Program Name : **Civil Engineering Program Group**

Program Code : **CE/CR/CS**

Semester : **Fifth**

Course Title : **Design of Steel and RCC Structures**

Course Code : **22502**

1. RATIONALE

For Civil Engineering technologist to understand the behaviour of various structural components for developing insight for the design concepts and will help the student in quality supervision on site. Design of steel and RCC structures is the core subject for the Civil Engineering. For the design of steel structures, the properties of steel, different steel sections, various grades and strength characteristics of steel and design of connections are required as per IS:800-2007. In the design of RCC structures Limit State Method is to be used as per IS:456-2000 for analysis and design and IS:875-1987 is to be used for Loading Standards.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Use the concepts of Steel and RCC structural design using Limit State Method at the site.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course using Limit State Method are to be taught and implemented, so that the student demonstrates the following ***industry oriented*** COs associated with the above mentioned competency:

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

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme											
				Theory							Practical				
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
4	1	2	7	3	70	28	30*	00	100	40	25#	10	25	10	50	20

(*): Under the theory PA; Out of 30 marks, 10 marks of theory PA are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the UOs required for the attainment of the COs.

***Legends: L**-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** - Practical; **C** - Credit, **ESE** - End Semester Examination; **PA** - Progressive Assessment.*

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

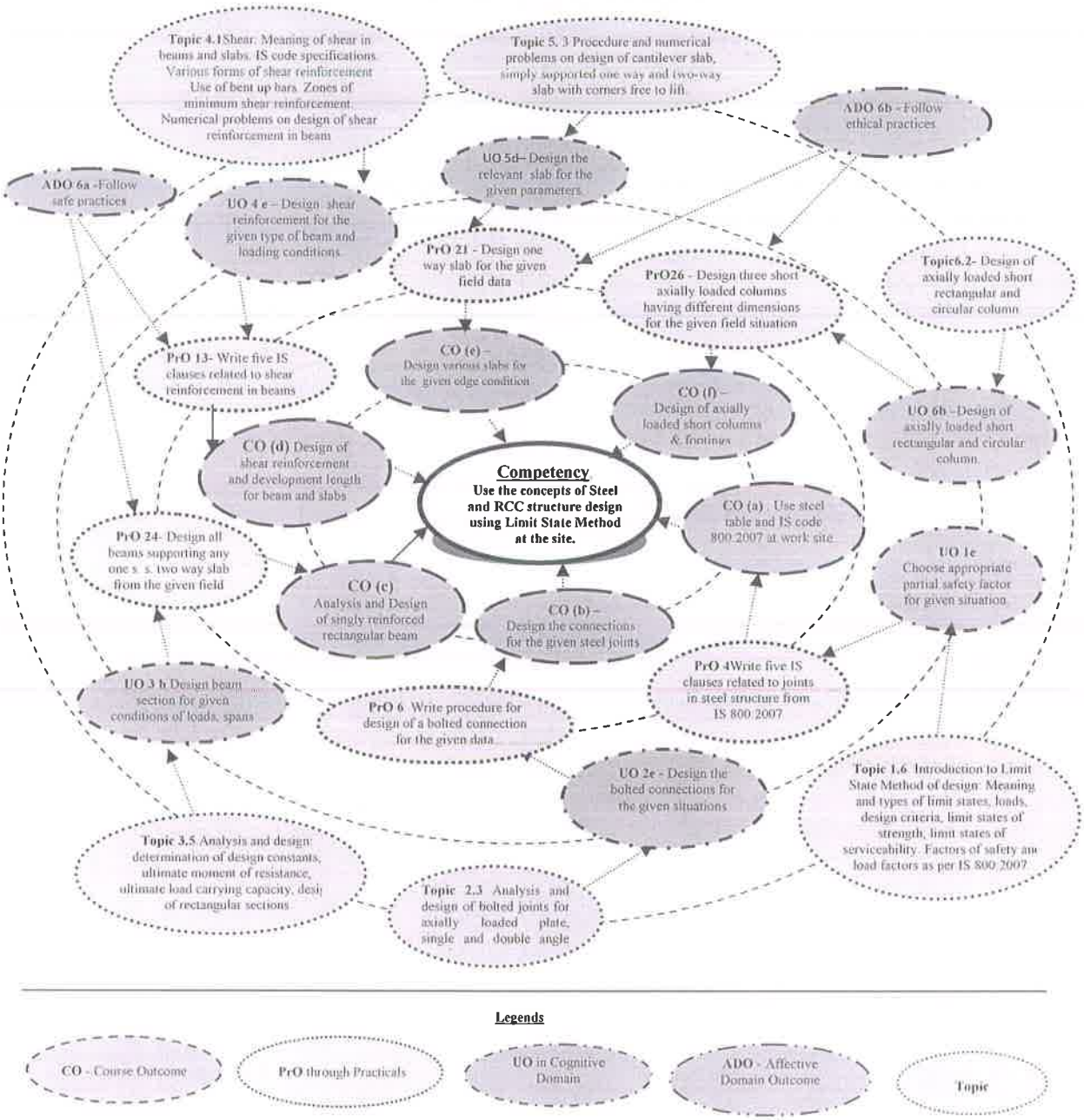

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency.

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1.	Draw five standard rolled steel sections showing all details.	I	

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
2.	Write five IS clauses related to load from IS 875:1987.	I	02
3.	Draw five commonly used built up sections.	I	
4.	Write five IS clauses related to joints in steel structure from IS 800:2007.	I	02
5.	Draw types of bolts with their modes of failure.	II	02*
6.	Design a bolted connection for the given data and compare it with design using open source software/IS code.	II	02
7.	Draw types of welds and types of welded joints.	II	02*
8.	Draw modes of failure for bolted connections.	II	02
9.	Write five IS clauses related to partial safety factors, characteristic strengths, characteristic load and design load from IS 456:2000.	III	02
10.	Draw cross section, strain –stress diagram for singly reinforced section giving design parameters and constants.	III	02*
11.	Draw stress block diagram for Under- reinforced, over-reinforced and balanced sections showing all details.	III	02
12.	Write five IS clauses related to shear reinforcement in beams and slabs from IS 456:2000.	IV	02*
13.	Write the procedure to calculate development length of main reinforcement in beams and slabs.	IV	02
14.	Write four IS clauses related to each for slab, beam and column from IS 456:2000.	III,V	
15.	Draw diagrams showing transfer of loads from one way simply supported slab and two way simply supported slab to the supporting beam as per I. S. 456:2000.	III,V	02
16.	Draw the table showing details of deflected shape along with effective length of column as per IS 456:2000.	VI	
17.	Design of a welded connection for the given data and compare it using open source software/IS code.	II	02
18.	Draw reinforcement detailing of dog legged stair.	V	02*
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.)	III, IV, V	02
20.	Design one cantilever slab from the given data.	V	02*
21.	Design a one way simply supported slab from the given data.	V	02*
22.	Design a two way simply supported slab from the given data.	V	02*
23.	Design the beam/s each supporting cantilever slab, one way simply supported slab and two way simply supported slab from the given data.	III	02*
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.	VI	02*
25.	Design footing for axially loaded short column designed in Sr. no.24.	VI	02*
26.	Draw the reinforcement details for cantilever slab, one way simply supported slab and two way simply supported slab	III, IV	02*#

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	designed in Sr. no. 20 to 22.	VI	
27.	Draw the reinforcement details for the beam, column and footing designed in Sr. no. 23 to 25.	III to VI	02*#
28.	Prepare a report on site visit for joints in Steel structures.	II	02
29.	Prepare a report on site visit for reinforcement detailing for various structural elements.	III to VI	02*
	Total		**32**

Note

3.1 *The term work should consist of manual, A3 size sketchbook and A2 size drawing sheets.*

3.2 *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.*

3.3 *Use A3 size sketchbook for Sr. No. 1,3,5,7,8,10,11,16,17,19.*

3.4 *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.*

3.5 *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.*

3.6 *For Sr. No. marked with (#), use AutoCAD software for drawing.*

3.7 *A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. All the above listed practical need to be performed compulsorily, so that the student reaches the 'Applying Level' of Blooms's 'Cognitive Domain Taxonomy' as generally required by the industry.*

3.8 *The 'Process' and 'Product' related skills associated with each PrO are to be assessed according to a suggested sample given below:*

S. No.	Performance Indicators	Weightage in %
1	Interpretation of given data and its presentation.	10
2	Selection of sketches /Process of designing of the given structural components using relevant I.S. Codes /writing of visit report.	30
3	Precision in sketch book, sheets and report and its neatness, cleanliness.	30
4	Individual work and working in groups	20
5	Submission of assigned work in time	10
	Total	**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safety practices.
b. Practice good housekeeping.
c. Demonstrate working as a leader/a team member.
d. Follow ethical practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organising Level' in 2nd year and
- 'Characterising Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

S. No.	Equipment Name with Broad Specifications	PrO. S. No.
1.1	Drawing boards and drawing equipments	1,2,5,7,11,12,17
1.2	Computers	26,27
1.3	Printers	26,27
1.4	Available CAD software.	26,27

8. UNDERPINNING THEORY COMPONENTS

The following topics/subtopics should be taught and assessed in order to develop UOs in cognitive domain for achieving the COs to attain the identified competency. More UOs could be added.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Fundamental of steel structures	1a. Select a relevant steel structure for the given condition. 1b. Use steel table to identify different properties of given steel sections. 1c. Explain the various type(s) of loads (Dead load, live load, impact load, seismic load, snow load etc.) acting on the given steel structures. 1d. Select the relevant factors to calculate seismic forces for given civil structure. 1e. Choose the partial safety factor as per the guidelines laid in IS for the given situation. 1f. Explain the Advantages and disadvantages of steel as construction material in the given situation. 1g. Describe the functions of the given steel structure. 1h. Identify the components of the	1.1 Steel as construction material. 1.2 Steel structures: Towers, Roof trusses, Water Tanks, Bridges, Gantry and Crane girders, Columns, Chimney, building frames etc. 1.3 Types, grades and strength of steel sections, Steel Table, IS 808-1989. Stress Strain graph for mild steel. 1.4 Loads acting on steel structures according to IS 875-1987 part I to IV. 1.5 Limit State Method of design: Meaning and types of limit states, loads, design criteria, limit states of strength, limit states of serviceability. 1.6 Factors of safety and load factors as per IS 800:2007.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	given steel structure	
Unit– II Design of Steel Connections	2a Compute the strength of the given bolted connections 2b Design the bolted connections for the given situations. 2c Compute the strength of the given welded connections. 2d Design the welded connections for given situations. 2e State the Specifications for cross-sectional area, pitch, spacing, gauge, end distance, edge distance, and diameter of bolt holes for bolted connections with justification. 2f Explain the advantages and disadvantages of given welded connection.	2.1 Type, uses of bolts and joints: Black bolts and High strength bolts, modes of failure, 2.2 Specifications of bolt holes for bolted connections. 2.3 Strength of bolt in shear, tension, bearing and efficiency of joint. 2.4 Analysis and design of bolted joints for axially loaded plate, single and double angle members 2.5 Welded connections: Butt and Fillet welds, size of weld, throat thickness 2.6 Analysis and design of fillet welded joint for plate, single and double angle members subjected to axial load.
Unit III- Analysis and Design of Singly Reinforced Sections	3a. Choose partial safety factor as laid in IS provisions for the given situation 3b. Explain the different type(s) of loads acting on the given RCC structure(s). 3c. Describe the procedure used in limit state method of design a RC member for the given data. 3d. Discuss the design parameters including constants for given types of materials. 3e. Calculate ultimate moment of resistance for given type of section. 3f. Infer the stability of the given beam section by applying the various checks. 3g. Design a beam section for given conditions. 3h. Draw reinforcement detailing for a given element as per the IS provisions. 3i. Identify the given section as Under- reinforced, over-reinforced or balanced section.	3.1 RCC: functions of reinforcement, material properties, types of limit states, partial safety factors for material strength, characteristic strengths, characteristic load, design load as per IS 456:2000. 3.2 Types of loads and combinations as per IS:875:2002 3.3 Limit State of collapse (flexure) : assumptions, steel, strain diagram and stress-strain relationship for concrete and block diagram for singly reinforced section, design parameters and constants, ultimate moment of resistance 3.4 Under- reinforced, over-reinforced and balanced sections. 3.5 IS specifications regarding spacing, cover, minimum reinforcement, effective span in beams 3.6 Analysis and design: determination of design constants, ultimate moment of resistance, ultimate load carrying capacity, design of rectangular sections.
Unit –IV Design of Shear reinforcement	4a. Explain the pattern of shear failure for a given member in structure.	4.1 Shear: Meaning of shear in beams and slabs. IS code specifications. Various forms of shear

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
and Bond	4b. Locate the zones of minimum shear reinforcement with sketch for the given loading conditions. 4c. Design shears reinforcement for the given conditions. 4d. Judge the beam with given reinforcement on the basis of the shear strength. 4e. Compute the bond length for the beam with given reinforcement. 4f. Identify the zone of minimum shear reinforcement in the given element.	reinforcement .Use of bent up bars. Zones of minimum shear reinforcement. Numerical problems on design of shear reinforcement in beam. 4.2 Bond: Meaning of bond as per IS code provisions. Meaning and calculation of development length in tension and compression.
Unit –V Design of Slabs	5a. Suggest the relevant type of slab for the given support condition. 5b. Suggest relevant corresponding values of design parameters in the given situation. 5c. Check the deflection of the given type of slab. 5d. Design the given type of slab using the given parameters. 5e. Check the development length of the given type of slab.	5.1 Slabs, support conditions, I.S. specifications regarding main steel, distribution steel, spacing and cover for reinforcement, effective span, minimum reinforcement. 5.2 Limit state of serviceability for slabs for deflection criteria only. 5.3 Design of one way and cantilever slab including development length check only. 5.4 Design of two-way slab with four edges discontinuous and provision of torsion reinforcement at corners (As per IS 456:2000, table no 26 case no 9 only). Check for deflection only.
Unit –VI Design of axially loaded short Columns and footing	6a. Identify the type of column in the given situation. 6b. Calculate the ultimate load carrying capacity of the column in the given situation. 6c. Design the axially loaded short column for the given data. 6d. Check the given structural drawing as per the specifications laid in relevant IS code. 6e. Design given type of column footing for the given data. 6f. Explain the assumptions made in the design of axially loaded short column.	6.1 Limit state of collapse in compression, assumptions, effective length, slenderness ratio, short and long columns, and minimum eccentricity. 6.2 IS specifications for reinforcement in column. 6.3 Load analysis for a column : load on an axially loaded column from beams at a different floor levels in a building 6.4 Design of axially loaded short square and rectangular column. 6.5 Various RC footings : Isolated and Sloped footings, combined footings, piles

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	6g. Select the given type of RCC footings in the given situation.	6.6 IS specifications for reinforcement in footing 6.7 Design of isolated square sloped footing: Flexural design with checks for one-way shear, two-way shear and bond. (Problems on design of footing for bending moment only in theory examination paper)

Note: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' of Bloom's 'Cognitive Domain Taxonomy'.

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Fundamental of steel structures	04	02	04	00	06
II	Design of Steel Connections	10	02	04	08	14
III	Analysis and Design of Singly Reinforced Sections	14	02	04	06	12
IV	Design of Shear and Bond	10	02	02	06	10
V	Design of Slabs	14	02	06	06	14
VI	Design of axially loaded short Columns and footing	12	02	06	06	14
Total		**64**	**12**	**26**	**32**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
Note*: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a. Prepare journals based on practical performed in laboratory.
b. Give seminar on relevant topic.
c. Undertake micro-projects.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various learning outcomes in this course:

a. Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Guide student(s) in undertaking micro-projects.
f. Demonstrate students thoroughly before they start doing the practice.
g. Encourage students to refer different websites to have deeper understanding of the subject.
h. Observe continuously and monitor the performance of students in Lab.
i. Demonstrate students thoroughly before they start doing the practice.
j. Encourage students to refer different websites to have deeper understanding of the subject.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects are given here. Similar micro-projects could be added by the concerned faculty.

a. Collect the information of various types of connections used in actual practice.
b. Enlist various software used for the design of steel structures and give details of any one software.
c. Enlist various software used for the design of RCC structures and give details of any one software.
d. Procure actual working drawing / blue print of structural design and write report after checking actual reinforcement placed at site.
e. Collect the details of various types of the formwork used for RCC structures at site.
f. Collect the details of safety norms followed during RCC construction at site and write a report.
g. Collect the details of safety norms followed during Steel construction at site and write a report
h. Visit the site and study the labor management for any one activity related to RCC component and write a report.
i. Visit the site and study the material management for any one activity related to RCC component and write a report.

j. Visit the site and check the level for slab, plumb of column and depth of column as per blue print and write detailed procedure of any one.
k. Identify the various human errors occurred while placing reinforcement and suggest remedial measures.
l. Enlist the activities during removal of formwork and precautions to be taken.
m. Enlist all the instruments used on site along with photograph and parallel terminology used by local mason/labour/worker.

13. SUGGESTED LEARNING RESOURCES :

S. No.	Title of Book	Author	Publication
1	Limit State Design of Steel Structures	Shah,V. L. Gore, Veena	Structures Publications, Pune ISBN-13: 1234567170961
2	Limit State Design of Steel Structures	Shiyekar, M. R.	PHI Learning, Delhi ISBN-13: 978-8120347847
3	Design of Steel Structures	Dayarathnam, P.	S. Chand and Company, Delhi. ISBN-13: 978-8121923200
4	Analysis and Design Practices of Steel Structures	Ghosh, Moy, Karuna	PHI Learning, Delhi. ISBN-13: 978-8120349377
5	Design of Steel Structures	Sairam, K.S.	Pearson Publication, Chennai, Delhi. ISBN-13:9332516308
6	Limit State Theory and Design of Reinforced Concrete Structures	Shah,V. L. Karve, S. R.	Structures Publications, Pune. ISBN-13: 9788190371711
7	Fundamentals of Reinforced Concrete	Sinha, N.C. Roy, S.K.	S. Chand & Co., New Delhi. ISBN-13: 978-8121901277
8	Reinforced Concrete Design Principles and Practice	Krishna Raju,N. Pranesh, R.N.	New Age International, Mumbai ISBN-13: 9788122414608
9	Reinforced concrete Design	Pillai, S.U. Menon, Devdas	McGraw Hill Publications, New Delhi, ISBN-13: 978-0070141100
10	Limit State Design of Reinforced Concrete	Varghese, P. C.	PHI Learning Private Limited, Delhi.ISBN-13: 978-8120320390
11	IS:800-2007 Indian Standard code of practice for use of structural steel in general building construction	BIS New Delhi	BIS New Delhi
12	IS:875-1987 Part-1 to 5: Indian Standard Code for Loading Standards	BIS New Delhi	BIS New Delhi

S. No.	Title of Book	Author	Publication
13	IS hand book No. 1 Properties of structural steel rolled section.	BIS New Delhi	BIS New Delhi
14	IS 456:2000 - Plain and Reinforced concrete code of Practice	BIS New Delhi	BIS New Delhi
15	SP16- Design Aids for reinforced concrete to IS 456	BIS New Delhi	BIS New Delhi
16	I.S. 875 (Part 1-5) - 1987 code of practice of design loads for Buildings and structures.	BIS New Delhi	BIS New Delhi
17	SP 24 - Explanatory Handbook on IS 456	BIS New Delhi	BIS New Delhi
18	SP34 : 1987 - Handbook on concrete reinforcement and Detailing.	BIS New Delhi	BIS New Delhi

Others:

1 Steel tables

14. SOFTWARE/LEARNING WEBSITES

a. https://www.youtube.com/watch?v=mtRR-5fzKo8
b. https://www.youtube.com/watch?v=X8WhkG70tAc
c. https://www.youtube.com/watch?v=zX8HNbHmToM
d. https://www.youtube.com/watch?v=-JMNMlMg-CE
e. freevideolectures.com › Civil Engineering › IIT Guwahati
f. www.youtube.com/playlist?list=PLF5B83BDDBB8FCBE3
g. nptel.ac.in/noc/individual_course.php?id=noc17-ce21
h. http://freevideolectures.com/Course/2686/Design-of-Reinforced-Concrete-Structures
i. https://www.youtube.com/watch?v=hVaB0jGcyB4
j. https://www.youtube.com/watch?v=AfHmpWlcqq4
k. https://www.youtube.com/watch?v=PDJPcQq3PZE
l. https://www.youtube.com/watch?v=GgatFNtQrBo
m. https://www.youtube.com/watch?v=A9JUGWhEW5A
n. freevideolectures.com › Civil Engineering › IIT Madras
o. https://www.youtube.com/watch?v=zwtVO3-_iNQ
p. https://www.youtube.com/watch?v=wJWt0dcgafs
q. https://www.youtube.com/watch?v=csK9eNk6S1c
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