Kandula Srinivasa Reddy Memorial College of Engineering
(Autonomous)

Kadapa-516003. AP

(Approved by AICTE, Affiliated to JNTUA, Ananthapuramu, Accredited by NAAC)

(An ISO 9001-2008 Certified Institution)

Department of Civil Engineering

Certification Course

on

Design of various structural elements of RCC buildings

Course Instructor:

Prof. A. Mohan, Professor, CED, KSRMCE

Course Coordinators:

Sri M. Rajasekhar and Sri S. Nowshad, Assistant Professor, CED, KSRMCE

Date: 13/11/20 to 30/11/20

Lr./KSRMCE/CE/2020-21/ Date: 9-11-2020

From
Sri M. Rajasekhar and Sri S. Nowshad,
Assistant Professor and Course Coordinator,
Dept. of Civil Engineering,
KSRMCE (A),
Kadapa.

To
The Principal,
KSRMCE (A),
Kadapa.

Sub: Permission to Conduct Certificate Course – Reg.

Dear Sir,

The Department of Civil Engineering is planning to offer a certification course on "Design of various structural elements of RCC buildings" for B. Tech. students of Civil Engineering. The course will start on 13th Nov. 2020 and the course will run for a total number of 30 hours. In this regard, I am requesting you to accept the proposal to conduct certificate course.

Thanking you

Yours faithfully

M. Rajasekhar

(Sri M. Rajasekhar and Sri S. Nowshad)

Permitted
V. S. S. Murthy

Cr./KSRMCE/CE/2020-21/ Date: 10/11/2020

Circular

The Department of Civil Engineering is offering a certification course on "Design of various structural elements of RCC buildings". The course will start on 13-11-2020 and the course will run for a total number of 30 hours. In this regard, interested students of Civil Engineering are required to register for the Certification Course using the link is given below.

https://docs.google.com/forms/f/g/2AFQPPLScsdZKShKSUFJBvAnYSjI4457WfgDASFCKnnkas2GfNdT10w/viewform

The Course Coordinators
Sri M. Rajasekhar and Sri S. Nowshad,
Assistant Professor,
Dept. of Civil Engg.-KSRMCE.

V. S.S. Murty

Principal

PRINCIPAL
K.S.R.M. COLLEGE OF ENGINEERING
KADAPA - 516 003. (A.P.)

Cc to:

The Director, KSRMCE

The HoD-Civil, KSRMCE

IQAC-KSRMCE

K.S.R.M. COLLEGE OF ENGINEERING

(UGC-AUTONOMOUS)

Kadapa, Andhra Pradesh, India– 516 003

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An ISO 14001:2004 & 9001: 2015 Certified Institution

Department of Civil Engineering

Registration list of Certification course

on

Design of various structural elements of RCC buildings

Sl. No.	Student Roll No.	Student Name	Mail ID	Class
1	189Y1A0104	Raghavendra Reddy Arikela	189Y1A0104@ksrmce.ac.in	A
2	189Y1A0108	Maheswari Bokkasam	189Y1A0108@ksrmce.ac.in	A
3	189Y1A0109	Rama Chandrareddy Bommireddy	189Y1A0109@ksrmce.ac.in	A
4	189Y1A0115	Satish Kumar Yadav Chennuboyina	189Y1A0115@ksrmce.ac.in	A
5	189Y1A0120	Anilkumar Chittiboyina	189Y1A0120@ksrmce.ac.in	A
6	189Y1A0126	Venkata Jithendhar Reddy Duddekunta	189Y1A0126@ksrmce.ac.in	A
7	189Y1A0130	Premkumar Gaddam	189Y1A0130@ksrmce.ac.in	A
8	189Y1A0132	Lakshmi Prasad Reddy Guddila	189Y1A0132@ksrmce.ac.in	A
9	189Y1A0134	Nitheesh Gunigari	189Y1A0134@ksrmce.ac.in	A
10	189Y1A0137	Gangaraju Jamalla	189Y1A0137@ksrmce.ac.in	A
11	189Y1A0141	Uday Kumar Kaipu	189Y1A0141@ksrmce.ac.in	A
12	189Y1A0144	Bhanumanikanta Reddy Kannapu	189Y1A0144@ksrmce.ac.in	A
13	189Y1A0146	Govardhan Kaveti	189Y1A0146@ksrmce.ac.in	A
14	189Y1A0160	Karthik Kumar Mangala	189Y1A0160@ksrmce.ac.in	A
15	189Y1A0161	Sai Karthik Maruboyana	189Y1A0161@ksrmce.ac.in	A
16	189Y1A0163	Sampath Kumar Meka	189Y1A0163@ksrmce.ac.in	B
17	189Y1A0165	Purushotham Reddy Mitta	189Y1A0165@ksrmce.ac.in	B
18	189Y1A0168	Mahammad Azeez Mulla	189Y1A0168@ksrmce.ac.in	B
19	189Y1A0171	Venkata Sai Poojith Nagalla Pati	189Y1A0171@ksrmce.ac.in	B

20	189Y1A0172	Venkatesh Nagirikanti	189Y1A0172@ksrmce.ac.in	B
21	189Y1A0175	Abhish Nanubala	189Y1A0175@ksrmce.ac.in	B
22	189Y1A0177	Ragasravani Pagati	189Y1A0177@ksrmce.ac.in	B
23	189Y1A0179	Jayachandra Sai Pandugolu	189Y1A0179@ksrmce.ac.in	B
24	189Y1A0181	Muni Kumar Parimisetti	189Y1A0181@ksrmce.ac.in	B
25	189Y1A0183	Siva Sai Pasupuleti	189Y1A0183@ksrmce.ac.in	B
26	189Y1A0187	Rakesh Prasanna Penubala	189Y1A0187@ksrmce.ac.in	B
27	189Y1A0193	Bindhu Rachamallu	189Y1A0193@ksrmce.ac.in	B
28	189Y1A0194	Neeraj Sale	189Y1A0194@ksrmce.ac.in	B
29	189Y1A0195	Swarna Latha Seelam	189Y1A0195@ksrmce.ac.in	B
30	189Y1A0198	Afroz Shaik	189Y1A0198@ksrmce.ac.in	B
31	189Y1A01A6	Zakke Hussain Shaik	189Y1A01A6@ksrmce.ac.in	B
32	189Y1A01A7	Pragathi (W) Somireddy	189Y1A01A7@ksrmce.ac.in	B
33	189Y1A01B0	Sateesh Kumar Reddy Thallapalle	189Y1A01B0@ksrmce.ac.in	B
34	189Y1A01B1	Sukumar Thati	189Y1A01B1@ksrmce.ac.in	B
35	189Y1A01B2	Siva Reddy Thatimakula	189Y1A01B2@ksrmce.ac.in	B
36	189Y1A01B4	Gayathri Thopudurthy	189Y1A01B4@ksrmce.ac.in	B
37	189Y1A01B8	Venkata Hemanth Usugari	189Y1A01B8@ksrmce.ac.in	B
38	189Y1A01B9	Nagarjun Utukuru	189Y1A01B9@ksrmce.ac.in	B
39	189Y1A01C3	Ganga Swetha Vennapusa	189Y1A01C3@ksrmce.ac.in	B
40	189Y1A01C8	Sivanatha Reddy Yeturu	189Y1A01C8@ksrmce.ac.in	B
41	199Y5A0102	Malik Akula	199Y5A0102@ksrmce.ac.in	C
42	199Y5A0105	Venugopal Reddy Atla	199Y5A0105@ksrmce.ac.in	C
43	199Y5A0107	Vijay Kumar Reddy Basireddygari	199Y5A0107@ksrmce.ac.in	C
44	199Y5A0108	Sai Bonthalapalli	199Y5A0108@ksrmce.ac.in	C
45	199Y5A0109	Mahesh Naik Bukke	199Y5A0109@ksrmce.ac.in	C
46	199Y5A0111	Rohit Chinna Swami Gari	199Y5A0111@ksrmce.ac.in	C
47	199Y5A0112	Mahesh Babu Chinthakunta	199Y5A0112@ksrmce.ac.in	C
48	199Y5A0115	Sreenivasulu Dasari	199Y5A0115@ksrmce.ac.in	C

49	199Y5A0116	Pavan Kalyan Dokka	199Y5A0116@ksrmce.ac.in	C
50	199Y5A0117	Dastagiri Dudekula	199Y5A0117@ksrmce.ac.in	C
51	199Y5A0118	Premaraju Erapogu	199Y5A0118@ksrmce.ac.in	C
52	199Y5A0123	Ramu Gosetty	199Y5A0123@ksrmce.ac.in	C
53	199Y5A0127	Venkateswarlu Kashetty	199Y5A0127@ksrmce.ac.in	C
54	199Y5A0130	Vinodkumar Madhuranthakam	199Y5A0130@ksrmce.ac.in	C
55	199Y5A0131	Bharath Venkata Sai Malle Bharath	199Y5A0131@ksrmce.ac.in	C
56	199Y5A0132	Mahesh Mallepogu Budigi	199Y5A0132@ksrmce.ac.in	C
57	199Y5A0134	Sai Kumar Mannula	199Y5A0134@ksrmce.ac.in	C
58	199Y5A0135	Sai Kumar Reddy Masireddy	199Y5A0135@ksrmce.ac.in	C
59	199Y5A0138	Reddaiah Nagulugari	199Y5A0138@ksrmce.ac.in	C
60	199Y5A0159	Chandu Thoti	199Y5A0159@ksrmce.ac.in	C
61	199Y5A0160	Siva Sai Udayagiri	199Y5A0160@ksrmce.ac.in	C
62	199Y5A0161	Manjunatha Udumala	199Y5A0161@ksrmce.ac.in	C

Coordinator

HoD-Civil Engg.

Head
Department of Civil Engineering
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Syllabus of Certification Course

Course Name: Design of various structural elements of RCC Buildings

Duration: 30 Hours

Module I:

Moment resistance and Design of singly, doubly and T-beams, Design for shear and torsion

Module II:

Design of One-way slab, Continuous one-way slab and two-way slab

Module III:

Design of axially loaded column with lateral ties and circular columns with helical ties, Analysis and Design of uniaxial moment

Module IV:

Design of Isolated square and rectangular footings, Deflection calculations and design of dog-legged staircase.

Text Books:

1. N. Subramanian, Design of Reinforced Concrete Structures; Oxford University Press, 2014
2. S Unnikrishna Pillai & Devdas Menon, Reinforced Concrete Design, McGraw Hill, 2021

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V. S. S. Murthy

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Department of Civil Engineering

Certification course on Design of various structural elements of RCC buildings

Date	Timing	Course Instructor	Topics to be covered
13-11-20	3 PM to 6 PM	Prof. A. Mohan	Moment resistance and Design of singly, doubly and T-beams, Design for shear and torsion
16-11-20	3 PM to 6 PM	Prof. A. Mohan	Moment resistance and Design of singly, doubly and T-beams, Design for shear and torsion
17-11-20	4 PM to 6 PM	Prof. A. Mohan	Moment resistance and Design of singly, doubly and T-beams, Design for shear and torsion
18-11-20	4 PM to 6 PM	Prof. A. Mohan	Design of One-way slab, Continuous one-way slab and two-way slab
19-11-20	4 PM to 6 PM	Prof. A. Mohan	Design of One-way slab, Continuous one-way slab and two-way slab
20-11-20	4 PM to 6 PM	Prof. A. Mohan	Design of One-way slab, Continuous one-way slab and two-way slab
21-11-20	4 PM to 6 PM	Prof. A. Mohan	Design of axially loaded column with lateral ties and circular columns with helical ties, Analysis and Design of uniaxial moment
23-11-20	4 PM to 6 PM	Prof. A. Mohan	Design of axially loaded column with lateral ties and circular columns with helical ties, Analysis and Design of uniaxial moment
24-11-20	4 PM to 6 PM	Prof. A. Mohan	Design of axially loaded column with lateral ties and circular columns with helical ties, Analysis and Design of uniaxial moment
25-11-20	4 PM to 6 PM	Prof. A. Mohan	Design of axially loaded column with lateral ties and circular columns with helical ties, Analysis and Design of uniaxial moment
26-11-20	4 PM to 6 PM	Prof. A. Mohan	Design of Isolated square and rectangular footings, Deflection calculations and design of dog-legged staircase.
27-11-20	4 PM to 6 PM	Prof. A. Mohan	Design of Isolated square and rectangular footings, Deflection calculations and design of dog-legged staircase.
28-11-20	4 PM to 6 PM	Prof. A. Mohan	Design of Isolated square and rectangular footings, Deflection calculations and design of dog-legged staircase.
30-11-20	3 PM to 6 PM	Prof. A. Mohan	Design of Isolated square and rectangular footings, Deflection calculations and design of dog-legged staircase.

V. S. S. Murthy

Principal

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Instructor:

Coordinators:

Report

of

Certification Course on Design of various structural elements of RCC Buildings

From 13/11/2020 to 30/11/2020

Target Group	:	**Students**
Details of Participants	:	**62 Students**
Co-coordinator(s)	:	**Sri M. Rajasekhar and Sri S. Nowshad**
Organizing Department	:	**Civil Engineering**
Venue	:	**Online (google meet)**
Link	:	**https://meet.google.com/lookup/ludspmw3w**

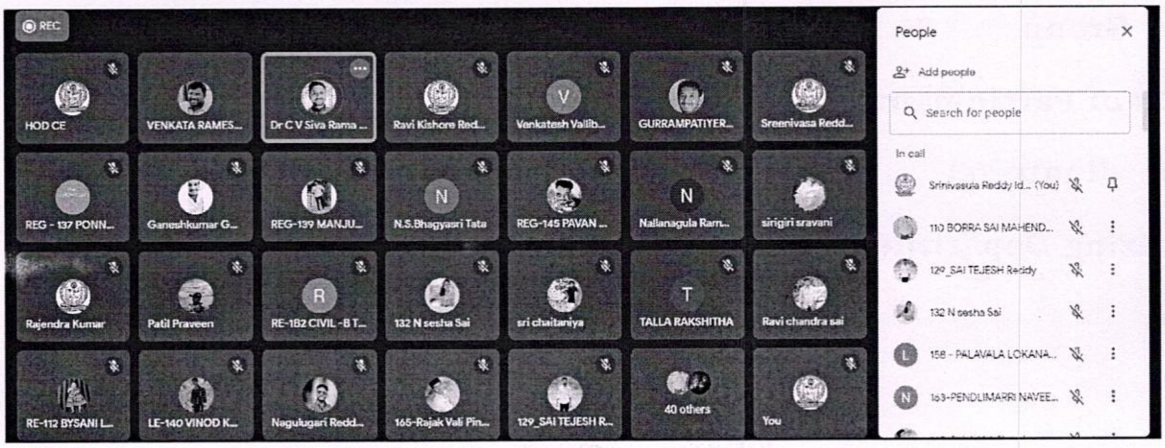
Description:

A certificate course on "Design of various structural elements of RCC buildings" is conducted in the Department of Civil Engineering from 13th to 30th November 2020. The course duration was planned for 30 hours. The course instructor is Prof. A. Mohan, Professor, Department Civil Engineering and Coordinator are Sri M. Rajasekhar and Sri S. Nowshad, Assistant Professor, Department of Civil Engineering.

The behavior of RC structural members is difficult to predict. Design of an RC structure involves the proportionating of different structural elements and detailing them to withstand the loads that are likely to act on the structure during its intended life. Structural knowledge is increasing continuously as the techniques for analysis, design, fabrication and erection of structures are being improved constantly. Hence the designer should have sound knowledge in terms of material and structural behavior.

In the preset course the analysis and design of various structural elements like beams, columns, slabs, footings and staircase have been done. The spread sheets designed in this course are very much useful the faculty and student community to verify the results within a minimum time. Proportioning of the member sizes can also be rigorously worked out to obtain the economical design if they have this spread sheets. This course encouraged the students to think beyond the class room teaching to have sound knowledge in structures.

Photo:



(Course Instructor)

(HoD, Civil Engg.)

Head
Department of Civil Engineering
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Principal

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DEPARTMENT OF CIVIL ENGINEERING

CERTIFICATE COURSE

ON

"Design Of Various Structural elements Of RCC buildings"

RESOURCE PERSON

Prof. A.Mohan

Department of civil Engineering

13-11-2020

30-11-2020

Coordinator:

Sri M. Rajasekhar and Sri S. Nowshad

Assistant Professor

Department of Civil Engineering

Attendance sheet of Certification course on "Design of various structural elements of RCC buildings"

Sl. No.	Student Roll No.	Student Name	13/11	16/11	17/11	18/11	19/11	20/11	21/11	23/11	24/11	25/11	26/11	27/11	28/11	30/11
1	189Y1A0104	Raghavendra Reddy Arikela	A	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	A
2	189Y1A0108	Maheswari Bokkasam	✓	✓	✓	✓	✓	A	A	✓	✓	✓	✓	✓	✓	✓
3	189Y1A0109	Rama Chandrareddy Bommireddy	✓	A	✓	✓	✓	✓	✓	✓	✓	✓	A	✓	✓	✓
4	189Y1A0115	Satish Kumar Yadav Chennuboyina	A	✓	✓	✓	✓	✓	A	✓	✓	✓	✓	✓	✓	✓
5	189Y1A0120	Anilkumar Chittiboyina	✓	✓	A	✓	✓	✓	✓	✓	A	✓	✓	✓	✓	✓
6	189Y1A0126	Venkata Jithendhar Reddy Duddekunta	A	✓	✓	✓	✓	A	✓	✓	✓	✓	✓	✓	✓	✓
7	189Y1A0130	Premkumar Gaddam	✓	A	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	A	✓
8	189Y1A0132	Lakshmi Prasad Reddy Guddila	A	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	A
9	189Y1A0134	Nitheesh Gunigari	✓	✓	A	✓	✓	✓	✓	A	✓	✓	✓	✓	✓	✓
10	189Y1A0137	Gangaraju Jamalla	A	✓	✓	✓	✓	✓	✓	✓	✓	✓	A	✓	✓	✓

11	189Y1A0141	Uday Kumar Kaipu	A	✓	✓	✓	✓	✓	✓	✓	✓	✓	A	✓	✓	✓
12	189Y1A0144	Bhanumanikanta Reddy Kannapu	✓	✓	A	✓	✓	✓	✓	A	✓	✓	✓	✓	✓	✓
13	189Y1A0146	Govardhan Kaveti	A	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	A
14	189Y1A0160	Karthik Kumar Mangala	✓	✓	✓	✓	A	✓	✓	✓	✓	✓	A	✓	✓	✓
15	189Y1A0161	Sai Karthik Maruboyana	✓	A	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	A
16	189Y1A0163	Sampath Kumar Meka	✓	✓	✓	✓	✓	A	✓	✓	✓	✓	✓	A	✓	✓
17	189Y1A0165	Purushotham Reddy Mitta	A	✓	✓	✓	✓	✓	✓	✓	✓	A	✓	✓	✓	✓
18	189Y1A0168	Mahammad Azeez Mulla	✓	✓	✓	A	✓	✓	✓	✓	✓	✓	✓	✓	✓	A
19	189Y1A0171	Venkata Sai Poojith Nagalla Pati	A	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	A	✓	✓
20	189Y1A0172	Venkatesh Nagirikanti	✓	✓	✓	A	✓	✓	✓	✓	A	✓	✓	✓	✓	✓
21	189Y1A0175	Abhish Nanubala	A	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	A
22	189Y1A0177	Ragasravani Pagati	✓	✓	✓	✓	✓	✓	A	A	✓	✓	✓	✓	✓	✓
23	189Y1A0179	Jayachandra Sai Pandugolu	✓	✓	✓	A	✓	✓	✓	✓	✓	✓	✓	A	✓	✓
24	189Y1A0181	Muni Kumar Parimisetti	A	✓	✓	✓	✓	✓	✓	A	✓	✓	✓	✓	✓	✓

39	189Y1A01C3	Ganga Swetha Vennapusa	✓	✓	✓	✓	✓	A	✓	✓	✓	✓	✓	✓	✓	A
40	189Y1A01C8	Sivanatha Reddy Yeturu	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	A	A
41	199Y5A0102	Malik Akula	✓	A	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
42	199Y5A0105	Venugopal Reddy Atla	A	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	A	✓
43	199Y5A0107	Vijay Kumar Reddy Basireddygari	✓	A	✓	✓	✓	✓	✓	✓	✓	✓	✓	A	✓	✓
44	199Y5A0108	Sai Bonthalapalli	✓	✓	✓	✓	✓	✓	A	✓	✓	✓	✓	✓	✓	A
45	199Y5A0109	Mahesh Naik Bukke	✓	A	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	A	✓
46	199Y5A0111	Rohit Chinna Swami Gari	✓	✓	✓	✓	✓	✓	A	✓	✓	A	✓	✓	✓	✓
47	199Y5A0112	Mahesh Babu Chinthakunta	✓	✓	A	✓	✓	✓	✓	✓	✓	✓	A	✓	✓	✓
48	199Y5A0115	Sreenivasulu Dasari	✓	A	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	A
49	199Y5A0116	Pavan Kalyan Dokka	✓	✓	✓	✓	A	✓	✓	✓	A	✓	✓	✓	✓	✓
50	199Y5A0117	Dastagiri Dudekula	✓	✓	A	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	A
51	199Y5A0118	Premaraju Erapogu	✓	✓	✓	✓	✓	✓	✓	A	✓	✓	A	✓	✓	✓
52	199Y5A0123	Ramu Gosetty	✓	A	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	A

25	189Y1A0183	Siva Sai Pasupuleti	A	✓	✓	✓	✓	✓	✓	A	✓	✓	✓	✓	✓	✓
26	189Y1A0187	Rakesh Prasanna Penubala	✓	✓	A	✓	✓	✓	✓	✓	✓	✓	✓	✓	A	✓
27	189Y1A0193	Bindhu Rachamallu	A	✓	✓	✓	✓	✓	✓	A	✓	✓	✓	✓	✓	✓
28	189Y1A0194	Neeraj Sale	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
29	189Y1A0195	Swarna Latha Seelam	✓	A	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	A
30	189Y1A0198	Afroz Shaik	A	✓	✓	✓	✓	✓	A	✓	✓	✓	✓	✓	✓	✓
31	189Y1A01A6	Zakke Hussain Shaik	A	✓	✓	✓	✓	✓	✓	✓	✓	✓	A	✓	✓	✓
32	189Y1A01A7	Pragathi (W) Somireddy	✓	✓	✓	✓	✓	A	✓	✓	✓	✓	✓	✓	A	✓
33	189Y1A01B0	Sateesh Kumar Reddy Thallapalle	✓	A	✓	✓	✓	✓	✓	✓	✓	✓	A	✓	✓	✓
34	189Y1A01B1	Sukumar Thati	A	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	A
35	189Y1A01B2	Siva Reddy Thatimakula	✓	✓	A	✓	✓	✓	✓	✓	✓	✓	A	✓	✓	✓
36	189Y1A01B4	Gayathri Thopudurthy	A	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	A
37	189Y1A01B8	Venkata Hemanth Usugari	A	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	A
38	189Y1A01B9	Nagarjun Utukuru	✓	✓	✓	✓	✓	✓	A	✓	✓	A	✓	✓	✓	✓

53	199Y5A0127	Venkateswarlu Kashetty	A	✓	✓	✓	✓	✓	✓	✓	✓	✓	A	✓	✓	✓
54	199Y5A0130	Vinodkumar Madhuranthakam	✓	✓	✓	✓	✓	✓	A	✓	✓	✓	✓	✓	✓	A
55	199Y5A0131	Bharath Venkata Sai Malle Bharath	✓	✓	A	✓	✓	✓	✓	✓	✓	✓	✓	✓	A	✓
56	199Y5A0132	Mahesh Mallepogu Budigi	A	✓	✓	✓	✓	✓	✓	A	✓	✓	✓	✓	✓	✓
57	199Y5A0134	Sai Kumar Mannula	✓	✓	✓	A	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
58	199Y5A0135	Sai Kumar Reddy Masireddy	✓	✓	✓	✓	✓	✓	✓	✓	A	A	✓	✓	✓	✓
59	199Y5A0138	Reddaiah Nagulugari	✓	✓	✓	✓	✓	A	✓	✓	✓	✓	✓	✓	✓	A
60	199Y5A0159	Chandu Thoti	✓	✓	✓	✓	✓	A	✓	✓	✓	A	✓	✓	✓	✓
61	199Y5A0160	Siva Sai Udayagiri	✓	✓	✓	A	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
62	199Y5A0161	Manjunatha Udumala	A	✓	✓	✓	✓	✓	✓	A	✓	✓	✓	✓	✓	A

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Given: b, d, A_{st}, f_{ck}, and f_y

Find: M_R

1. Given data
   a. Section properties

Width	=b	=	200 mm
Effective depth	=d	=	350 mm
Area of tension steel	$=A_{st}$	=	339 mm^2

   b. Material properties

Concrete strength	$=f_{ck}$	=	25 MPa
Steel strength	$=f_y$	=	415 MPa

2. Type of section

Limiting value of $= \frac{x_{u\,max}}{d} = \frac{0.0035}{0.0055 + \frac{0.87 f_y}{E_s}}$ = 0.479

NA depth factor $= \frac{x_u}{d} = \frac{0.87 f_y A_{st}}{0.362 f_{ck} bd}$ = 0.193

$< x_{umax}/d$

Hence, the section is under-reinforced

3. Moment of resistance

Moment of resistance $= M_R = 0.362 \frac{x_u}{d}\left[1 - 0.416 \frac{x_u}{d}\right] f_{ck} bd^2$ = 39.40 kNm

4. Questions
   a. What is x_{umax}/d for Fe500 steel?
   b. What is the value of E_s?
   c. What is the expression for M_R for balanced section?
   d. What is limiting moment of resistance?

Given: b, d, A_{st}, f_{ck}, and f_y

Find: M_R

1. Given data
   a. Section properties

Width	=b	=	200 mm
Effective depth	=d	=	350 mm
Area of tension steel	$=A_{st}$	=	942 mm^2

   b. Material properties

Concrete strength	$=f_{ck}$	=	25 MPa
Steel strength	$=f_y$	=	415 MPa

2. Type of section

Limiting value of $= \frac{x_{u\,max}}{d} = \frac{0.0035}{0.0055 + \frac{0.87 f_y}{E_s}}$ = 0.479

NA depth factor $= \frac{x_u}{d} = \frac{0.87 f_y A_{st}}{0.362 f_{ck} bd}$ = 0.537

$> x_{umax}/d$

Hence, the section is over-reinforced

3. Moment of resistance is found by following iterative procedure
   a. Assume a suitable initial (trial) value for x_u ($x_{umax}<x_u<d$)
   b. Calculate $\varepsilon_{st}=0.0035(d/x_u-1)$
   c. Read f_{st} corresponding to ε_{st}
   d. Calculate $x_u=f_{st}A_{st}/(0.362f_{ck}b)$
   e. Repeat steps a to d till x_u converges
   f. Moment of resistance $M_R=f_{st}A_{st}(d-0.416x_u)$
4. Calculation (final iteration)

Trial depth of NA	$=x_u$	=	184.8 mm
Strain in steel	$=\varepsilon_{st}$	=	0.0031
Stress in steel	$=f_{st}$	=	355 MPa
New depth of NA	$=x_u$	=	184.8 mm
Hence, x_u converged			
Moment of resistance	$=M_R=f_{st}A_{st}(d-0.416x_u)$	=	91.34 kNm

5. Questions
   a. Why the Code puts a limit on value of x_u/d?
   b. What is the alternate expression for M_R?
   c. What is the significance of 0.0035 in line 3(b)?
   d. How you can convert a over-reinforced section to an under-reinforced section?

Given: b, d, d', A_{st}, A_{sc}, f_{ck}, and f_y

Find: M_R

1. Given data
   a. Section properties

Width	=b	=	200 mm
Eff depth to tension steel	=d	=	350 mm
Eff depth to compression steel	=d'	=	50 mm
Area of tension steel	$=A_{st}$	=	942 mm^2
Area of compression steel	$=A_{sc}$	=	226 mm^2

   b. Material properties

Concrete strength	$=f_{ck}$	=	25 MPa
Steel strength	$=f_y$	=	415 MPa

2. Type of section

Limiting value of $= \frac{x_{u\,max}}{d} = \frac{0.0035}{0.0055 + \frac{0.87 f_y}{E_s}}$ = 0.479

Assuming that both steels yield, i.e.., $f_{st}=f_{sc}=0.87f_y$

NA depth factor $= \frac{x_u}{d} = \frac{f_{st} A_{st} - (f_{sc} - 0.447 f_{ck}) A_{sc}}{0.362 f_{ck} bd}$ = 0.412

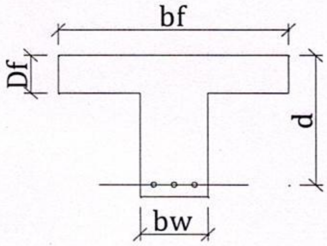
$< x_{umax}/d$

Hence, the section is under-reinforced & tension steel yields. Check for compression steel

3. Moment of resistance
   a. Assume a suitable initial (trial) value for x_u ($x_u<x_{umax}$)
   b. Calculate $\varepsilon_{sc}=0.0035(1-d'/x_u)$
   c. Read f_{sc} corresponding to ε_{sc}
   d. Calculate x_u
   e. Repeat steps a to d till x_u converges
   f. Moment of resistance $M_R=0.362f_{ck}bx_u(d-0.416x_u)+(f_{sc}-0.447f_{ck})A_{sc}(d-d')$
4. Calculation (final iteration)

Trial depth of NA	$=x_u$	=	146.9 mm
Strain in steel	$=\varepsilon_{sc}$	=	0.0023
Stress in compression steel	$=f_{sc}$	=	339.1 MPa
New depth of NA	$=x_u$	=	147.0 mm
Hence, x_u converged			
Moment of resistance	$=M_R$	=	99.07 kNm

5. Questions
   a. What are the advantages of a doubly-reinforced section?



Given: b_f, b_w, D_f, d, A_{st}, f_{ck}, and f_y

Find: M_R

1. Given data
   a. Section properties

Flange width	$=b_f$	=	850 mm
Flange depth	$=D_f$	=	100 mm
Web width	$=b_w$	=	250 mm
Eff depth to tension steel	=d	=	520 mm
Area of tension steel	$=A_{st}$	=	3695 mm^2

   b. Material properties

Concrete strength	$=f_{ck}$	=	20 MPa
Steel strength	$=f_y$	=	250 MPa

2. Location of NA

Limiting value of $= \dfrac{x_{u\,max}}{d} = \dfrac{0.0035}{0.0055 + \dfrac{0.87 f_y}{E_s}}$ = 0.531

Assuming that f_{st}=0.87f_y (under-reinforced) and NA lies in flange (x_u<D_f)

NA depth factor $= \dfrac{x_u}{d} = \dfrac{f_{st} A_{st}}{0.362 f_{ck} b_f d}$ = 0.251

< x_{umax}/d

Depth of NA = 130.6 mm

> D_f

Hence, the section is under-reinforced & NA lies in web. (But x_u is to be corrected)

3. Moment of resistance
   a. Assume a suitable initial (trial) value for x_u (D_f<x_u<x_{umax})
   b. Calculate $y_f=0.15x_u+0.65D_f$ if xu<(7/3)D_f

      $y_f=D_f$ if xu>=(7/3)D_f
   c. Calculate $x_u = \dfrac{0.87 f_y A_{st} - 0.447 f_{ck} (b_f - b_w) y_f}{0.362 f_{ck} b_w}$
   d. Repeat steps b and c till x_u converges
   e. Moment of resistance $M_R=0.362f_{ck}b_wx_u(d-0.416x_u)+0.447f_{ck}(b_f-b_w)y_f(d-y_f/2)$
4. Calculation (final iteration)

Trial depth of NA	$=x_u$	=	174.0 mm
Equivalent depth	$=y_f$	=	91.1 mm
New depth of NA	$=x_u$	=	174.0 MPa
Moment of resistance	$=M_R$	=	372.84 kNm

5. Questions
   a. What is implied for the condition x_u>=(7/3)D_f?

Given: b, d, f_{ck}, f_y, and M_u

Find: A_{st}

1. Given data
   a. Section properties

Width	=b	=	200 mm
Effective depth	=d	=	350 mm

   b. Material properties

Concrete strength	$=f_{ck}$	=	25 MPa
Steel strength	$=f_y$	=	415 MPa

   c. Design moment $=M_u$ = 40.0 kNm

2. Type of design

NA depth factor	$=x_{umax}/d$	=	0.479
Factor	$= Q = 0.362\,\frac{x_{u\max}}{d}\left(1-0.416\,\frac{x_{u\max}}{d}\right)$	=	0.139
Limiting moment	$=M_{ulim}=Qf_{ck}bd^2$	=	85.1 kNm

   M_u<M_{ulim}. Hence, design the section as singly reinforced

3. Calculation of A_{st}

Required steel	$= A_{st} = \frac{1}{2}\frac{f_{ck}}{f_y}\left[1-\sqrt{1-\frac{4.6M_u}{f_{ck}bd^2}}\right]bd$	=	344.9 mm^2

4. Checks

Minimum steel	$=0.85bd/f_y$	=	143 mm^2
Maximum steel	=0.04bD	=	2800 mm^2

   Hence Ok

Given: b, d, d', f_{ck}, f_y, and M_u

Find: A_{st}, and A_{sc}

1. Given data
   a. Section properties

Width	=b	=	200 mm
Effective depth	=d	=	350 mm
Eff depth to comp steel	=d'	=	40 mm

   b. Material properties

Concrete strength	$=f_{ck}$	=	25 MPa
Steel strength	$=f_y$	=	415 MPa
c. Design moment	$=M_u$	=	100.0 kNm

2. Type of design

NA depth factor	$=x_{umax}/d$	=	0.479
Factor	$= Q = 0.362 \frac{x_{u\max}}{d}\left(1-0.416\frac{x_{u\max}}{d}\right)$	=	0.139
Limiting moment	$=M_{ulim}=Qf_{ck}bd^2$	=	85.1 kNm

$M_u > M_{ulim}$. Hence, design the section as doubly reinforced

3. Calculation of A_{st}, and A_{sc}

Balanced tension steel	$= A_{st1} = \frac{1}{2}\frac{f_{ck}}{f_y}\left[1-\sqrt{1-\frac{4.6M_{u\lim}}{f_{ck}bd^2}}\right]bd$	=	841.3 mm^2
Additional tension steel	$= A_{st2} = \frac{(M_u - M_{u\lim})}{0.87f_y(d-d')}$	=	133.5 mm^2
Strain in compression steel	$=\varepsilon_{sc}=0.0035(1-(d'/d)(d/x_{umax}))$	=	0.0027
Stress in compression steel	$=f_{sc}$	=	349.4 MPa
Compression steel	$= A_{sc} = \frac{0.87f_y A_{st2}}{f_{sc}-0.447f_{ck}}$	=	142.5 mm^2
Total tension steel	$=A_{st}=A_{st1}+A_{st2}$	=	974.8 mm^2
Total compression steel	$=A_{sc}$	=	142.5 mm^2

Given: b, d, A_{st}, f_{ck}, f_y, and V_u

Find: Shear reinforcement

1. Given data
   a. Section properties

Width	=b	=	350 mm
Effective depth	=d	=	500 mm
Area of tension steel	$=A_{st}$	=	1963 mm^2

   b. Material properties

Concrete strength	$=f_{ck}$	=	15 MPa
Steel strength	$=f_y$	=	415 MPa

   c. Design forces

Factored shear force	$=V_u$	=	350 kN

2. Shear design

Nominal shear stress	$=\tau_v=V_u/bd$	=	2.0 MPa
Percentage tension steel	$=p=100A_{st}/bd$	=	1.12 %
Design shear strength	$=\tau_c$	=	0.62 MPa
Max shear strength	$=\tau_{cmax}$	=	2.5 MPa
	$\tau_v<\tau_{cmax}$. Hence section is Ok		
	$\tau_v>\tau_c$. Hence provide shear reinforcement		
Shear resisted by steel	$=V_{us}=V_u-\tau_c bd$	=	241.6 kN
Adopt 8 mm, 2-legged vertical stirrups. Then			
Area of shear reinforcement	$=A_{sv}$	=	101 mm^2
Spacing of stirrups	$=s=0.87f_yA_{sv}d/V_{us}$	=	75 mm
	<0.75d	<	375 mm
	<300 mm	<	300 mm
Hence provide 8ϕ, 2-legged vertical stirrups at spacing s		=	75 mm
Minimum area of shear steel	$=A_{sv}>=0.4bs/0.87f_y$	=	29 mm^2

Hence Ok.

Given: b, d, M_u, V_u, T_u, f_{ck}, and f_y

Find: Flexure and shear reinforcements

1. Given data
   a. Section properties

Width	=b	=	350 mm
Depth	=D	=	750 mm

   b. Material properties

Concrete strength	$=f_{ck}$	=	25 MPa
Steel strength	$=f_y$	=	415 MPa

   c. Design forces

Factored moment	$=M_u$	=	200 kNm
Factored torsion	$=T_u$	=	140 kNm
Factored shear	$=V_u$	=	110 kN

2. Design for flexure

Effective BM due to torsion	$=M_t=T_u(1+D/b)/1.7$	=	258.8 kNm
Equivalent BM for design			
For flexural tension zone	$=M_{e1}=M_t+M_u$	=	458.8 kNm
For flexural comp zone	$=M_{e2}=M_t-M_u$ (if >0, else ignore)	=	58.8 kNm
Assume effective cover	=	=	50 mm
Available effective depth	=d	=	700 mm
NA depth factor	$=x_{umax}/d$	=	0.479
Factor	$= Q = 0.362\,\frac{x_{u\,max}}{d}\left(1-0.416\,\frac{x_{u\,max}}{d}\right)$	=	0.139

   a. Design for M_{e1} (Steel placed in flexural tension zone)

Limiting moment	$=M_{ulim}=Qf_{ck}bd^2$	=	595.4 kNm

Hence design as singly reinforced section

Required steel	$= A_{st} = \frac{1}{2}\frac{f_{ck}}{f_y}\left[1-\sqrt{1-\frac{4.6M_u}{f_{ck}bd^2}}\right]bd$	=	2121.2 mm^2

Hence, provide 2-28ϕ + 2-25ϕ giving A_{st} = 2213.3 mm^2

   b. Design for M_{e2} (Steel placed in flexural compression zone)

Required steel	$=A_{sc}$	=	236.7 mm^2
Minimum steel	$=(0.85/f_y)bd$	=	501.8 mm^2
Hence, provide	$=A_{sc}$	=	501.8 mm^2

Hence, provide 3-16ϕ giving A_{st} = 603 mm^2

   c. Side face reinforcement (as D>450)

Required steel	=0.1% of bD	=	245 mm^2

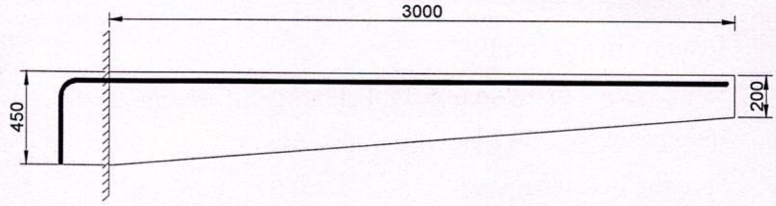
Distribute the steel equally on both vertical sides

3. Design for shear

Equivalent nominal shear	$=V_{ue}=V_u+1.6T_u/b$	=	750.0 kN
Nominal shear stress	$=\tau_{ve}=V_{ue}/bd$	=	3.1 MPa
Max allowable shear stress	$=\tau_{cmax}$	=	3.1 MPa
Hence, the section is Ok.			
Percentage steel	$=p$	=	0.90 %
Design shear stress	$=\tau_c$	=	0.62 MPa
Using 2-legged 12ϕ stirrups, area of stirrup A_{sv}		=	226 mm^2
Distance b_1 (c/c horizontal distance b/w corner bars)		=	250 mm
Distance d_1 (c/c vertical distance b/w corner bars)		=	650 mm
Required	$= s_v = \dfrac{0.87 f_y A_{sv} d_1}{\dfrac{T_u}{b_1} + \dfrac{V_u}{2.5}}$	=	88 mm
Required	$= s_v = \dfrac{0.87 f_y A_{sv}}{(\tau_{ve} - \tau_c) b}$	=	95 mm
Short leg of stirrup	$=x_1$	=	290 mm
Long leg of stirrup	$=y_1$	=	684 mm
Spacing requirement s_v	$<= x_1$	=	290 mm
	$<= (x_1+y_1)/4$	=	244 mm
	$<=300$ mm	=	300 mm
Hence required spacing	$=s_v$	=	88 mm

Provide 2-legged 12ϕ stirrups at 85 mm c/c

A tapered cantilever beam, shown in figure, is supporting a total service load of 12 kN/m over its entire length. Width of beam is 250 mm. Design the beam. Use f_{ck}=20 MPa and f_y=415 MPa.



1. Given data
   a. Section properties

Width	=b	=	250 mm
Depth	=D	=	450 mm
Let effective cover	=c	=	40 mm
Effective span	=l	=	3000 mm

   b. Material properties

Concrete strength	=f_{ck}	=	20 MPa
Steel strength	=f_y	=	415 MPa

   c. Service load =w = 12 kN/m

2. Design for flexure

Critical section for flexure is at face of support

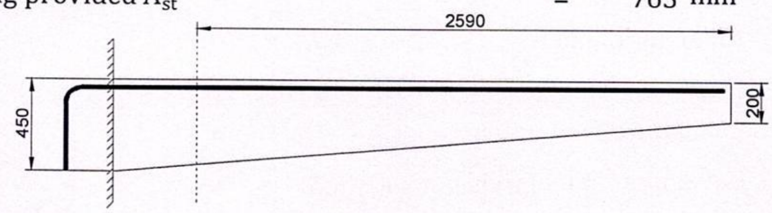
At critical section, max BM	=$M = wl^2/2$	=	54.0 kNm
Factored BM	=$M_u = 1.5M$	=	81.0 kNm
Eff depth available	=d = D-c	=	410 mm
Limiting moment of section	=$M_{ulim} = Qf_{ck}bd^2$	=	116.8 kNm

Hence, design the section as singly-reinforced

Required A_{st} $= A_{st} = \frac{1}{2}\frac{f_{ck}}{f_y}\left[1-\sqrt{1-\frac{4.6M_u}{f_{ck}bd^2}}\right]bd$ = 627 mm^2

Provide 3 nos of 18ϕ bars giving provided A_{st} = 763 mm^2

3. Design for shear



Critical section for shear is distance d=410mm from face of support

At critical section,

Shear force	=V	=	31.1 kN
Factored shear force	=$V_u = 1.5V$	=	46.6 kN
Factored BM	=M_u	=	60.4 kNm
tan β	= (450-200)/3000	=	0.083
Effective depth	=d = 410-(410-160)*410/3000	=	376 mm
Nominal shear stress	$= \tau_v = \frac{V_u - \frac{M_u}{d}\tan\beta}{bd}$	=	0.35 MPa

Max shear strength	$=\tau_{cmax}$	=	2.8 MPa

$\tau_v<\tau_{cmax}$. Hence section is Ok

Percentage steel	=p	=	0.81 %
Design shear strength	$=\tau_c$	=	0.58 MPa

$\tau_v<\tau_c$. Hence provide nominal shear reinforcement

Using 2-legged 6ϕ bars, area of stirrup A_{sv}		=	57 mm^2
Spacing of stirrups s	$< 0.87f_yA_{sv}/0.4b$	=	204 mm
	<0.75d	=	282 mm
	<300 mm	=	300 mm

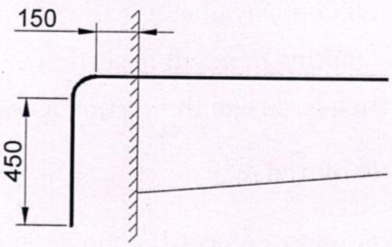
Hence, provide 2-legged 6ϕ stirrups at spacing s=200 mm c/c

4. Check for deflection

Basic l/d ratio for cantilever	=	=	7
Percentage tension steel	=p	=	0.74 %
Service stress	$=f_s = 0.58f_y*(A_{st}\,req/A_{st}\,prov)$	=	198 MPa
Modification factor	$=F_1$	=	1.28
Max allowable l/d ratio	$=F_1$*Basic l/d	=	9.0
Provided l/d	=	=	7.3

Provided l/d < allowable l/d. Hence Ok

5. Check for development length at support



Diameter of bar	=ϕ	=	18 mm
Required development length	$=L_d=f_s\phi/4\tau_{bd}$	=	846 mm
Available development length	=150+8ϕ	=	294 mm

Development length is not satisfied.
Hence, use 6-12ϕ (A_{st}=678 mm^2) instead of 3-18ϕ

Diameter of bar	=ϕ	=	12 mm
Required development length	$=L_d=f_s\phi/4\tau_{bd}$	=	564 mm

Extending the bars by 450 mm from end of bend in to support,

Available development length	=150+8ϕ+(450-4ϕ)	=	648 mm

Hence, Ok

Design a simply supported floor slab for a room 8.0x3.5 m clear in size. The imposed load is 5.0 kN/m^2. Floor finishes is 1.2 kN/m^2. The slab is supported on 250 mm thick masonry walls on all four sides. Use f_{ck}=20 MPa, and f_y=415 MPa.

1. Given data
   a. Geometry of slab

Width, clear	$=l_c$	=	3500 mm
Length	=	=	8000 mm
Support thickness	=	=	250 mm

   b. Loads

Imposed load	=	=	5.0 kN/m^2
Floor finish	=	=	1.2 kN/m^2

   c. Materials

Concrete strength	$=f_{ck}$	=	20 MPa
Steel strength	$=f_y$	=	415 MPa

2. Type of design

Aspect ratio	$=\lambda$=length/width	=	2.29

$\lambda>2$. Hence design as one-way slab

3. Effective span and design forces
   a. Trial depth

For simply supported spans, basic l/d ratio		=	20
Let modification factor	$=F_1$	=	1.2
Trial allowable l/d ratio	$=F_1$*basic l/d	=	24
Trail depth	=d	=	146 mm
Adopt total depth	=D	=	175 mm
Let clear cover	=c	=	20 mm
Let main bar size	$=\phi$	=	10 mm
Available effective depth	$=d=D-c-\phi/2$	=	150 mm

   b. Effective span

Clear span + effective depth	=	=	3650 mm
c/c distance b/w supports	=	=	3750 mm
Hence, effective span	=l=least of two	=	3650 mm

   c. Loads and design forces

Self weight of slab	=25D	=	4.38 kN/m^2
Floor finish	=	=	1.20 kN/m^2
Imposed load	=	=	5.00 kN/m^2
Service load	=w	=	10.58 kN/m^2
Factored load	$=w_u=1.5w$	=	15.86 kN/m^2

Consider b=1m width of slab

Design BM	$=M_u=w_u l^2/8$	=	26.42 kNm/m
Design SF	$=V_u=w_u l_c/2$	=	27.76 kN/m

4. Design for flexure (short bars)

Required depth	$=\sqrt{\dfrac{M_u}{Qf_{ck}b}}$	=	97.5 mm
Hence Ok			
Required steel	$=A_{st}=\dfrac{1}{2}\dfrac{f_{ck}}{f_y}\left[1-\sqrt{1-\dfrac{4.6M_u}{f_{ck}bd^2}}\right]bd$	=	526 mm^2
Required spacing	$=s=1000A_\phi/A_{st}$	=	149 mm
Provide spacing	=s	=	125 mm
	<3d	=	450 mm
	<300 mm		Hence Ok
Provided steel	$=A_{st}=1000A_\phi/s$	=	628 mm^2

Hence provide 10 mm dia bars at 125 mm c/c

Percentage steel	=p	=	0.42 %

>0.12%. Hence Ok

5. Temperature steel (long bars)

Required temperature steel	=0.12% of bD	=	210 mm
Provide 8 mm dia bars at 150 mm c/c giving provided steel		=	335 mm^2

6. Check for shear

Nominal shear stress	$=\tau_v=V_u/bd$	=	0.19 MPa

Bend alternate bars at $l_c/7$ from face of support to resist partial -ve moment

Available tension steel near support		=	314 mm^2
Percentage steel available		=	0.21 %
Design strength of concrete	$=\tau_c$	=	0.33 MPa

$\tau_v<\tau_c$. Hence Ok

7. Check for deflection

Basic l/d ratio for SS slab	=	=	20
Percentage tension steel	=p	=	0.42 %
Service stress	$=f_s = 0.58f_y*(A_{st}\,req/A_{st}\,prov)$	=	202 MPa
Modification factor	$=F_1$	=	1.57
Max allowable l/d ratio	$=F_1$*Basic l/d	=	31.3
Provided l/d	=	=	24.3

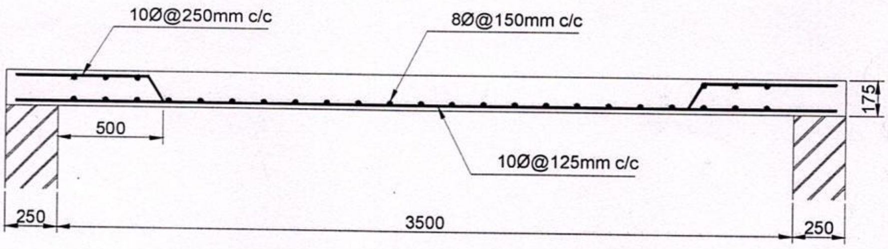
Provided l/d < allowable l/d. Hence Ok

8. Check for development length

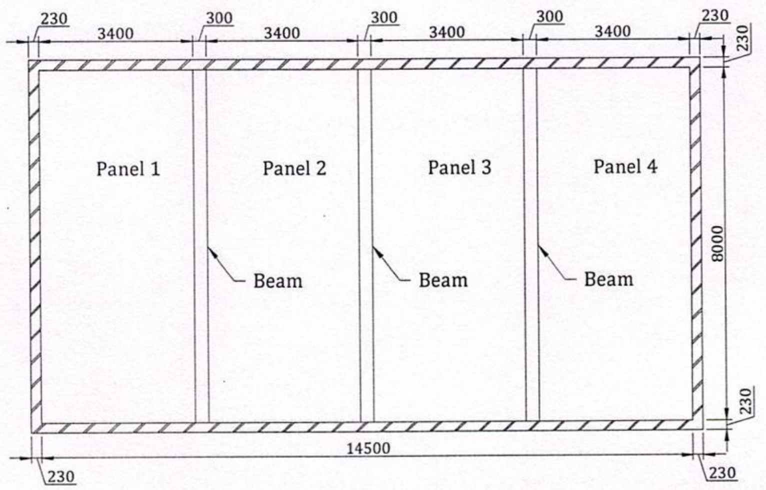
Main bar diameter	$=\phi$	=	10 mm
Allowable bond stress	$=\tau_{bd}$	=	1.92 MPa
Development length	$=L_d=f_s\phi/4\tau_{bd}$	=	470 mm
Anchorage beyond centre of support L_o=		=	50 mm
A_{st} available at support	$=A_{st}$	=	314 mm^2
Depth of NA	$=x_u=0.87f_yA_{st}/0.362f_{ck}b$	=	15.7 mm
Moment of resistance	$=M_1=0.87f_yA_{st}(d-0.416x_u)$	=	16.3 kNm
$1.3M_1/V_u+L_o$	=	=	812 mm

L_d<=$1.3M_1/V_u+L_o$. Hence Ok

The reinforcement details are shown below



The plan of a floor slab, covering an area 8.0x14.5 m (clear size), is shown in figure. The slab rests on 230 mm thick masonry wall all around. The floor is provided with three, 300 mm wide, beams so the floor is divided into four equal slab panels. The loading consists of 4 kN/m^2 live load, and 1.5 kN/m^2 floor finishes in addition to self weight. The materials are M20 concrete and Fe415 steel. Design the exterior slab panel.



1. Given data (exterior panel)
   a. Geometry of slab

Width, clear	$=l_{xc}$	=	3400 mm
Length	$=l_{yc}$	=	8500 mm
Support thickness, wall	=	=	230 mm
Support thickness, beam	=	=	300 mm

   b. Loads

Imposed load	=	=	4.0 kN/m^2
Floor finish	=	=	1.5 kN/m^2

   c. Materials

Concrete strength	$=f_{ck}$	=	20 MPa
Steel strength	$=f_y$	=	415 MPa

2. Type of design

Aspect ratio	$=\lambda$=length/width	=	2.50

   $\lambda>2$. Hence design as one-way slab

3. Effective span and design forces
   a. Trial depth

Let avg l/d ratio (one end continuous, other simply supported)		=	23
Let modification factor	$=F_1$	=	1.2
Trial allowable l/d ratio	$=F_1$*basic l/d	=	27.6
Trail depth	=d	=	123 mm
Adopt total depth	=D	=	150 mm
Let clear cover	=c	=	20 mm

Let main bar size	$=\phi$	=	10 mm
Available effective depth	$=d=D-c-\phi/2$	=	125 mm
b. Effective span l_x			
1/12 of clear span	=	=	283 mm
Hence, beam width is greater than 1/12 of clear span			
Hence, effective span	=clear span + wall thickness/2	=	3515 mm
	=clear span + effective depth/2	=	3463 mm
Effective span	$=l_x$=Least of above two	=	3463 mm
c. Service loads			
Self weight of slab	=25D	=	3.75 kN/m^2
Floor finish	=	=	1.50 kN/m^2
Total dead load	$=w_D$	=	5.25 kN/m^2
Imposed load	$=w_L$	=	4.00 kN/m^2
d. Design moments			
Service moments			
Mid span moment (+ve)	$=M=(w_D/12+w_L/10)l_x^2$	=	10.0 kNm/m
Interior support moment (-ve)	$=M=(w_D/10+w_L/9)l_x^2$	=	11.6 kNm/m
Design moments			
Mid span moment (+ve)	$=M_u$	=	15.1 kNm/m
Interior support moment (-ve)	$=M_u$	=	17.4 kNm/m
4. Design for flexure			
Required depth	=	=	79.2 mm
Available depth	=d	=	125 mm
			Hence Ok
Required steel at mid span	$=A_{st}$	=	355 mm^2
Required steel at support	$=A_{st}$	=	415 mm^2
Main bar diameter	$=\phi$	=	10 mm
Required spacing	$=s=1000A\phi/A_{st}$	=	189 mm
	<=3d	=	375 mm
	<=300 mm	=	300 mm
Provided spacing at both mid span (bottom) and support (top)		=	175 mm
Provided steel	$=A_{st}$	=	449 mm^2
Percentage steel	=p	=	0.36 %
Distribution steel	=0.12% of bD	=	180 mm^2
Bar size	$=\phi$	=	8 mm
Required spacing	=	=	279 mm
Provided spacing	=s	=	250 mm

5. Check for deflection

Avg basic l/d ratio for exterior s =		=	23
Percentage tension steel	=p	=	0.36 %
Service stress	$=f_s = 0.58f_y*(A_{st}\ req/A_{st}\ prov)$	=	190 MPa
Modification factor	$=F_1$	=	1.79
Max allowable l/d ratio	$=F_1$*Basic l/d	=	41.1
Provided l/d	=	=	27.7

Provided l/d < allowable l/d. Hence Ok

6. Check for development length (at exterior simple support)

Main bar diameter	$=\phi$	=	10 mm
Allowable bond stress	$=\tau_{bd}$	=	1.92 MPa
Development length	$=L_d=f_s\phi/4\tau_{bd}$	=	470 mm
Anchorage beyond centre of support L_o=		=	50 mm
A_{st} available at support	$=A_{st}$	=	224 mm^2
Depth of NA	$=x_u=0.87f_yA_{st}/0.362f_{ck}b$	=	11.2 mm
Moment of resistance	$=M_1=0.87f_yA_{st}(d-0.416x_u)$	=	9.8 kNm
Shear force	$=Vu=1.5*(0.4w_D+0.45w_L)l_x$	=	20.3 kN
$1.3M_1/V_u+L_o$	=	=	676 mm

L_d<=$1.3M_1/V_u+L_o$. Hence Ok

Design the slab for a room of clear size 5.5x4.0 m. The imposed load is 5 kN/m^2, and floor finishes is 1.2 kN/m^2. The edges are simply supported on four edges on 250 mm thick masonry walls. The corners are held down from lifting up. Use M20 concrete and Fe415 steel.

1. Given data
   a. Geometry of slab

Width, clear	$=l_{xc}$	=	4000	mm
Length	$=l_{yc}$	=	5500	mm
Support thickness	=	=	250	mm

   b. Loads

Imposed load	=	=	5.0	kN/m^2
Floor finish	=	=	1.2	kN/m^2

   c. Materials

Concrete strength	$=f_{ck}$	=	20	MPa
Steel strength	$=f_y$	=	415	MPa

2. Type of design

Aspect ratio	$=\lambda$=length/width	=	1.38	

   $\lambda<2$. Hence design as two-way slab

3. Effective span and design forces
   a. Trial depth

For simply supported spans, basic l/d ratio		=	20	
Let modification factor	$=F_1$	=	1.2	
Trial allowable l/d ratio	$=F_1$*basic l/d	=	24	
Trail depth	=d	=	167	mm
Adopt total depth	=D	=	175	mm
Let clear cover	=c	=	20	mm
Let main bar size	$=\phi$	=	10	mm
Available effective depth	$=d=D-c-\phi/2$	=	150	mm

   b. Effective span l_x

Clear span + effective depth	=	=	4150	mm
c/c distance b/w supports	=	=	4250	mm
Hence, effective span	$=l_x$=least of two	=	4150	mm

   c. Effective span l_y

Clear span + effective depth	=	=	5650	mm
c/c distance b/w supports	=	=	5750	mm
Hence, effective span	$=l_x$=least of two	=	5650	mm
Aspect ratio	$=l_y/l_x$	=	1.36	

d. Loads and design forces

Self weight of slab	=25D	= 4.38 kN/m^2
Floor finish	=	= 1.20 kN/m^2
Imposed load	=	= 5.00 kN/m^2
Service load	=w	= 10.58 kN/m^2
Factored load	$=w_u=1.5w$	= 15.86 kN/m^2
Edge condition	=Four edges discontinuous, with provision for torsion	
(i) Short span (middle strip - mid span)		
+ve moment coefficient	$=\alpha_x$	= 0.083
+ve bending moment	$=M_x=\alpha_x w_u l_x^2$	= 22.67 kNm/m
(ii) Long span (middle strip - mid span)		
+ve moment coefficient	$=\alpha_y$	= 0.056
+ve bending moment	$=M_y=\alpha_y w_u l_x^2$	= 15.30 kNm/m

4. Design for flexure

a. Short span

Required depth	=	= 90.3 mm
Available depth	=d	= 150 mm
		Hence Ok
Required steel	$=A_{stx}$	= 446 mm^2
Main bar size	$=\phi$	= 10 mm
Required spacing	$=s=1000A\phi/A_{st}$	= 176 mm
	<=3d	= 450 mm
	<=300mm	= 300 mm
Providing spacing of	=s	= 175 mm
Provided steel	$=A_{stx}$	= 449 mm^2
Percentage steel	=p	= 0.30 %
		>0.12% Hence Ok

b. Long span

Required effective depth	=	= 74.2 mm
Available effective depth	=d	= 140 mm
		Hence Ok
Required steel	$=A_{sty}$	= 318 mm^2
Main bar size	$=\phi$	= 8 mm
Required spacing	$=s=1000A\phi/A_{st}$	= 158 mm
	<=3d	= 420 mm
	<=300mm	= 300 mm
Provide spacing of	=s	= 150 mm
Provided steel	$=A_{sty}$	= 335 mm^2
Percentage steel	=p	= 0.24 %
		>0.12% Hence Ok

5. check for shear (at short edge)

Design shear force	$=V_u=w_u l_{xc}/2$	=	31.7 kN
Effective depth	=d	=	140 mm
Nominal shear stress	$=\tau_v=V_u/bd$	=	0.23 MPa
Taking alternate bars to top at supports,			
Percentage steel available	=p	=	0.12 %
Design shear stress	$=\tau_c$	=	0.26 MPa
			$>\tau_v$ Hence Ok

6. Check for deflection

Basic l/d ratio for SS slab	=	=	20
Percentage tension steel	=p	=	0.30 %
Service stress	$=f_s = 0.58f_y*(A_{st}\ req/A_{st}\ prov)$	=	239 MPa
Modification factor	$=F_1$	=	1.50
Max allowable l/d ratio	$=F_1$*Basic l/d	=	29.9
Provided l/d	=	=	26.7

Provided l/d < allowable l/d. Hence Ok

7. Check for development length (short span bars)

Main bar diameter	$=\phi$	=	10 mm
Allowable bond stress	$=\tau_{bd}$	=	1.92 MPa
Development length	$=L_d=f_s\phi/4\tau_{bd}$	=	470 mm
Anchorage beyond centre of support L_o=		=	50 mm
A_{st} available at support	$=A_{st}$	=	224 mm^2
Depth of NA	$=x_u=0.87f_yA_{st}/0.362f_{ck}b$	=	11.2 mm
Moment of resistance	$=M_1=0.87f_yA_{st}(d-0.416x_u)$	=	11.8 kNm
$1.3M_1/V_u+L_o$	=	=	533 mm

$L_d<=1.3M_1/V_u+L_o$. Hence Ok

8. Reinforcement in edge strips

Minimum reinforcement	=0.12% of bD	=	210 mm^2
Bar size	$=\phi$	=	10 mm
Required spaceing	=s	=	374 mm
Provide spacing of		=	300 mm

9. Corner reinforcement

Area of each layer required	=75% of max mid span steel	=	335 mm^2
Bar size	$=\phi$	=	8 mm
Number of bars	=	=	7

Length of corner reinforcement = 1/5 of span length

Hence provide 7 no of 8 mm dia bars in a length of 800 mm in short span
1100 mm in long span

A 3.5 m long column is effectively held in position at both ends and restrained against rotation at one end. Its diameter is 400 mm. The factored axial load on column is 1500 kN. Find the reinforcement. Use M20 concrete and Fe415 steel

1. Given data
   a. Section properties

Length	$=l$	=	3500 mm
Diameter	$=D$	=	400 mm
End condition	=held in position at both ends & restrained against rotation at one end		

   b. Material properties

Concrete strength	$=f_{ck}$	=	20 MPa
Steel strength	$=f_y$	=	415 MPa

   c. Design forces

Factored axial force	$=P_u$	=	1500 kN

2. Design
   a. Slenderness ratio

Effective length	$=l_e=0.8*l$	=	2800 mm
Slenderness ratio	$=\lambda=l_e/D$	=	7

   $\lambda<12$. Hence design the column as short column

   b. Eccentricity

Minimum eccentricity	$=e=l_e/500+D/30$	=	18.9 mm
Compare this with	$=0.05D$	=	20 mm

   $e<0.05D$. Hence, design column as axially loaded

   c. Longitudinal steel

   Using $P_u=0.4f_{ck}A_c+0.67f_yA_{sc}$

   with $A_c=A_g-A_{sc}$

   $A_g=\pi D^2/4$

   and solving $A_{sc}=3100\ mm^2$

   Minimum steel @0.8% of A_g $=1000\ mm^2$ Hence Ok

   Provide 10 nos of 20ϕ giving $A_{sc}=3140\ mm^2$

   d. Lateral ties

   Diameter ϕ >= 6 mm

   >= Main bar dia/4 = 5 mm

   Adopt 6 mm dia ties

   Pitch <= least lateral dimension = 400 mm

   <= 16 times main bar dia = 320 mm

   <= 300 mm

   Provide 6 mm dia ties at 300 mm c/c

Design a circular column to carry an axial load of 1500 kN using helical reinforcement.
Use M25 concrete and Fe415 steel.

1. Given data

Service axial load	=P	=	1500 kN
Concrete strength	$=f_{ck}$	=	25 MPa
Steel strength	$=f_y$	=	415 MPa

2. Design for longitudinal steel

Factored axial load	P_u	=	2250 kN
Enhanced axial load capacity	$P_u = 1.05(0.4f_{ck}A_c+0.67f_yA_{sc})$	=	2362.5 kN
Assuming 0.8% steel	$P_u = 1.05(0.4f_{ck}(A_g-0.008A_g)+0.67f_y(0.008A_g))$		
Solving	$A_g=$	=	185271 mm^2
Required diameter	D=	=	486 mm
Required steel	$A_{st}=$	=	1482 mm^2
Provide an overall diameter	D=	=	500 mm
Provide 10 - 14ϕ bars giving	$A_{st}=$	=	1539 mm^2

3. Helical reinforcement

a. Diameter of tie ϕ $\quad$ >= 6 mm

>= Main bar dia/4 = 4 mm

Adopt diameter tie $\quad \phi=$ $\quad$ = 6 mm

b. Pitch $\quad$ =p

Clear cover to main steel	c=	=	40 mm
Diameter of core	$D_c=D-2(c-\phi)$	=	432 mm
Ratio	$A_g/A_c=(D/D_c)^2$	=	1.34
Factor	$=0.36\left(\frac{A_g}{A_c}-1\right)\frac{f_{ck}}{f_y}$	=	0.0074
C/s area of spiral	A_{sp}	=	28.3 mm^2

Ratio ρ_s $\quad$ =Volume of spiral in one pitch/Volume of core in one pitch

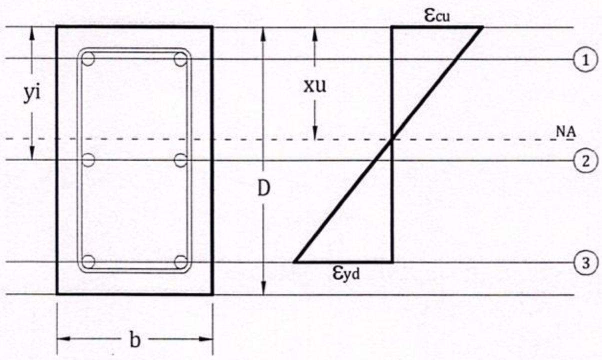
$$=4\frac{A_{sp}(D_c-\phi)}{D_c^2 p}$$

$$\rho_s >= 0.36\left(\frac{A_g}{A_c}-1\right)\frac{f_{ck}}{f_y}$$

Solving	p<=	35 mm
Also	p<=	75 mm
	<= $D_c/6$ =	72 mm
	>	25 mm
	> 3ϕ	18 mm

Provide 6 mm helical tie at 25 mm pitch

A 300x500 mm column is reinforced with 6-25ϕ bars. Find the design strength components Pu and Mu corresponding to the condition of balanced failure. Use M25 concrete and Fe415 steel. Consider the loading eccentricity with respect to major axis. Assume 40 mm clear cover to ties. Diameter of ties is 8 mm.



1. Given data
   a. Section properties

Width	=b	=	300 mm
Depth	=D	=	500 mm
Clear cover	=c	=	40 mm
Main bar size	=ϕ	=	25 mm
Size of tie	=ϕ_T	=	8 mm

   b. Material properties

Concrete strength	=f_{ck}	=	25 MPa
Steel strength	=f_y	=	415 MPa

2. Analysis
   a. Depth of neutral axis

   For balanced failure condition:

Strain in most compressive conc fibre	=ε_{cu}	=	0.0035
Strain in most tensile steel layer	=ε_{st}=0.002+0.87f_y/E_s	=	0.0038
Depth to most tensile steel layer	=d=D-c-ϕ_T-ϕ/2	=	439.5 mm
Depth of neutral axis	=x_u=d(ε_{cu}/(ε_{cu}+ε_{st}))	=	210.6 mm

   b. Force and moment due to concrete (moment about centroidal axis)

Compressive force in concrete	=C_c=0.362f_{ck}bx_u	=	571.7 kN
Moment of C_c about centroidal axis	=M_c=C_c(0.5D-0.416x_u)	=	92.8 kNm

c. Force and moment due to steel (moment about centroidal axis)

Let y_i=depth to steel layer from most compressed fibre. Then at layer i

Strain in steel $\varepsilon_{si}=0.0035(1-y_i/x_u)$; is +ve if compression

Stress in steel f_{si} is read from design stress-strain curve

Stress in concrete $f_{ci} = 0.447 f_{ck}\left[2\left(\frac{\varepsilon_i}{0.002}\right)-\left(\frac{\varepsilon_i}{0.002}\right)^2\right]$ for $\varepsilon_{si}>0$ else $f_{ci}=0$

Force in steel $C_{si}=(f_{si}-f_{ci})A_{si}$

Moment of f_{si} $M_{si}=f_{si}(0.5D-y_i)$

Design axial load $P_u=C_c+\Sigma C_{si}$

Design moment $M_u=M_c+\Sigma M_{si}$

The calculations are given in the following table

Layer	y_i mm	A_{si} mm^2	ε_{si}	f_{si} MPa	f_{ci} MPa	C_{si} kN	M_{si} kNm
1	60.5	981.7	0.00249	345.0	10.5	328.4	62.2
2	250.0	981.7	-0.00066	-131.4	0.0	-129.0	0.0
3	439.5	981.7	-0.00381	-360.9	0.0	-354.3	67.1
					Sum	-154.9	129.4

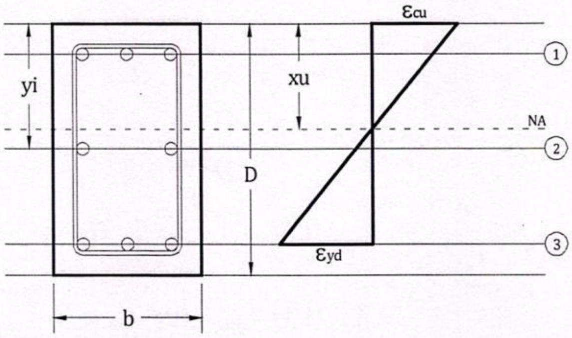
d. Balanced failure design forces

Axial load capacity $P_u=C_c+\Sigma C_{si}$ = 416.7 kN

Moment capacity $M_u=M_c+\Sigma M_{si}$ = 222.2 kNm

Balanced failure eccentricity $e_b=M_u/P_u$ = 533.2 mm

A, 4 m long, 300x500 mm column is subjected to a factored load of 1400 kN and factored moment of 280 kNm with respect to major axis. Design the longitudinal .reinforcement. Use M25 concrete and Fe415 steel. Assume effective length coefficient as 0.8.



1. Given data
   a. Section properties

Width	=b	=	300 mm
Depth	=D	=	500 mm
Length	=l	=	4000 mm
Let effective cover	=c'	=	50 mm

   b. Material properties

Concrete strength	$=f_{ck}$	=	25 MPa
Steel strength	$=f_y$	=	415 MPa

   c. Factored forces

Factored axial load	$=P_u$	=	1400 kN
Factored moment	$=M_{u1}$	=	280 kNm

2. Design forces

Effective length	$=l_e$	=	3200 mm
Slenderness ratio	$=\lambda$	=	6.4 <12

Hence, consider minimum eccentricity and neglect slenderness effects

Minimum eccentricity	$=e_{min}=l_e/500+D/30>=20$ mm	=	23.1 mm
Moment due to e_{min}	$=M_{umin}$	=	32.3 kNm
Hence, design moment	$=M_u=Max(M_{u1}, M_{umin})$	=	280.0 kNm
Arrangement of steel	=equally distributed on four faces		
No of bars	=8		

3. Design procedure
   a. Assume a suitable value of A_{sc} and x_u
   b. Estimate force capacity P_u' and M_u'
   c. If $P_u=P_u$' goto step (e) else revise x_u & goto step (b)
   d. If $M_u=M_u$' goto step (f)
   e. If Mu>Mu' increase A_{sc} else decrease A_{sc} & goto step (b)
   f. Required A_{sc} is obtained

4. Formulae for estimating P_u' and M_u' (in 3(b))

Concrete force and moment =

$$\text{Total compressive force } C_c = af_{ck}bD$$

$$\text{Moment of } C_c \text{ about centroidal axis } M_c = C_c\left(\frac{D}{2} - \bar{x}\right)$$

$$\text{where } a = 0.362\frac{x_u}{D} \quad \text{for } x_u \le D$$

$$= 0.447\left(1 - \frac{4g}{21}\right) \quad \text{for } x_u > D$$

$$\bar{x} = 0.416x_u \quad \text{for } x_u \le D$$

$$= \frac{\left(0.5 - \frac{8g}{49}\right)}{\left(1 - \frac{4g}{21}\right)}D \quad \text{for } x_u > D$$

$$\text{and } g = \frac{16}{\left(\frac{7x_u}{D} - 3\right)^2}$$

Steel force and moment =

$$\text{Total compressive force } C_s = \sum (f_{si} - f_{ci})A_{si}$$

$$\text{Moment of } C_s \text{ about centroidal axis } M_s = \sum (f_{si} - f_{ci})A_{si}\left(\frac{D}{2} - y_i\right)$$

$$\text{where } f_{ci} = 0 \quad \text{for } \varepsilon_{si} \le 0$$

$$= 0.447f_{ck} \quad \text{for } \varepsilon_{si} \ge 0.002$$

$$= 0.447f_{ck}\left[2\left(\frac{\varepsilon_{si}}{0.002}\right) - \left(\frac{\varepsilon_{si}}{0.002}\right)^2\right] \quad \text{otherwise}$$

$$\text{and } \varepsilon_{si} = 0.0035\left(1 - \frac{y_i}{x_u}\right) \quad \text{for } x_u \le D$$

$$= 0.002\left(1 + \frac{\frac{3}{7}D - y_i}{x_u - \frac{3}{7}D}\right) \quad \text{for } x_u > D$$

5. Calculation (final iteration)

Assumed percentage steel	=p	=	2.96 %
Area of steel	$=A_{sc}$	=	4440 mm^2
Assumed neutral axis depth	$=x_u$	=	350 mm

Layer	y_i mm	A_{si} mm^2	ε_{si}	f_{si} MPa	f_{ci} MPa	C_{si} kN	M_{si} kNm
1	50.0	1665.0	0.00300	353.9	11.2	570.6	114.1
2	250.0	1110.0	0.00100	200.5	8.4	213.2	0.0
3	450.0	1665.0	-0.00100	-200.5	0.0	-333.8	66.8
					Sum	450.1	180.9

Compressive force in concrete	$=C_c$	=	950.3 kN
Moment of C_c about centroidal axis	$=M_c$	=	99.2 kNm
Axial load capacity	$P_u'=C_c+\Sigma C_{si}$	=	1400.3 kN
Moment capacity	$M_u'=M_c+\Sigma M_{si}$	=	280.1 kNm

Hence calculated P_u'=given P_u and calculated M_u'=given M_u

Required steel	$=A_{sc}$	=	4440 mm^2
Required diameter of each bar	$=\phi$	=	26.6 mm
Hence provide 8-28ϕ bars giving	$=A_{sc}$	=	4926 mm^2
Percentage steel	=p	=	3.3 %

>0.8%

<4% Hence Ok

Design a square footing to carry a column service load of 1000 kN from a 400x400 mm column. The bearing capacity soil is 100 kN/m^2. Use M20 concrete and Fe415 steel.

1. Given data
   a. Section properties of column

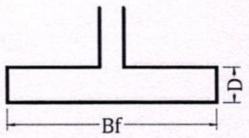
Width	$=b$	=	400 mm
Depth	$=h$	=	400 mm

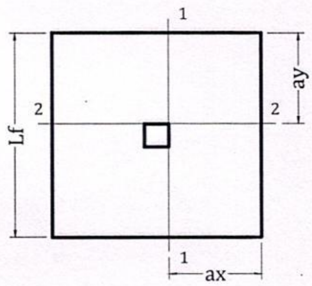
   b. Material properties

Concrete strength	$=f_{ck}$	=	20 MPa
Steel strength	$=f_y$	=	415 MPa

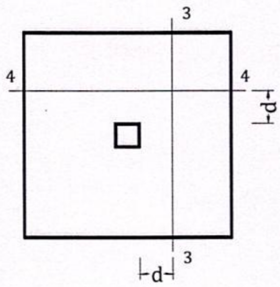
   c. Design forces

Service axial force	$=P$	=	1000 kN
Safe bearing capacity	$=q_{safe}$	=	100 kN/m^2

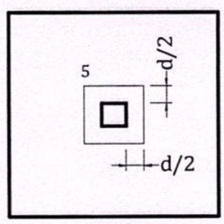




CRITICAL SECTIONS
FOR MOMENT



CRITICAL SECTIONS
FOR ONE-WAY SHEAR



CRITICAL SECTION
FOR TWO-WAY SHEAR

2. Footing size

Service load on footing	$=P$	=	1000 kN
Self weight of footing	=10% of P	=	100 kN
Total weight	=	=	1100 kN
Required footing area	=	=	11 m^2
Provide footing width	$=B_f$	=	3400 mm
footing length	$=L_f$	=	3400 mm
Provided footing area	$=A_f$	=	11.56 m^2
Hence Ok			
Projection	$=a_x=(B_f-b)/2$	=	1500 mm
	$=a_y=(L_f-h)/2$	=	1500 mm

3. Design for flexure

Net earth pressure on footing	$=q=1.5P/A_f$	=	129.8 kN/m^2
Critical section for bending moment is face of column			
For section 1-1			
Bending moment	$=M_{u1}=qL_fa_x^2/2$	=	496.3 kNm
Required footing depth	$=\sqrt{(M_{u1}/Qf_{ck}L_f)}$	=	229 mm
Adopt total depth	=D	=	600 mm
Let clear cover	=c	=	50 mm
Let bar diameter	$=\phi$	=	10 mm
Available effective depth	$=d=D-c-\phi/2$	=	545 mm
Required steel	=	=	2599 mm^2
Percentage steel	=	=	0.14 %
			>0.12% Hence Ok
Required spacing	=	=	103 mm
Provoded spacing	$=s_1$	=	100 mm
Provided steel	$=A_{st1}$	=	2670 mm
Provided percentage steel	=p	=	0.14 %

Provide this steel in both directions as projection is same in both directions

4. Check for one-way shear

Distance of critical from face of column is d=545 mm

For section 3-3			
Shear force	$=V_{u3}=qL_f(a_x-d)$	=	421 kN
Nominal shear stress	$=\tau_v=V_{u3}/L_fd$	=	0.23 MPa
Design shear strength	$=\tau_c$	=	0.28 MPa
			$>\tau_v$ Hence Ok

Check will satisfy for section 4-4 also

5. Check for two-way shear

Distance of critical section from face of column is d/2=272.5 mm

Width of critical section	$=b_4=b+d$	=	945 mm
Height of critical section	$=h_4=h+d$	=	945 mm
Shear resisted by the section	$=V_{u4}=q(A_f-b_4h_4)$	=	1384 kN
Area of the section	$A_4=2(b_4+h_4)d$	=	2.06 m^2
Nominal shear stress	$=\tau_v=V_{u4}/A_4$	=	0.67 MPa
Factor	$=k_s=0.5+B_f/L_f<=1$	=	1.0
Design shear strength	$=\tau_c=k_s*0.25\sqrt{f_{ck}}$	=	1.12 MPa
			$>\tau_v$ Hence Ok

6. Check for bearing pressure

Area of column	$=A_c=bh$	=	160000 mm^2
Nominal bearing pressure	$=1.5P/A_c$	=	9.4 MPa
Allowable bearing pressure	$=0.45f_{ck}$	=	9.0 MPa

This is less than allowable pressure. Hence provide dowels to carry extra force

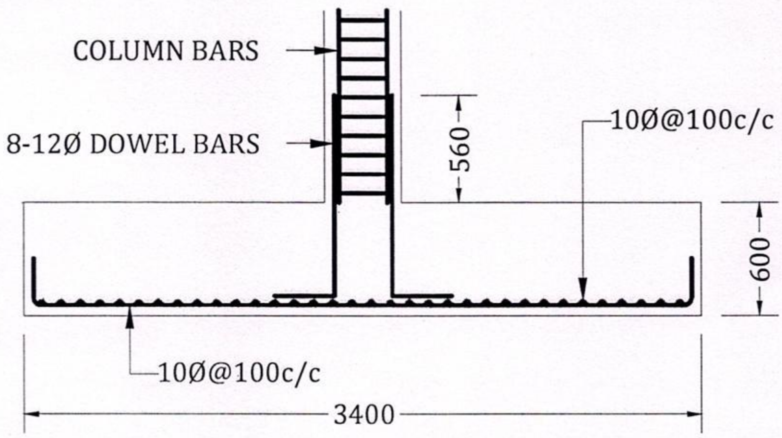
Required dowel area	=Ac*(9.4-9)/0.67fy	=	216 mm^2
Minimum dowel area	=0.5% of column area	=	800 mm^2
Provided dowel area	=	=	800 mm^2
Dowel bar size	=	=	12 mm
No of bars required	=	=	8

Provide 8 nos of 12 mm dowel bars

7. Check for development length

Main bar size	$=\phi$	=	10 mm
Required anchorage length	$=L_d=f_s\phi/4\tau_{bd}$	=	470 mm
Available anchorage length	$=a_x-c$	=	1450 mm

Hence Ok. However provide standard bend at the end.



REINFORCEMENT DETAILS

Design a footing for a column of size 400x400 mm which carries a load of 800 kN. The SBC of soil is 200 kN/m^2. One side of footing is to be restricted to 1.5 m. Use M20 concrete and Fe415 steel.

1. Given data
   a. Section properties of column

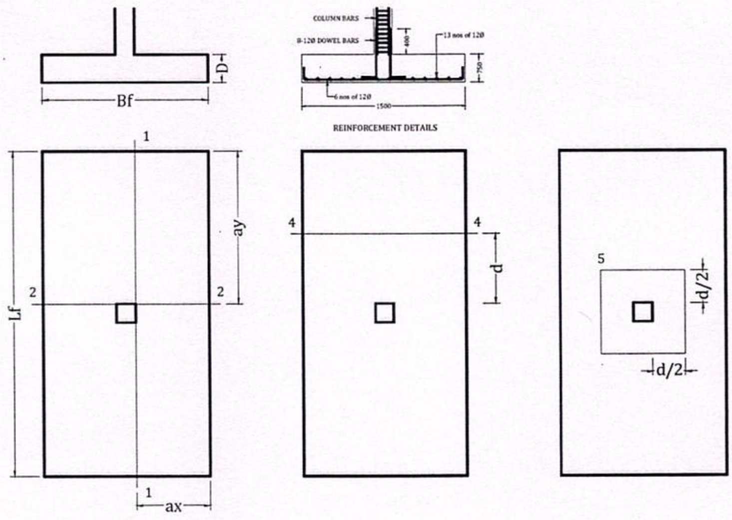
Width	=b	=	400 mm
Depth	=h	=	400 mm

   b. Material properties

Concrete strength	=f_{ck}	=	20 MPa
Steel strength	=f_y	=	415 MPa

   c. Design forces

Service axial force	=P	=	800 kN
Safe bearing capacity	=q_{safe}	=	200 kN/m^2



CRITICAL SECTIONS FOR MOMENT — CRITICAL SECTIONS FOR ONE-WAY SHEAR — CRITICAL SECTION FOR TWO-WAY SHEAR

2. Footing size

Service load on footing	=P	=	800 kN
Self weight of footing	=10% of P	=	80 kN
Total weight	=	=	880 kN
Required footing area	=	=	4.4 m^2
Provide footing width	=B_f	=	1500 mm
footing length	=L_f	=	3000 mm
Provided footing area	=A_f	=	4.5 m^2
Hence Ok			
Projection	=a_x=$(B_f$-b)/2	=	550 mm
	=a_y=$(L_f$-h)/2	=	1300 mm

3. Design for flexure

Net earth pressure on footing	$=q=1.5P/A_f$	=	266.7 kN/m^2
Adopt total depth	$=D$	=	750 mm
Let clear cover	$=c$	=	50 mm
Let bar diameter	$=\phi$	=	12 mm

a. Long bars - critical section 2-2

Critical section for bending moment is face of column

For section 2-2 (Let short bars be placed above long bars)

Available effective depth	$=d=D-c-\phi/2$	=	694 mm
Bending moment	$=M_{u2}=qB_f a_y^2/2$	=	338.0 kNm
Required footing depth	$=\sqrt{(M_{u1}/Qf_{ck}L_f)}$	=	285 mm
			Hence Ok
Required steel	=	=	1388 mm^2
Provided no of bars	=	=	13
Provided steel	$=A_{st2}$	=	1470 mm^2
			Hence Ok
Percentage steel	$=p_{t2}$	=	0.14 %

b. Short bars - critical section 1-1

Available effective depth	$=d=D-c-1.5\phi$	=	682 mm
Bending moment	$=M_{u1}=qL_f a_x^2/2$	=	121.0 kNm
Required steel	=	=	494 mm^2
Provided no of bars	=	=	6
Provided steel	$=A_{st1}$	=	679 mm^2

4. Check for one-way shear

Distance of critical from face of column is d=694 mm

For section 4-4

Shear force	$=V_{u4}=qB_f(a_y-d)$	=	242 kN
Nominal shear stress	$=\tau_v=V_{u3}/L_f d$	=	0.23 MPa
Percentage steel	=	=	0.14 %
Design shear strength	$=\tau_c$	=	0.28 MPa
			$>\tau_v$ Hence Ok

5. Check for two-way shear

Distance of critical section from face of column is d/2=347 mm

Width of critical section	$=b_4=b+d$	=	1094 mm
Height of critical section	$=h_4=h+d$	=	1094 mm
Shear resisted by the section	$=V_{u4}=q(A_f-b_4h_4)$	=	881 kN
Area of the section	$A_4=2(b_4+h_4)d$	=	3.04 m^2
Nominal shear stress	$=\tau_v=V_{u4}/A_4$	=	0.29 MPa
Factor	$=k_s=0.5+B_f/L_f<=1$	=	1.0

Design shear strength	$=\tau_c=k_s*0.25\sqrt{f_{ck}}$	=	1.12 MPa
			$>\tau_v$ Hence Ok

6. Check for bearing pressure

Area of column	$=A_c=bh$	=	160000 mm^2
Nominal bearing pressure	$=1.5P/A_c$	=	7.5 MPa
Allowable bearing pressure	$=0.45f_{ck}$	=	9.0 MPa

Hence Ok. However provide minimum dowel steel.

Minimum dowel area	=0.5% of column area	=	800 mm^2
Dowel bar size	=	=	12 mm
No of bars required	=	=	8

Provide 8 nos of 12 mm dowel bars

7. Check for development length

Main bar size	$=\phi$	=	12 mm
Required anchorage length	$=L_d=f_s\phi/4\tau_{bd}$	=	564 mm
Available anchorage length	$=a_x\text{-}c$	=	500 mm

Hence, provide standard bend at the end.

A rectangular cantilever beam of span 4 m is 350x650 mm in cross section. Bending moment at the support due to uniformly distributed service loads is 150 kNm, out of which 50% moment is due to permanent loads. Check the beam for deflection. It carries 3-25ϕ bars in tension at an effective cover of 50 mm. Use f_{ck}=20MPa, and f_y=415 MPa.

1. Given data

   a. Properties

Width	=b	=	350 mm
Depth	=D	=	650 mm
Effective cover	=d'	=	50 mm
Hence, effective depth	=d = D-d'	=	600 mm
Area of tension steel	=A_{st} = 3-25ϕ	=	1473 mm^2

   b. Material properties

Concrete strength	=f_{ck}	=	20 MPa
Steel strength	=f_y	=	415 MPa

2. Total deflection is given by $\Delta = \Delta_e + \Delta_s + \Delta_c$

   where Δ_e = short term elastic deflection

   Δ_s = long term shrinkage deflection

   Δ_c = long term creep deflection due to permanent loads

3. Short term elastic deflection

   Elastic deflection at end of cantilever is =$\Delta_e = ML^2/4E_cI_{eff}$

Service moment (at support)	=M	=	150 kNm
Effective span	=L	=	4000 mm
Short term elastic modulus of concrete	=$E_c = 5000(f_{ck})^{1/2}$	=	22361 MPa
Elastic modulus of steel	=E_s	=	200000 MPa
Modular ratio	=$m = E_s/E_c$	=	8.9

   a. Calculation of M_{cr} (neglecting reinforcement)

Modulus of rupture	=$f_{cr} = 0.7(f_{ck})^{1/2}$	=	3.13 MPa
MI of gross section	=$I_{gr} = bD^3/12$	=	8.01E+9 mm^4
Distance to extreme tension fibre	=$y_t = D/2$	=	325 mm
Cracking moment	=$M_{cr} = f_{cr}I_{gr}/y_t$	=	77.2 kNm

   b. Calculation of I_{cr}

   Let x be the depth of NA from most compression fibre

   Equating the first moments of compression and tension (transformed) areas about NA,

we have $bx^2/2 = mA_{st}(d-x)$, and solving,	x=	=	178.2 mm
Lever arm	=z = d-x/3	=	540.6 mm
MI of cracked section	=$I_{cr} = bx^3/3 + mA_{st}(d-x)^2$	=	3.00E+9 mm^4

c. Calculation of I_{eff}

Effective moment of inertia	$= I_{eff} = \dfrac{I_{cr}}{1.2 - \dfrac{M_{cr}}{M}\dfrac{z}{d}\left(1-\dfrac{x}{d}\right)\dfrac{b_w}{b}}$	= 3.44E+9 mm^4

$I_{cr}<I_{eff}<I_g$. Hence Ok

d. Elastic deflection	$=\Delta_e$	= 7.81 mm

4. Long term shrinkage deflection

Shrinkage deflection	$=\Delta_s = k_3\Psi_{cs}L^2$	
Shrinkage curvature	$=\Psi_{cs} = k_4\varepsilon_{cs}/D$	
Ultimate shrinkage strain	$=\varepsilon_{cs}$	= 0.0003
Factor	$k_4 = 0.72\dfrac{P_t - P_c}{\sqrt{P_t}} \le 1.0$ for $0.25 \le P_t - P_c < 1.0$ $= 0.65\dfrac{P_t - P_c}{\sqrt{P_t}} \le 1.0$ for $P_t - P_c \ge 1.0$	
For cantilevers, k_3	=	= 0.5
Percentage tension steel	$=P_t = 100A_{st}/bd$	= 0.70 %
Percentage compression steel	$=P_c = 100A_{sc}/bd$	= 0.00 %
Factor, k_4	=	= 0.60
Shrinkage curvature	$=\Psi_{cs} = k_4\varepsilon_{cs}/D$	= 2.78E-7
Shrinkage deflection	$=\Delta_s = k_3\Psi_{cs}L^2$	= 2.23 mm

5. Long term creep deflection

Creep deflection $\Delta_c = \Delta_{ci} - \Delta_{cs}$

where Δ_{ci} = initial + creep deflection due to permanent loads using E_{ce}

Δ_{cs} = short term deflection due to permanent loads using E_c

Creep coefficient, for 28-days loading	$=\theta$	= 1.6
Effective modulus of elasticity	$=E_{ce} = E_c/(1+\theta)$	= 8600 MPa

a. Calculation of I_{cr}, and I_{eff}

Modular ratio	$=m = E_s/E_{ce}$	= 23.3
Solving $bx^2/2 = mA_{st}(d-x)$, depth of NA	$=x$	= 258.5 mm
Lever arm	$=z = d-x/3$	= 513.8 mm
MI of cracked section	$=I_{cr} = bx^3/3 + mA_{st}(d-x)^2$	= 6.01E+9 mm^4
Effective moment of inertia	$= I_{eff} = \dfrac{I_{cr}}{1.2 - \dfrac{M_{cr}}{M}\dfrac{z}{d}\left(1-\dfrac{x}{d}\right)\dfrac{b_w}{b}}$	= 6.33E+9 mm^4
BM due to permanent loads	$=M_1$	= 75 kNm
b. Deflction Δ_{ci}	$=M_1L^2/4E_{ce}I_{eff}$	= 5.51 mm

c. For Δ_{cs}, we use I_{eff} computed in step 3.c

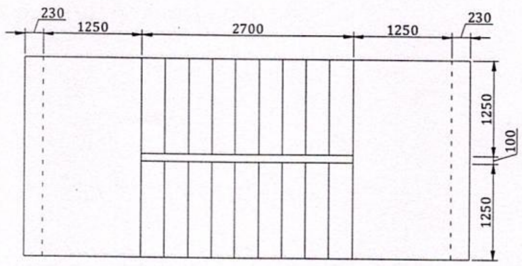
Deflction Δ_{cs}	$=M_1L^2/4E_cI_{eff}$	= 3.90 mm
d. Creep deflection	$=\Delta_c = \Delta_{ci} - \Delta_{cs}$	= 1.61 mm

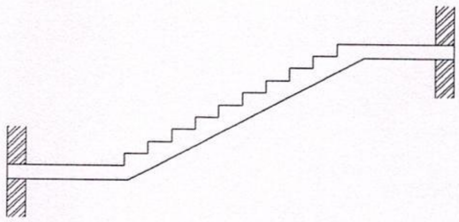
6. Total deflection and check

Total deflection	$=\Delta$	=	11.64 mm
Permissible deflection	$=L/250$	=	16 mm

Hence Ok

Design a waist slab type dog-legged staircase for an office building given the following data: i) height between floors = 3.2 m, ii) riser = 160 mm, iii) tread = 300 mm, iv) width of flight = width of landing = 1.25 m, v) live load = 5.0 kN/m2, floor finishes = 0.8 kN/m2. The flights are supported on 230 mm thick masonry walls at the outer edges of the landing, parallel to the risers. Use M20 concrete and Fe415 steel.





1. Given data
   a. Geometry

Riser	=R	=	160 mm
Tread	=T	=	300 mm
Landing width	=	=	1250 mm
Flight width	=	=	1250 mm
Storey height	=	=	3200 mm
Wall thickness	=	=	230 mm

   b. Material properties

Concrete strength	$=f_{ck}$	=	20 MPa
Steel strength	$=f_y$	=	415 MPa

   c. Loads

Live load	=	=	5.0 kN/m^2
Floor finishes	=	=	0.8 kN/m^2

2. Flight geometry

Total rise per flight	=storey heght/2	=	1600 mm
No of risers	=rise per flight/R	=	10 mm
No of treads	=no of risers - 1	=	9
Total going	=no of treads*T	=	2700 mm
Total flight length, clear	=	=	5200 mm

3. Effctive span

Let waist slab thickness	=D	=	250 mm

Let clear cover	=c	=	20 mm
Let bar size	=ϕ	=	12 mm
Available effective depth	=D-c-ϕ/2	=	224 mm
Effctive span	=clear span+eff depth	=	5424 mm
	=c/c distance b/w supports	=	5430 mm
Hence, effective span	=L	=	5424 mm

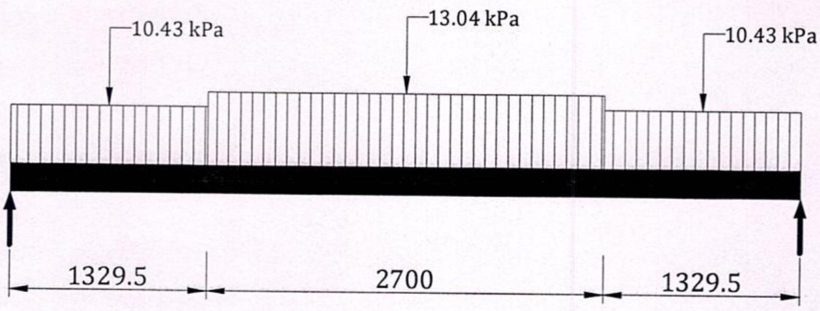
4. Design

a. Loads of going

Self weight of slab	=$25D(R^2+T^2)^{1/2}/T$	=	7.08 kN/m^2
Self weight of step	=25R/2	=	2.00 kN/m^2
Floor finishes	=	=	0.8 kN/m^2
Live load	=	=	5.0 kN/m^2
Total load	=	=	14.88 kN/m^2

b. Loads on landing

Self weight of slab	=25D	=	6.25 kN/m^2
Floor finishes	=	=	0.8 kN/m^2
Live load	=	=	5.0 kN/m^2
Total load	=	=	12.05 kN/m^2



c. Design moment & steel

From the loading diagram

Reaction	=	=	36.5 kN
Mid span moment	=M	=	52.1 kNm/m
Factored moment	=M_u = 1.5M	=	78.1 kNm/m
Required depth	=	=	168 mm
			Hence Ok
Required steel	=A_{st}	=	1073 mm^2/m
Required spacing	=s = $1000A_\phi/A_{st}$	=	105 mm
Hence, provode spacing	=s	=	100 mm
Provided steel	=A_{st}	=	1131 mm^2/m
Percentage steel	=p_t	=	0.50 %

Distribution steel			
Bar size	=	=	10 mm
Required steel	=0.12% of bD	=	269 mm^2
Required spacing	=	=	292 mm
Hence, provode spacing	=	=	250 mm

5. Check for dflection

Basic l/d ratio	=	=	20
Percentage steel	=	=	0.50 %
Service stress	$=f_s = 0.58f_y*(A_{st}\,req/A_{st}\,prov)$	=	228 MPa
Modification factor	$=F_1$	=	1.29
Max allowable l/d ratio	$=F_1$*Basic l/d	=	25.8
Provided l/d	=	=	24.2

Provided l/d < allowable l/d. Hence Ok

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Course Duration: 30 Hours;
From 13/11/20 to 30/11/20

Course Instructor:
Prof. A. Mohan,
Professor, CE, KSRMCE-Kadapa

Coordinator

Head of the Department

V. S. S. Murthy
Principal

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From 13/11/20 to 30/11/20

Course Instructor:
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Feedback of students on Certification Course on "Design of various structural elements of RCC buildings"

Sl. No.	Name	Reg. No.	Is the course covered out of curriculum topics?	Do you understand the economical design of RCC structures?	Rate the course instructor	Is this course useful for your Carrier?	Rate the entire course?
1	Raghavendra Reddy Arikela	189Y1A0104	Yes	Yes	5	Yes	5
2	Maheswari Bokkasam	189Y1A0108	Yes	Yes	5	Yes	5
3	Rama Chandrareddy Bommireddy	189Y1A0109	Yes	Yes	5	Yes	4
4	Satish Kumar Yadav Chennuboyina	189Y1A0115	Yes	Yes	5	Yes	5
5	Anilkumar Chittiboyina	189Y1A0120	Yes	Yes	5	Yes	5
6	Venkata Jithendhar Reddy Duddekunta	189Y1A0126	Yes	Yes	5	Yes	5
7	Premkumar Gaddam	189Y1A0130	Yes	Yes	5	Yes	5
8	Lakshmi Prasad Reddy Guddila	189Y1A0132	Yes	May be	5	Yes	5
9	Nitheesh Gunigari	189Y1A0134	Yes	Yes	5	Yes	5
10	Gangaraju Jamalla	189Y1A0137	Yes	Yes	5	Yes	5
11	Uday Kumar Kaipu	189Y1A0141	Yes	Yes	5	Yes	5
12	Bhanumanikanta Reddy Kannapu	189Y1A0144	Yes	Yes	5	Yes	5
13	Govardhan Kaveti	189Y1A0146	Yes	Yes	5	Yes	5
14	Karthik Kumar Mangala	189Y1A0160	Yes	Yes	5	Yes	5

15	Sai Karthik Maruboyana	189Y1A0161	Yes	May be	5	Yes	5
16	Sampath Kumar Meka	189Y1A0163	Yes	May be	5	Yes	5
17	Purushotham Reddy Mitta	189Y1A0165	Yes	Yes	5	Yes	5
18	Mahammad Azeez Mulla	189Y1A0168	Yes	Yes	5	Yes	5
19	Venkata Sai Poojith Nagalla Pati	189Y1A0171	Yes	Yes	5	Yes	5
20	Venkatesh Nagirikanti	189Y1A0172	Yes	May be	5	Yes	5
21	Abhish Nanubala	189Y1A0175	Yes	Yes	5	Yes	5
22	Ragasravani Pagati	189Y1A0177	Yes	Yes	5	Yes	5
23	Jayachandra Sai Pandugolu	189Y1A0179	Yes	Yes	5	Yes	5
24	Muni Kumar Parimisetti	189Y1A0181	Yes	Yes	5	Yes	5
25	Siva Sai Pasupuleti	189Y1A0183	Yes	Yes	5	Yes	5
26	Rakesh Prasanna Penubala	189Y1A0187	Yes	Yes	5	Yes	5
27	Bindhu Rachamallu	189Y1A0193	Yes	Yes	5	Yes	5
28	Neeraj Sale	189Y1A0194	Yes	Yes	5	Yes	4
29	Swarna Latha Seelam	189Y1A0195	Yes	Yes	5	Yes	5
30	Afroz Shaik	189Y1A0198	Yes	Yes	5	Yes	5
31	Zakke Hussain Shaik	189Y1A01A6	Yes	Yes	5	Yes	5
32	Pragathi (W) Somireddy	189Y1A01A7	Yes	Yes	5	Yes	5
33	Sateesh Kumar Reddy Thallapalle	189Y1A01B0	Yes	Yes	5	Yes	5
34	Sukumar Thati	189Y1A01B1	Yes	Yes	5	Yes	5

35	Siva Reddy Thatimakula	189Y1A01B2	Yes	Yes	5	Yes	5
36	Gayathri Thopudurthy	189Y1A01B4	Yes	Yes	5	Yes	4
37	Venkata Hemanth Usugari	189Y1A01B8	Yes	Yes	5	Yes	5
38	Nagarjun Utukuru	189Y1A01B9	Yes	Yes	5	Yes	5
39	Ganga Swetha Vennapusa	189Y1A01C3	Yes	Yes	5	Yes	5
40	Sivanatha Reddy Yeturu	189Y1A01C8	Yes	Yes	5	Yes	4
41	Malik Akula	199Y5A0102	Yes	Yes	5	Yes	5
42	Venugopal Reddy Atla	199Y5A0105	Yes	Yes	5	Yes	5
43	Vijay Kumar Reddy Basireddygari	199Y5A0107	Yes	Yes	5	Yes	5
44	Sai Bonthalapalli	199Y5A0108	Yes	Yes	5	Yes	5
45	Mahesh Naik Bukke	199Y5A0109	Yes	Yes	5	Yes	5
46	Rohit Chinna Swami Gari	199Y5A0111	Yes	Yes	5	Yes	4
47	Mahesh Babu Chinthakunta	199Y5A0112	Yes	Yes	5	Yes	5
48	Sreenivasulu Dasari	199Y5A0115	Yes	Yes	5	Yes	5
49	Pavan Kalyan Dokka	199Y5A0116	Yes	Yes	5	Yes	5
50	Dastagiri Dudekula	199Y5A0117	Yes	Yes	5	Yes	5
51	Premaraju Erapogu	199Y5A0118	Yes	May be	5	Yes	5
52	Ramu Gosetty	199Y5A0123	Yes	Yes	5	Yes	5
53	Venkateswarlu Kashetty	199Y5A0127	Yes	Yes	5	Yes	5
54	Vinodkumar Madhuranthakam	199Y5A0130	Yes	Yes	5	Yes	5

55	Bharath Venkata Sai Malle Bharath	199Y5A0131	Yes	Yes	5	Yes	5
56	Mahesh Mallepogu Budigi	199Y5A0132	Yes	Yes	5	Yes	5
57	Sai Kumar Mannula	199Y5A0134	Yes	Yes	5	Yes	5
58	Sai Kumar Reddy Masireddy	199Y5A0135	Yes	May be	5	Yes	5
59	Reddaiah Nagulugari	199Y5A0138	Yes	May be	5	Yes	5
60	Chandu Thoti	199Y5A0159	Yes	Yes	5	Yes	5
61	Siva Sai Udayagiri	199Y5A0160	Yes	Yes	5	Yes	5
62	Manjunatha Udumala	199Y5A0161	Yes	Yes	5	Yes	5

M. Rajasekar

Coordinators

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