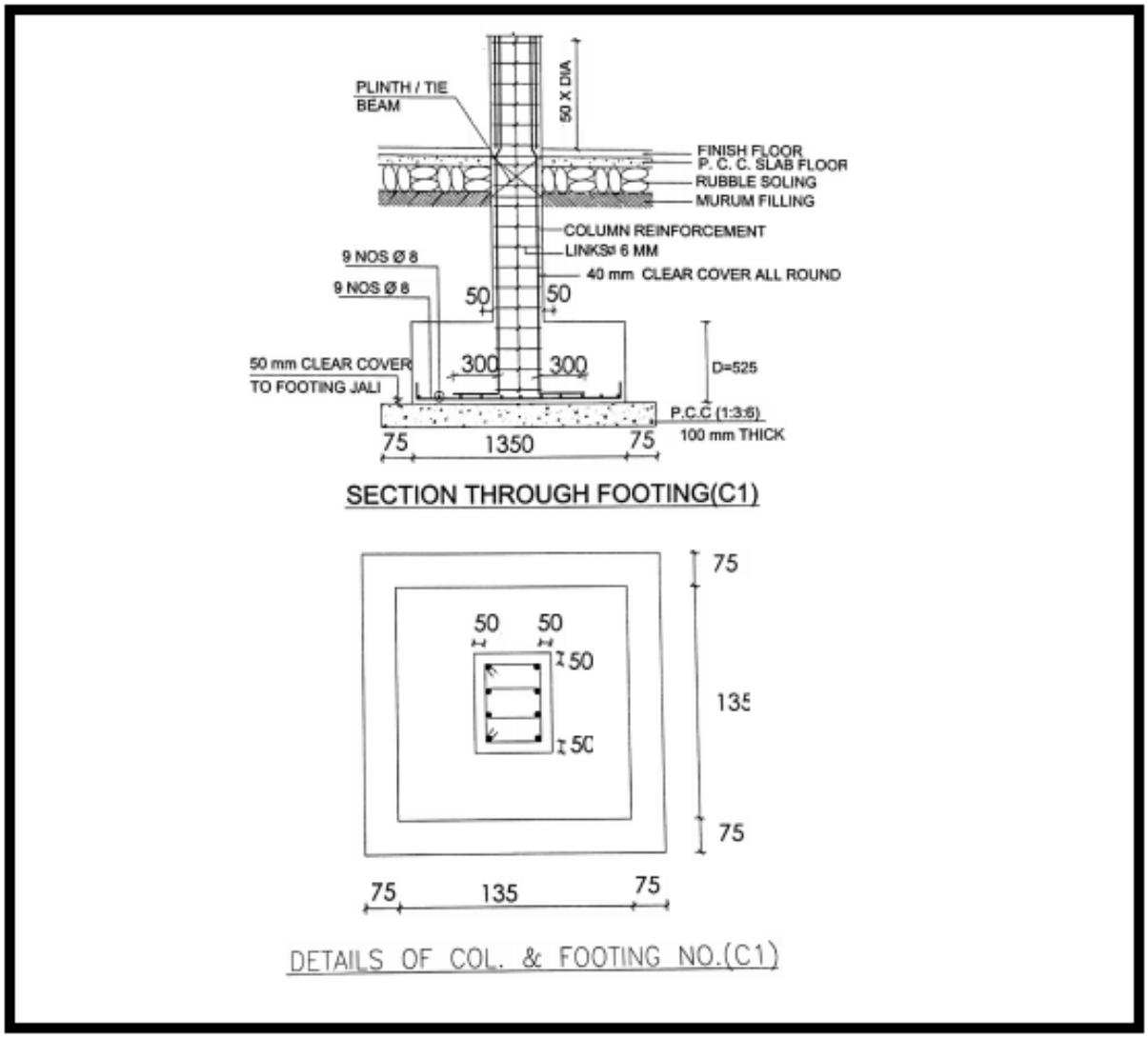
NOTE:- TOP & BOTTOM BARS OF ALL BEAMS TO BE BEND MIN 300mm AT THE END.


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)
50
50
50
50
75
135
75
75
135
75
DETAILS OF COL. & FOOTING NO.(C1)

IX. Resources required

Sr. No.	Particulars	Specification	Quantity	Remark
1	Limit State Theory and Design of Reinforced Concrete Structures	Dr. Shah V. L. and Dr. S. R. Karve	1 No.	Per 5 students
2	A3 size sketchbook and Drawing tools (scale, pencil, eraser etc.)	--------	1set	Per student

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 sketchbook. (Refer point no. VIII Experimental set-up.)

XI. Precautions to be followed

1. Select suitable scale.
2. While drawing reinforcement details show development length, extra bars properly.
3. Sketches should be drawn with appropriate scale along with the font size used for labeling.

XII. Resources used

Sr. No.	Name of Resource	Broad Specifications		Quantity	Remark
		Make	Details		

XIII. Conclusions

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XIV. 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. Preparation of structural drawing is useful for _____ (analysis/design/execution) of RCC structure.
2. State the function of bent up bars in beams.
3. State the function of anchor bars in beams.
4. State the value of cover used for column.
5. Draw a typical two legged vertical stirrup and label its legs.
6. State the reason for providing a lesser spacing of shear stirrups near supports than in the middle zone of beams.
7. Write the percentage of steel provided for column.
8. Write the percentage of steel provided for beam.
9. Write depth of footing provided for column.

Space to Write Answers

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XV. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related:15 Marks		**60%**
1	Draw details of beam, column, footing	25%
2	Precision in sketchbook, neatness, cleanliness.	30 %
3	Working in team.	5 %
Product related:10 Marks		**40%**
3	Interpretation of given data.	10%
4	Answers to practical related questions.	20%
5	Submission of report in time.	10%
Total: 25 Marks		**100%**

List of Student Team Members (Roll No.)

1. ……
2. ……
3. ……
4. ……

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

Practical No. 28: Prepare a report on site visit for joints in Steel structures

I. Practical Significance

The main aim of this visit is to be familiar with industrial environment and to get practical knowledge of Construction process. The need of steel in construction industry is increasing due to so many reasons which should be economical, Eco-friendly, safe and efficient. The other reason is to figure out the joint (bolted connection & welded connection), roof truss etc. which used in steel structure. As a civil engineer how these structures are constructed is always interesting. Students will get very clear idea about the importance of different components of Industrial Building. It also provides students a good opportunity to gain full awareness about industrial practices. This practical will help the students to get the information and knowledge about the components of Steel Structure, its connections and erection.

II. Relevant Program Outcomes

PO. 2 Discipline knowledge*: An ability to apply Civil engineering knowledge to solve broad-based Civil engineering related problems.*

PO. 4 Engineering Tools: *An ability to apply relevant civil technologies and tools with an understanding of the limitations.*

PO. 8 Individual and Team Work: *Function effectively as leader and team member in diverse / multidisciplinary team.*

PO. 9 Communication: *An ability to communicate effectively in oral and written form.*

III. Relevant Course Outcomes

a. Design the connections for the given steel joints.

IV. Practical Outcome

Prepare a report on site visit for joints in steel structures.

V. Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency, ***"Proper execution of the activities on the site with desired 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.

VI. Relevant Affective domain related

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

VII. Minimum Theoretical Background

Site Visit: It is the process of inspecting the site prior to erection which assures accuracy in implementation of structural drawing on the site.

Objectives of site visit:

1) To get an understanding how the theoretical knowledge is transferred in practice.
2) To observe the different activities, techniques carried out on site.
3) To have a feel of how condition of site really is and how safety is priority.
4) Observe complex detailing at joints of members.

Expected outcomes of site visit:

1) Teacher should divide the total number of students into groups such that each group can be assigned a task for collection of data.
2) Prior to site visit teacher should allocate the task to be performed by each group.
3) During site visit each group will observe and note down points related to given task (a sample list of data to be collected is given below. A teacher can add additional points which will be beneficial from student's point of view).
4) It is preferable to carry a three meter metallic tape by each group of students to measure the required dimensions.

   For connections:

   - 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.

5) The teacher and students should check the connections provided for various structural elements using blue print / working drawing available on the site.
6) Data from all groups should be combined together to prepare visit report along with minimum four photographs.

VIII. Resources required

Sr. No.	Particulars	Specification	Quantity	Remark
1	Steel structure construction site in nearby college premises	-------	1 No.	Per group of 10 students

IX. Procedure

1. Institute shall contact the site authorities and should confirm date of visit.
2. Institute shall also prepare and deliver a letter of request to be signed by Principal ōf the institute for the site authorities.
3. Student shall procure the structural drawing of the site to be visited.
4. Visit the construction site as scheduled and record your observations.
5. Institute shall issue letter of thanks to the site authorities.

X. Precautions to be followed

1. Each student must follow the instructions given by the site engineer.
2. Safety precautions should be followed as per the requirement of site.
3. Student should wear college uniform (if any), safety shoes, cap, sun glasses and should carry water bottles.
4. Take precaution while walking on formwork and below the formwork.
5. Special precautions must be taken for high rise structures / buildings.
6. Do not operate switches of any of the equipment/ machinery present at site.
7. Students should not rush or create nuisance while taking photographs.
8. No student should take selfie photograph on site.

Space to Write Visit Report

Date and time of visit: ……

Name of site: ……

Address of site: ……

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Name of site engineer: …..……

Name of Architecture: …..……

Name of structural consultant: …..……

Type and description of structure: ……

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XI. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related:15 Marks		**60%**
1	Interpretation of given data	20%
2	Writing visit report	35%
3	Working in team.	5 %
Product related:10 Marks		**40%**
4	Interpretation of given data.	10%
5	Answers to practical related questions.	20%
6	Submission of report in time.	10%
Total: 25 Marks		**100%**

List of Student Team Members (Roll No.)

1. ……
2. ……
3. ……
4. …….

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

Practical No. 29: Prepare a report on site visit for reinforcement detailing for various structural elements

I. Practical Significance

The purpose of this visit is to help the students to understand the real life aspects of RCC construction work and preventive measures to be taken at the site. Faculty can encourage the enthusiasm of the students by arranging the site visit. This will help in clearing the doubts of the students related to RCC construction work. It will also help the students to correlate the field work with the theoretical aspects of the course work.

II. Relevant Program Outcomes

PO. 2 ***Discipline knowledge****: An ability to apply Civil engineering knowledge to solve broad-based Civil engineering related problems.*

PO. 4 ***Engineering Tools:*** *An ability to apply relevant civil technologies and tools with an understanding of the limitations.*

PO. 8 ***Individual and Team Work:*** *Function effectively as leader and team member in diverse /multidisciplinary team.*

PO. 9 ***Communication:*** *An ability to communicate effectively in oral and written form.*

III. Relevant Course Outcomes

a. Analysis and design of singly reinforced rectangular beams.
b. Design of shear reinforcement and development length for beam and slabs.
c. Design various slabs for the given edge condition.
d. Design of axially loaded short columns and footings.

IV. Practical Outcome

Prepare a report on site visit for reinforcement detailing for various structural elements.

V. Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency, ***"Proper execution of the activities on the site with desired performance."***

a. Observation skill.
b. Ability to understand the reinforcement detailing.
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 RCC construction.

VI. Relevant Affective domain related

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

VII. Minimum Theoretical Background

Site Visit: In case of RCC site visit includes observing the reinforcement details and check it according to structural drawing.

Objectives of site visit:

1) To get an understanding how the theoretical knowledge is transferred in practice.
2) To observe the different activities, techniques carried out on site.
3) To know extent of major construction sites and to observe safety precautions.
4) Observe the reinforcement detailing at construction site.

Expected outcomes of site visit:

1) Teacher should divide the total number of students into groups such that each group can be assigned a task for collection of data for various structural elements like slab, beam, column, footing etc. which can be seen on the site.
2) Prior to site visit teacher should allocate the task to be performed by each group.
3) During sit visit each group will observe and note down points related to given task (a sample list of data to be collected is given below. A teacher can add additional points which will be beneficial from student's point of view.
4) It is preferable to carry a three meter metallic tape by each group of students to measure the required dimensions.

   For slab:

   - Grade of concrete and steel used for slab
   - Number of slabs
   - Type of slabs
   - Minimum and maximum dimensions of slab
   - Thickness of slab
   - Maximum and minimum diameter of bar used for slab
   - Cover used for slab and how it is provided
   - Spacing of main and distribution bars
   - Number of cement bags consumed for a particular area of slab
   - Number of slabs casted together
   - Material of formwork used for slab
   - Mix proportion used for concrete per bag of cement in terms of no. of ghamela or pharma (wooden box)
   - Method of concrete mixing
   - List of instruments used for casting the slab i.e. for transportation, placing and compaction of concrete along with their local terminology used on site
   - Method of compaction / vibration of concrete (manual / mechanical means)
   - Stripping time for formwork of slab
   - Method of curing
   - No. of masons / labors required for casting the slab and their rates
   - List of admixture used if any
   - Any additional precaution taken while casting

For beam:

- Grade of concrete and steel used for beam
- Number of beams
- Types of beams
- Minimum and maximum dimensions of beam
- Span of beam
- Maximum and minimum diameter of bar used for reinforcement
- Cover used for beam and how it is provided
- Spacing of main bars / Number of bars used for a particular size of beam
- Spacing of stirrups at the centre and near the support
- Number of cement bags consumed for a particular number of beams
- Number of beams casted together
- Material of formwork used for beam
- Mix proportion used for concrete per bag of cement in terms of no. of ghamela or pharma (wooden box)
- Method of concrete mixing
- List of instruments used for casting the beam i.e. for transportation, placing and compaction of concrete along with their local terminology used on site
- Method of compaction / vibration of concrete (manual / mechanical means)
- Stripping time for formwork of beam
- Method of curing
- No. of masons / labours required for casting the beam and their rates
- List of admixture used if any
- Any additional precaution taken while casting

For column:

- Grade of concrete and steel used for column
- Number of columns
- Number of columns - supporting two beams, three beams and four beams
- Minimum and maximum dimensions of column
- Length of column
- Maximum and minimum diameter of bar used for column
- Cover used for column and how it is provided
- Number of bars used for particular size of column and spacing of links
- Number of cement bags consumed for a particular number of columns
- Number of columns casted together
- Material of formwork used for column
- Mix proportion used for concrete per bag of cement in terms of no. of ghamela or pharma (wooden box)
- Method of concrete mixing
- List of instruments used for casting the column i.e. for transportation, placing and compaction of concrete along with their local terminology used on site
- Method of compaction / vibration of concrete (manual / mechanical means)

- Stripping time for formwork of column
- Method of curing
- No. of masons / labours required for casting the column and their rates
- List of admixture used if any
- Any additional precaution taken while casting

For column footing:

- Grade of concrete and steel used for footing
- Number of footings
- Types of footings (Isolated / combined etc.)
- Minimum and maximum dimensions of footing
- Depth of footing
- Maximum and minimum diameter of bar used for footing
- Cover used for footing and how it is provided
- Spacing of main bars
- Number of cement bags consumed for a particular area of footing
- Number of footings casted together
- Material of formwork used for footing
- SBC of soil
- Depth of excavation
- Mix proportion used for concrete per bag of cement in terms of no. of ghamela or pharma (wooden box)
- Method of concrete mixing
- List of instruments used for casting the footing i.e. for transportation, placing and compaction of concrete along with their local terminology used on site
- Method of compaction / vibration of concrete (manual / mechanical means)
- Stripping time for formwork of footing
- Method of curing
- No. of masons / labours required for casting the footing and their rates
- List of admixture used if any
- Any additional precaution taken while casting

5) The teacher and students should check the reinforcement provided for various structural elements using blue print / working drawing available on the site.
6) Data from all groups should be combined together to prepare visit report along with minimum four photographs.
7) No selfie photograph should be attached to visit report.

VIII. Resources required

Sr. No.	Particulars	Specification	Quantity	Remark
1	RCC construction site nearby college premises	-------	1 No.	Total number of students

IX. Procedure

1. Institute shall contact the site authorities and should confirm date of visit.
2. Institute shall also prepare and deliver a letter of request to be signed by Principal of the institute for the site authorities.
3. Student shall procure the structural drawing of the site to be visited.
4. Visit the construction site as scheduled and record your observations.
5. Institute shall issue letter of thanks to the site authorities.

X. Precautions to be followed

1. Each student must follow the instructions given by the site engineer.
2. Safety precautions should be followed as per the requirement of site.
3. Student should wear college uniform (if any), safety shoes, cap, sun glasses and should carry water bottles.
4. Take precaution while walking on formwork and below the formwork.
5. Special precautions must be taken for high rise structures / buildings.
6. Do not operate switches of any of the equipment/ machinery present at site.
7. Students should not rush or create nuisance while taking photographs.
8. No student should take selfie photograph on site.

Space to write report

Date and time of visit: ……..….

Name of site:……...

Address of site: ……

……..…

…….

Name of site engineer: …..……..…

Name of Architecture: …..……..…

Name of structural consultant: …..…….

Type and description of structure: ……..……...

Area of plot:……Builtup area:……FSI consumed:….……...……

Visit Report:-……...……

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XI. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related:15 Marks		**60%**
1	Interpretation of given data	20 %
2	Writing visit report	35 %
3	Working in team.	5 %
Product related:10 Marks		**40%**
3	Interpretation of given data.	20%
4	Submission of report in time.	20%
Total: 25 Marks		**100%**

List of Student Team Members (Roll No.)

1. ……
2. ……
3. ……
4. ……

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

List Of Laboratory Manuals Developed by MSBTE

First Semester:

1	Fundamentals of ICT	22001
2	English	22101
3	English Work Book	22101
4	Basic Science (Chemistry)	22102
5	Basic Science (Physics)	22102

Second Semester:

1	Bussiness Communication Using Computers	22009
2	Computer Peripherals & Hardware Maintenace	22013
3	Web Page Design with HTML	22014
4	Applied Science (Chemistry)	22202
5	Applied Science (Physics)	22202
6	Applied Machines	22203
7	Basic Surveying	22205
8	Applied Science (Chemistry)	22211
9	Applied Science (Physics)	22211
10	Fundamental of Electrical Engineering	22212
11	Elements of Electronics	22213
12	Elements of Electrical Engineering	22215
13	Basic Electronics	22216
14	'C' programming Language	22218
15	Basic Electronics	22225
16	Programming in "C"	22226
17	Fundamentals of Chemical Engineering	22231

Third Semester:

1	Applied Multimedia Techniques	22024
2	Advanced Serveying	22301
3	Highway Engineering	22302
4	Mechanics of Structures	22303
5	Building Construction	22304
6	Concrete Technology	22305
7	Strength Of Materials	22306
8	Automobile Engines	22308
9	Automobile Transmission System	22309
10	Mechanical Operations	22313
11	Technology Of Inorganic Chemicals	22314
12	Object Oriented Programming Using C++	22316
13	Data Structure Using 'C'	22317
14	Computer Graphics	22318
15	Database Management System	22319
16	Digital Techniques	22320
17	Principles Of Database	22321
18	Digital Techniques & Microprocessor	22323
19	Electrical Circuits	22324
20	Electrical & Electronic Measurment	22325
21	Fundamental Of Power Electronics	22326
22	Electrical Materials & Wiring Practice	22328
23	Applied Electronics	22329
24	Electrical Circuits & Networks	22330
25	Electronic Measurments & Instrumentation	22333
26	Principles Of Electronics Communication	22334
27	Thermal Engineering	22337
28	Engineering Matrology	22342
29	Mechanical Engineering Materials	22343
30	Theory Of Machines	22344

Fourth Semester:

1	Hydraulics	22401
2	Geo Technical Engineering	22404
3	Chemical Process Instrumentation & Control	22407
4	Fluid Flow Operation	22409
5	Technology Of Organic Chemicals	22410
6	Java Programming	22412
7	GUI Application Development Using VB.net	22034
8	Microprocessor	22415
9	Database Managment	22416
10	Electric Motors And Transformers	22418
11	Industrial Measurements	22420
12	Digital Electronics And Microcontroller Applications	22421
13	Linear Integrated Circuits	22423
14	Microcontroller & Applications	22426
15	Basic Power Electronics	22427
16	Digital Communication Systems	22428
17	Mechanical Engineering Measurments	22443
18	Fluid Mechanics and Machinery	22445
19	Fundamentals Of Mechatronics	22048

Fifth Semester:

1	Design of Steel and RCC Structures	22502
2	Public Health Engineering	22504
3	Heat Transfer Operation	22510
4	Environmental Technology	22511
5	Operating Systems	22516
6	Advanced Java Programming	22517
7	Software Testing	22518
8	Control Systems and PLC's	22531
9	Embedded Systems	22532
10	Mobile and Wireless Communication	22533
11	Industrial Machines	22523
12	Switchgear and Protection	22524
13	Energy Conservation and Audit	22525
14	Power Engineering and Refrigeration	22562
15	Solid Modeling and Additive Manufacturing	22053
16	Guidelines & Assessment Manual for Micro Projects & Industrial Training	22057

Sixth Semester:

1	Solid Modeling	17063
2	Highway Engineering	17602
3	Contracts & Accounts	17603
4	Design of R.C.C. Structures	17604
5	Industrial Fluid Power	17608
6	Design of Machine Elements	17610
7	Automotive Electrical and Electronic Systems	17617
8	Vehicle Systems Maintenance	17618
9	Software Testing	17624
10	Advanced Java Programming	17625
11	Mobile Computing	17632
12	System Programing	17634
13	Testing & Maintenance of Electrical Equipments	17637
14	Power Electronics	17638
15	Illumination Engineering	17639
16	Power System Operation & Control	17643
17	Environmental Technology	17646
18	Mass Transfer Operation	17648
19	Advanced Communication System	17656
20	Mobile Communication	17657
21	Embedded System	17658
22	Process Control System	17663
23	Industrial Automation	17664
24	Industrial Drives	17667
25	Video Engineering	17668
26	Optical Fiber & Mobile Communication	17669
27	Therapeutic Equipment	17671
28	Intensive Care Equipment	17672
29	Medical Imaging Equipment	17673

Pharmacy Lab Manual

First Year:

1	Pharmaceutics - I	0805
2	Pharmaceutical Chemistry - I	0806
3	Pharmacognosy	0807
4	Biochemistry and Clinical Pathology	0808
5	Human Anatomy and Physiology	0809

Second Year:

1	Pharmaceutics - II	0811
2	Pharmaceutical Chemistry - II	0812
3	Pharmacology & Toxicology	0813
4	Hospital and Clinical Pharmacy	0816

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