KANDULA SRINIVASA REDDY MEMORIAL COLLEGE OF ENGINEERING (AUTONOMOUS)

KADAPA-516003. AP

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

(An ISO 9001-2015 Certified Institution)

DEPARTMENT OF CIVIL ENGINEERING

VALUE ADDED COURSE

ON

"Excel Solutions for Compression Member Design"

Resource Person : **Dr. N. Amaranatha Reddy, Associate Professor, Dept. of CE, KSRMCE**

Course Coordinator : **Dr. B. Sudheer Kumar Reddy, Assistant Professor, Dept. of CE, KSRMCE**

Duration : **07/08/2023 to 04/09/2023**

K.S.R.M. COLLEGE OF ENGINEERING

(UGC-AUTONOMOUS)

Kadapa, Andhra Pradesh, India– 516 003

Approved by AICTE, New Delhi & Affiliated to JNTUA, Ananthapuramu.

An ISO 14001:2004 & 9001: 2015 Certified Institution

Lr./KSRMCE/CE/2023-24/ Date:02-08-2023

To
The Principal,
KSRMCE,
Kadapa.

Respected Sir,

Sub: Permission to Conduct Value added Course on “Excel Solutions for Compression Member Design” from **07/08/2023 to 04/09/2023**–Req- Reg.

The Department of Civil Engineering is planning to offer a Value Added Course on “Excel Solutions for Compression Member Design” to B. Tech. students. The course will be conducted from **07/08/2023 to 04/09/2023**. In this regard, I kindly request you to grant permission to conduct the Value Added Course.

Thanking you sir,

Forwarded to principal sir

Yours faithfully

(Dr. B. Sudheer Kumar Reddy)

Permitted
V.S.S. Murthy
02/08/2023

KSNR lives on..

Cr./KSRMCE/CE/2023-24/

Date: 02/08/2023

Circular

The Department of Civil Engineering is offering a Value Added Course on "Excel Solutions for Compression Member Design" from **07/08/2023 to 04/09/2023** to B.Tech students. In this regard, interested students are requested to register their names for the Value Added Course with Course Coordinator.

For further information contact Course Coordinators.

Course Coordinators: Dr. B. Sudheer Kumar Reddy, Asst. Professor, Dept. of CE.-KSRMCE, Contact No: 8208654524

HOD

Dept. of CE

Cc to:

IQAC-KSRMCE

Faculty, Dept. of Civil Engg., KSRMCE

Students, Dept. of Civil Engg., KSRMCE

K.S.R.M. COLLEGE OF ENGINEERING

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Kadapa, Andhra Pradesh, India- 516 003

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ESTD: 1980

DEPARTMENT OF CIVIL ENGINEERING

KSNR
lives on..

Excel Solutions for Compression Member Design

Coordinator

Dr. B. Sudheer Kumar Reddy
Assistant Professor
Department of Civil Engineering

Venue

CADD Lab,
Department of Civil Engineering

Date

From
07/08/2023 to
04/09/2023

Dr. N. Amaranatha Reddy	Dr. V S S Murthy	Prof. A Mohan	Dr. K Chandra Obul Reddy	Smt. K Rajeswari	Sri K Madan Mohan Reddy	Sri K Raja Mohan Reddy
HOD	Principal	Director	Managing Director	Correspondent Secretary, Treasurer	Vice Chairman	Chairman

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Date: 07/08/2023

DEPARTMENT OF CIVIL ENGINEERING

REGISTRATION LIST

Value Added Course

On

"Excel Solutions for Compression Member Design" From 07/08/2023 to 04/09/2023

S.No	Full Name	Roll Number	Branch	Semester
1	Kanta Eswar Sai	209Y1A0128	Civil	VII
2	Kanuparthi Vishnu Vardhan	209Y1A0129	Civil	VII
3	Kateeb Syed Noor Mohammed	209Y1A0130	Civil	VII
4	Kethamreddy Praveen Kumar Reddy	209Y1A0131	Civil	VII
5	Koppala Venkata Sampath	209Y1A0133	Civil	VII
6	Kora Pavan Kumar Reddy	209Y1A0134	Civil	VII
7	Kottam Ganesh	209Y1A0135	Civil	VII
8	Kovuru Srivalli (W)	209Y1A0136	Civil	VII
9	Madanapuri Abhilash	209Y1A0137	Civil	VII
10	Maddur Suresh	209Y1A0138	Civil	VII
11	Maddur Vishnu	209Y1A0139	Civil	VII
12	Malisetty Vamsi Kumar	209Y1A0140	Civil	VII
13	Malle Venkata Tharun	209Y1A0141	Civil	VII
14	Mangali Madhu Krishna	209Y1A0142	Civil	VII
15	Manigala Reddysai	209Y1A0143	Civil	VII
16	Manyam Sai Teja Reddy	209Y1A0144	Civil	VII
17	Meesala Subbarayudu	209Y1A0145	Civil	VII
18	Meesala Venkata Sai	209Y1A0146	Civil	VII
19	Mothukuri Rahul	209Y1A0147	Civil	VII
20	Mothukuru Srinath	209Y1A0148	Civil	VII
21	Mude Narendranaik	209Y1A0149	Civil	VII
22	Nadivinti Saleem	209Y1A0150	Civil	VII
23	Nakka Damodar	209Y1A0151	Civil	VII
24	Nandyala Naga Siva Sai	209Y1A0153	Civil	VII
25	Nerniki Valmeeki Sai Kiran	209Y1A0155	Civil	VII
26	Pagadala Siva Sai Kumar	209Y1A0157	Civil	VII
27	Palavala Lokanath	209Y1A0158	Civil	VII

Coordinator

HoD

Head
Department of Civil Engineering
K.S.R.M. College of Engineering
(Autonomous)
KADAPA - 516 003. (A.P.)

Syllabus of the Value Added Course

Course Name: Excel Solutions for Compression Member Design

Course Objectives:

- Understand the principles of the Limit State Method and its application in the design of compression members.
- Develop proficiency in using Microsoft Excel for engineering calculations and design processes.
- Design axially loaded short columns and analyze their performance using Excel.
- Analyze and design short columns subjected to uniaxial and biaxial bending.
- Integrate theoretical knowledge with practical applications to solve real-world engineering problems.

Course Outcomes: Upon completing the course students will be able to:

- Explain the principles of the Limit State Method and differentiate between the limit state of collapse and serviceability.
- Utilize Microsoft Excel for performing engineering calculations and design of compression members.
- Design and analyze axially loaded short columns using Excel, ensuring compliance with relevant codes and standards.
- Perform analysis and design of short columns subjected to uniaxial bending using Excel.
- Conduct analysis and design of short columns subjected to biaxial bending using Excel.
- Apply the knowledge and skills acquired to solve practical engineering problems related to the design of compression members.

Course Contents:

Module I: Review of Limit State Method

Review the principles of the Limit State Method, including the limit state of collapse and serviceability. Understand factors affecting both limit states through practical examples and case studies. Introduction to Microsoft Excel for basic engineering calculations.

Module II: Design of Axially Loaded Short Columns

Learn design principles and codes for axially loaded short columns. Utilize Microsoft Excel to calculate axial load capacity, verify designs against codes, and reinforce learning with practical examples and case studies.

Module III: Analysis and Design of Short Columns with Uniaxial Bending

Module IV: Analysis and Design of Short Columns with Biaxial Bending

Explore biaxial bending in short columns, covering design principles and codes. Apply Microsoft Excel to analyze moments and stresses in two directions, verify against codes, and design columns considering axial load and biaxial bending effects. Enhance understanding through practical examples and case studies.

Textbooks:

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

SCHEDULE

Department of Civil Engineering

Value Added Course

On

"Excel Solutions for Compression Member Design" From 07/08/2023 to 04/09/2023

<table>
<tr><th>Date</th><th>Timing</th><th>Resource Person</th><th>Topic to be covered</th></tr>
<tr><td>07/08/2023</td><td>1 PM to 4 PM</td><td>Dr. N. Amaranatha Reddy</td><td>Review the principles of the Limit State Method, including the limit state of collapse and serviceability.</td></tr>
<tr><td>13/08/2023</td><td>9 AM to 4 PM</td><td>Dr. N. Amaranatha Reddy</td><td>Understand factors affecting both limit states through practical examples and case studies. Introduction to Microsoft Excel for basic engineering calculations.</td></tr>
<tr><td>14/08/2023</td><td>1 PM to 4 PM</td><td>Dr. N. Amaranatha Reddy</td><td>Learn design principles and codes for axially loaded short columns.</td></tr>
<tr><td>20/08/2023</td><td>9 AM to 4 PM</td><td>Dr. N. Amaranatha Reddy</td><td>Utilize Microsoft Excel to calculate axial load capacity, verify designs against codes, and reinforce learning with practical examples and case studies.</td></tr>
<tr><td>21/08/2023</td><td>1 PM to 4 PM</td><td>Dr. N. Amaranatha Reddy</td><td>Study uniaxial bending in short columns, including relevant design principles and codes.</td></tr>
<tr><td>27/08/2023</td><td>9 AM to 4 PM</td><td>Dr. N. Amaranatha Reddy</td><td rowspan="2">Use Microsoft Excel to analyze moments and bending stresses, verify compliance with design codes, zand design columns combining axial load and uniaxial bending effects. Practice with real-world examples and case studies.</td></tr>
<tr><td>28/08/2023</td><td>1 PM to 4 PM</td><td>Dr. N. Amaranatha Reddy</td></tr>
<tr><td>03/09/2023</td><td>9 AM to 4 PM</td><td>Dr. N. Amaranatha Reddy</td><td rowspan="2">Explore biaxial bending in short columns, covering design principles and codes. Apply Microsoft Excel to analyze moments and stresses in two directions, verify against codes, and design columns considering axial load and biaxial bending effects. Enhance understanding through practical examples and case studies.</td></tr>
<tr><td>04/09/2023</td><td>1 PM to 4 PM</td><td>Dr. N. Amaranatha Reddy</td></tr>
</table>

Resource Person(s) Coordinator(s) HoD

Head
Department of Civil Engineering
K.S.R.M. College of Engineering
(Autonomous)
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Report of
Value Added Course on "Excel Solutions for Compression Member Design"
From 07/08/2023 to 04/09/2023

Target Group	:	**B.Tech Students**
Details of Participants	:	**27 Students**
Co-coordinator(s)	:	**Dr B. Srudheer Kumar Reddy**
Resource Person(s)	:	**Dr. N. Amaranatha Reddy**
Organizing Department	:	**Civil Engineering**
Venue	:	**CADD Lab, Civil Engineering Department**

Description:

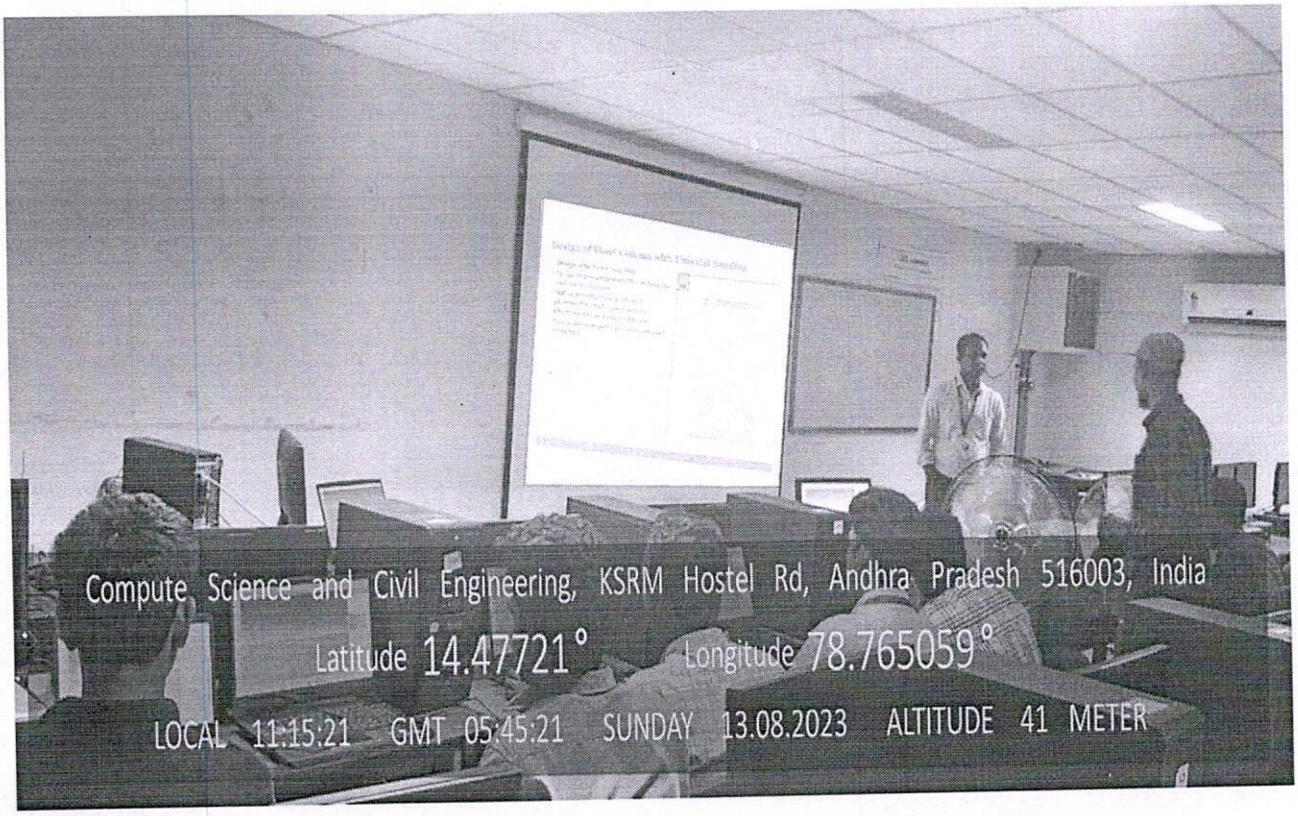
The Civil Engineering Department organized a Value Added Course on "Excel Solutions for Compression Member Design" from 7th August 2023 to 4th September 2023. The course targeted B.Tech students, with a total of 27 participants. Dr. B. Srudheer Kumar Reddy coordinated the course, and Dr. N. Amaranatha Reddy served as the resource person. The sessions were held in the CADD Lab, providing a hands-on learning environment.

The course aimed to equip students with practical skills in designing compression members using Excel. It covered fundamental principles, design theories, and real-world applications, ensuring a comprehensive understanding of the subject. The interactive and practical sessions facilitated active learning, allowing students to work on real-world problems and develop solutions using Excel.

Feedback from the participants was overwhelmingly positive. Students appreciated the practical approach and the opportunity to enhance their Excel skills for engineering applications. The course successfully bridged the gap between theoretical knowledge and practical application, contributing significantly to the students' professional development.

Photos

The pictures taken during the course are given below:



Coordinator(s)

HoD

Head
Department of Civil Engineering
K.S.R.M. College of Engineering
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DEPARTMENT OF CIVIL ENGINEERING

Attendance sheet of Certification Course on "Excel Solutions for Compression Member Design" From 07/08/2023 to 04/09/2023

Sl. No.	Roll No.	Name	07/08	13/08	14/08	20/08	21/08	27/08	28/08	03/09	04/09
1	209Y1A0128	Kanta Eswar Sai	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]
2	209Y1A0129	Kanuparthi Vishnu Vardhan	A	K.V. Vishnu	K.V. Vishnu	K.V. Vishnu	K.V. Vishnu	K.V. Vishnu	K.V. Vishnu	K.V. Vishnu	K.V. Vishnu
3	209Y1A0130	Kateeb Syed Noor Mohammed	K.S.N	K.S.N	K.S.N	K.S.N	K.S.N	K.S.N	K.S.N	K.S.N	K.S.N
4	209Y1A0131	Kethamreddy Praveen Kumar Reddy	K.P.K reddy	A	K.P.K reddy	K.P.K reddy	K.P.K reddy	K.P.K reddy	A	K.P.K reddy	K.P.K reddy
5	209Y1A0133	Koppala Venkata Sampath	K.S.V	K.S.V	K.S.V	K.S.V	K.S.V	K.V.S	K.V.S	K.V.S	K.V.S
6	209Y1A0134	Kora Pavan Kumar Reddy	K.pavan	K.pavan	A	K.pavan	K.pavan	K.pavan	K.pavan	K.pavan	K.pavan
7	209Y1A0135	Kottam Ganesh	K.Ganesh	K.Ganesh	K.Ganesh	K.Ganesh	K.Ganesh	K.Ganesh	K.Ganesh	K.Ganesh	K.Ganesh
8	209Y1A0136	Kovuru Srivalli (W)	K.Srivalli	Srivalli	Srivalli	Srivalli	Srivalli	Srivalli	Srivalli	Srivalli	Srivalli

9	209Y1A0137	Madanapuri Abhilash	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]
10	209Y1A0138	Maddur Suresh	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]
11	209Y1A0139	Maddur Vishnu	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]
12	209Y1A0140	Malisetty Vamsi Kumar	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]
13	209Y1A0141	Malle Venkata Tharun	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	A	[signature]
14	209Y1A0142	Mangali Madhu Krishna	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]
15	209Y1A0143	Manigala Reddysai	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]
16	209Y1A0144	Manyam Sai Teja Reddy	[signature]	[signature]	[signature]	A	[signature]	[signature]	[signature]	[signature]	[signature]
17	209Y1A0145	Meesala Subbarayudu	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]
18	209Y1A0146	Meesala Venkata Sai	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]
19	209Y1A0147	Mothukuri Rahul	[signature]	A	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]
20	209Y1A0148	Mothukuru Srinath	[signature]	[signature]	[signature]	[signature]	[signature]	A	[signature]	[signature]	[signature]
21	209Y1A0149	Mude Narendranaik	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]
22	209Y1A0150	Nadivinti Saleem	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]
23	209Y1A0151	Nakka Damodar	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]
24	209Y1A0153	Nandyala Naga Siva Sai	[signature]	[illegible]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]

25	209Y1A0155	Nerniki Valmeeki Sai Kiran	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]
26	209Y1A0157	Pagadala Siva Sai Kumar	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]
27	209Y1A0158	Palavala Lokanath	[signature]	[signature]	A	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]

Coordinator(s)

HoD

Head
Department of Civil Engineering
K.S.R.M. College of Engineering
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K.S.R.M. COLLEGE OF ENGINEERING (AUTONOMOUS), KADAPA-516003
DEPARTMENT OF CIVIL ENGINEERING
VALUE ADDED COURSE ON
"EXCEL SOLUTIONS FOR COMPRESSION MEMBER DESIGN" FROM
07/08/2023 to 04/09/2023

AWARD LIST

S.NO	Roll Number	Name of the Student	Marks Obtained
1	209Y1A0128	Kanta Eswar Sai	11
2	209Y1A0129	Kanuparthi Vishnu Vardhan	10
3	209Y1A0130	Kateeb Syed Noor Mohammed	15
4	209Y1A0131	Kethamreddy Praveen Kumar Reddy	14
5	209Y1A0133	Koppala Venkata Sampath	14
6	209Y1A0134	Kora Pavan Kumar Reddy	13
7	209Y1A0135	Kottam Ganesh	19
8	209Y1A0136	Kovuru Srivalli (W)	14
9	209Y1A0137	Madanapuri Abhilash	19
10	209Y1A0138	Maddur Suresh	15
11	209Y1A0139	Maddur Vishnu	12
12	209Y1A0140	Malisetty Vamsi Kumar	19
13	209Y1A0141	Malle Venkata Tharun	17
14	209Y1A0142	Mangali Madhu Krishna	11
15	209Y1A0143	Manigala Reddysai	10
16	209Y1A0144	Manyam Sai Teja Reddy	20
17	209Y1A0145	Meesala Subbarayudu	14
18	209Y1A0146	Meesala Venkata Sai	15
19	209Y1A0147	Mothukuri Rahul	18
20	209Y1A0148	Mothukuru Srinath	10
21	209Y1A0149	Mude Narendranaik	20
22	209Y1A0150	Nadivinti Saleem	14
23	209Y1A0151	Nakka Damodar	16
24	209Y1A0153	Nandyala Naga Siva Sai	14
25	209Y1A0155	Nerniki Valmeeki Sai Kiran	12
26	209Y1A0157	Pagadala Siva Sai Kumar	13
27	209Y1A0158	Palavala Lokanath	13

Coordinator

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14/20

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DEPARTMENT OF CIVIL ENGINEERING
VALUE ADDED COURSE ON
"EXCEL SOLUTIONS FOR COMPRESSION MEMBER DESIGN" FROM 07/08/2023 to 04/09/2023

ASSESSMENT TEST

Roll Number: 219Y1A0131 **Name of the Student:** P. Praveen Kumar Reddy

Time: 20 Min **(Objective Questions)** **Max.Marks: 20**

Note: Answer the following Questions and each question carries **one** mark.

Q)	Description	Answer
1	What is the primary objective of the Limit State Method? a) To design structures to fail at service load; b) To ensure safety and serviceability of structures; c) To minimize the cost of construction; d) To maximize the aesthetic appeal of structures	[B]
2	Which of the following is a limit state of collapse? a) Deflection; b) Durability; c) Buckling; d) Fire resistance	[B]
3	What factors affect the limit state of serviceability? a) Load capacity and stability; b) Deflection and crack width; c) Load factor and material strength; d) Aesthetics and cost	[B]
4	How does Microsoft Excel assist in engineering calculations? a) By providing aesthetic design options; b) By automating basic engineering calculations; c) By replacing engineering judgment; d) By offering material testing features	[B]
5	Which code is typically used for designing axially loaded short columns in civil engineering? a) ACI 318; b) AISC; c) BS 8110; d) ASCE 7	[B]
6	What is the main factor considered in the design of axially loaded short columns? a) Lateral load; b) Axial load capacity; c) Bending moment; d) Shear force	[C]
7	In Microsoft Excel, which function is primarily used for calculating axial load capacity? a) SUM; b) VLOOKUP; c) IF; d) PMT	[A]
8	What is the significance of verifying column designs against codes? a) To ensure aesthetic appeal; b) To meet safety and durability requirements; c) To reduce construction costs; d) To simplify the design process	[B]
9	What is uniaxial bending in short columns? a) Bending about two axes simultaneously; b) Bending about a single axis; c) Axial compression without bending; d) Lateral displacement without bending	[B]

10	Which formula is commonly used to calculate the moment capacity of a column with uniaxial bending? a) M=P·e; b) M=f·A; c) $M=P/A$; d) $M=I{\cdot}c$	[B]
11	What does the term 'e' represent in the moment capacity formula $M=P{\cdot}e$? a) Axial load; b) Eccentricity; c) Bending moment; d) Area of cross-section	[B]
12	In Excel, how can you model the interaction between axial load and uniaxial bending moment? a) Using pie charts; b) Using interaction diagrams; c) Using simple formulas only d) Using text annotations	[B]
13	What distinguishes biaxial bending from uniaxial bending? a) Biaxial bending involves bending about one axis; b) Biaxial bending involves bending about two axes; c) Biaxial bending involves no bending; d) Biaxial bending is only theoretical	[B]
14	Which of the following must be considered in the design of columns with biaxial bending? a) Bending about only one axis; b) Interaction of moments in both directions; c) Axial load capacity only; d) Shear force in one direction	[B]
15	In Microsoft Excel, what tool can be used to analyze moments in two directions? a) Scatter plots; b) Pivot tables; c) Interaction diagrams; d) Bar charts	[C]
16	What is the primary challenge in designing columns under biaxial bending? a) Ensuring aesthetic appeal; b) Simplifying the design process; c) Accounting for interaction of stresses; d) Reducing material cost	[C]
17	Why is it important to verify designs against codes when dealing with biaxial bending? a) To reduce design time; b) To ensure safety and compliance; c) To increase profitability; d) To simplify the calculation process	[B]
18	Which code provisions are typically used for the design of columns under biaxial bending? a) AISC; b) ACI 318; c) ASCE 7; d) BS 8110	[C]
19	How can practical examples and case studies enhance the understanding of biaxial bending in columns? a) By providing real-world context and applications; b) By simplifying theoretical concepts; c) By eliminating the need for codes; d) By reducing the need for calculations	[A]
20	What is the role of Microsoft Excel in the design process for biaxial bending? a) To provide visual representation of interaction diagrams; b) To replace engineering judgment; c) To verify designs against codes; d) To reduce the material cost	[B]

19/20

K.S.R.M. COLLEGE OF ENGINEERING (AUTONOMOUS), KADAPA-516003
DEPARTMENT OF CIVIL ENGINEERING
VALUE ADDED COURSE ON
"EXCEL SOLUTIONS FOR COMPRESSION MEMBER DESIGN" FROM 07/08/2023 to 04/09/2023

ASSESSMENT TEST

Roll Number: 2094 1A0135 **Name of the Student:** K. Ganesh

Time: 20 Min **(Objective Questions)** **Max.Marks: 20**

Note: Answer the following Questions and each question carries **one** mark.

Q)	Description	Answer
1	What is the primary objective of the Limit State Method? a) To design structures to fail at service load; b) To ensure safety and serviceability of structures; c) To minimize the cost of construction; d) To maximize the aesthetic appeal of structures	[B]
2	Which of the following is a limit state of collapse? a) Deflection; b) Durability; c) Buckling; d) Fire resistance	[C]
3	What factors affect the limit state of serviceability? a) Load capacity and stability; b) Deflection and crack width; c) Load factor and material strength; d) Aesthetics and cost	[B]
4	How does Microsoft Excel assist in engineering calculations? a) By providing aesthetic design options; b) By automating basic engineering calculations; c) By replacing engineering judgment; d) By offering material testing features	[B]
5	Which code is typically used for designing axially loaded short columns in civil engineering? a) ACI 318; b) AISC; c) BS 8110; d) ASCE 7	[A]
6	What is the main factor considered in the design of axially loaded short columns? a) Lateral load; b) Axial load capacity; c) Bending moment; d) Shear force	[B]
7	In Microsoft Excel, which function is primarily used for calculating axial load capacity? a) SUM; b) VLOOKUP; c) IF; d) PMT	[A]
8	What is the significance of verifying column designs against codes? a) To ensure aesthetic appeal; b) To meet safety and durability requirements; c) To reduce construction costs; d) To simplify the design process	[B]
9	What is uniaxial bending in short columns? a) Bending about two axes simultaneously; b) Bending about a single axis; c) Axial compression without bending; d) Lateral displacement without bending	[B]

10	Which formula is commonly used to calculate the moment capacity of a column with uniaxial bending? a) M=P·e; b) M=f·A; c) $M=P/A$; d) $M=I\cdot c$	[A]
11	What does the term 'e' represent in the moment capacity formula $M=P\cdot e$? a) Axial load; b) Eccentricity; c) Bending moment; d) Area of cross-section	[B]
12	In Excel, how can you model the interaction between axial load and uniaxial bending moment? a) Using pie charts; b) Using interaction diagrams; c) Using simple formulas only d) Using text annotations	[A]
13	What distinguishes biaxial bending from uniaxial bending? a) Biaxial bending involves bending about one axis; b) Biaxial bending involves bending about two axes; c) Biaxial bending involves no bending; d) Biaxial bending is only theoretical	[B]
14	Which of the following must be considered in the design of columns with biaxial bending? a) Bending about only one axis; b) Interaction of moments in both directions; c) Axial load capacity only; d) Shear force in one direction	[B]
15	In Microsoft Excel, what tool can be used to analyze moments in two directions? a) Scatter plots; b) Pivot tables; c) Interaction diagrams; d) Bar charts	[C]
16	What is the primary challenge in designing columns under biaxial bending? a) Ensuring aesthetic appeal; b) Simplifying the design process; c) Accounting for interaction of stresses; d) Reducing material cost	[C]
17	Why is it important to verify designs against codes when dealing with biaxial bending? a) To reduce design time; b) To ensure safety and compliance; c) To increase profitability; d) To simplify the calculation process	[B]
18	Which code provisions are typically used for the design of columns under biaxial bending? a) AISC; b) ACI 318; c) ASCE 7; d) BS 8110	[B]
19	How can practical examples and case studies enhance the understanding of biaxial bending in columns? a) By providing real-world context and applications; b) By simplifying theoretical concepts; c) By eliminating the need for codes; d) By reducing the need for calculations	[A]
20	What is the role of Microsoft Excel in the design process for biaxial bending? a) To provide visual representation of interaction diagrams; b) To replace engineering judgment; c) To verify designs against codes; d) To reduce the material cost	[A]

10/20

K.S.R.M. COLLEGE OF ENGINEERING (AUTONOMOUS), KADAPA-516003
DEPARTMENT OF CIVIL ENGINEERING
VALUE ADDED COURSE ON
"EXCEL SOLUTIONS FOR COMPRESSION MEMBER DESIGN" FROM 07/08/2023 to 04/09/2023

ASSESSMENT TEST

Roll Number: 209Y1A0148 **Name of the Student:** M. Srinath

Time: 20 Min **(Objective Questions)** **Max.Marks: 20**

Note: Answer the following Questions and each question carries **one** mark.

Q)	Description	Answer
1	What is the primary objective of the Limit State Method? a) To design structures to fail at service load; b) To ensure safety and serviceability of structures; c) To minimize the cost of construction; d) To maximize the aesthetic appeal of structures	[b] ✓
2	Which of the following is a limit state of collapse? a) Deflection; b) Durability; c) Buckling; d) Fire resistance	[C] ✓
3	What factors affect the limit state of serviceability? a) Load capacity and stability; b) Deflection and crack width; c) Load factor and material strength; d) Aesthetics and cost	[A] ✗
4	How does Microsoft Excel assist in engineering calculations? a) By providing aesthetic design options; b) By automating basic engineering calculations; c) By replacing engineering judgment; d) By offering material testing features	[C] ✗
5	Which code is typically used for designing axially loaded short columns in civil engineering? a) ACI 318; b) AISC; c) BS 8110; d) ASCE 7	[A] ✓
6	What is the main factor considered in the design of axially loaded short columns? a) Lateral load; b) Axial load capacity; c) Bending moment; d) Shear force	[b] ✓
7	In Microsoft Excel, which function is primarily used for calculating axial load capacity? a) SUM; b) VLOOKUP; c) IF; d) PMT	[C] ✗
8	What is the significance of verifying column designs against codes? a) To ensure aesthetic appeal; b) To meet safety and durability requirements; c) To reduce construction costs; d) To simplify the design process	[d] ✗
9	What is uniaxial bending in short columns? a) Bending about two axes simultaneously; b) Bending about a single axis; c) Axial compression without bending; d) Lateral displacement without bending	[b] ✓

10	Which formula is commonly used to calculate the moment capacity of a column with uniaxial bending? a) M=P·e; b) M=f·A; c) $M=P/A$; d) $M=I \cdot c$	[a] ✓
11	What does the term 'e' represent in the moment capacity formula $M=P \cdot e$? a) Axial load; b) Eccentricity; c) Bending moment; d) Area of cross-section	[c] ✗
12	In Excel, how can you model the interaction between axial load and uniaxial bending moment? a) Using pie charts; b) Using interaction diagrams; c) Using simple formulas only d) Using text annotations	[b] ✗
13	What distinguishes biaxial bending from uniaxial bending? a) Biaxial bending involves bending about one axis; b) Biaxial bending involves bending about two axes; c) Biaxial bending involves no bending; d) Biaxial bending is only theoretical	[a] ✗
14	Which of the following must be considered in the design of columns with biaxial bending? a) Bending about only one axis; b) Interaction of moments in both directions; c) Axial load capacity only; d) Shear force in one direction	[b] ✓
15	In Microsoft Excel, what tool can be used to analyze moments in two directions? a) Scatter plots; b) Pivot tables; c) Interaction diagrams; d) Bar charts	[c] ✓
16	What is the primary challenge in designing columns under biaxial bending? a) Ensuring aesthetic appeal; b) Simplifying the design process; c) Accounting for interaction of stresses; d) Reducing material cost	[b] ✗
17	Why is it important to verify designs against codes when dealing with biaxial bending? a) To reduce design time; b) To ensure safety and compliance; c) To increase profitability; d) To simplify the calculation process	[a] ✗
18	Which code provisions are typically used for the design of columns under biaxial bending? a) AISC; b) ACI 318; c) ASCE 7; d) BS 8110	[b] ✓
19	How can practical examples and case studies enhance the understanding of biaxial bending in columns? a) By providing real-world context and applications; b) By simplifying theoretical concepts; c) By eliminating the need for codes; d) By reducing the need for calculations	[d] ✗
20	What is the role of Microsoft Excel in the design process for biaxial bending? a) To provide visual representation of interaction diagrams; b) To replace engineering judgment; c) To verify designs against codes; d) To reduce the material cost	[a] ✓

20/20

K.S.R.M. COLLEGE OF ENGINEERING (AUTONOMOUS), KADAPA-516003
DEPARTMENT OF CIVIL ENGINEERING
VALUE ADDED COURSE ON
"EXCEL SOLUTIONS FOR COMPRESSION MEMBER DESIGN" FROM 07/08/2023 to 04/09/2023

ASSESSMENT TEST

Roll Number: 209Y1A0144 **Name of the Student:** M. Sai teja reddy.

Time: 20 Min **(Objective Questions)** **Max.Marks: 20**

Note: Answer the following Questions and each question carries **one** mark.

Q)	Description	Answer
1	What is the primary objective of the Limit State Method? a) To design structures to fail at service load; b) To ensure safety and serviceability of structures; c) To minimize the cost of construction; d) To maximize the aesthetic appeal of structures	[B]
2	Which of the following is a limit state of collapse? a) Deflection; b) Durability; c) Buckling; d) Fire resistance	[C]
3	What factors affect the limit state of serviceability? a) Load capacity and stability; b) Deflection and crack width; c) Load factor and material strength; d) Aesthetics and cost	[B]
4	How does Microsoft Excel assist in engineering calculations? a) By providing aesthetic design options; b) By automating basic engineering calculations; c) By replacing engineering judgment; d) By offering material testing features	[B]
5	Which code is typically used for designing axially loaded short columns in civil engineering? a) ACI 318; b) AISC; c) BS 8110; d) ASCE 7	[A]
6	What is the main factor considered in the design of axially loaded short columns? a) Lateral load; b) Axial load capacity; c) Bending moment; d) Shear force	[B]
7	In Microsoft Excel, which function is primarily used for calculating axial load capacity? a) SUM; b) VLOOKUP; c) IF; d) PMT	[A]
8	What is the significance of verifying column designs against codes? a) To ensure aesthetic appeal; b) To meet safety and durability requirements; c) To reduce construction costs; d) To simplify the design process	[B]
9	What is uniaxial bending in short columns? a) Bending about two axes simultaneously; b) Bending about a single axis; c) Axial compression without bending; d) Lateral displacement without bending	[B]

10	Which formula is commonly used to calculate the moment capacity of a column with uniaxial bending? a) M=P·e; b) M=f·A; c) $M=P/A$; d) $M=I \cdot c$	[A]
11	What does the term 'e' represent in the moment capacity formula $M=P \cdot e$? a) Axial load; b) Eccentricity; c) Bending moment; d) Area of cross-section	[B]
12	In Excel, how can you model the interaction between axial load and uniaxial bending moment? a) Using pie charts; b) Using interaction diagrams; c) Using simple formulas only d) Using text annotations	[B]
13	What distinguishes biaxial bending from uniaxial bending? a) Biaxial bending involves bending about one axis; b) Biaxial bending involves bending about two axes; c) Biaxial bending involves no bending; d) Biaxial bending is only theoretical	[B]
14	Which of the following must be considered in the design of columns with biaxial bending? a) Bending about only one axis; b) Interaction of moments in both directions; c) Axial load capacity only; d) Shear force in one direction	[B]
15	In Microsoft Excel, what tool can be used to analyze moments in two directions? a) Scatter plots; b) Pivot tables; c) Interaction diagrams; d) Bar charts	[C]
16	What is the primary challenge in designing columns under biaxial bending? a) Ensuring aesthetic appeal; b) Simplifying the design process; c) Accounting for interaction of stresses; d) Reducing material cost	[C]
17	Why is it important to verify designs against codes when dealing with biaxial bending? a) To reduce design time; b) To ensure safety and compliance; c) To increase profitability; d) To simplify the calculation process	[B]
18	Which code provisions are typically used for the design of columns under biaxial bending? a) AISC; b) ACI 318; c) ASCE 7; d) BS 8110	[B]
19	How can practical examples and case studies enhance the understanding of biaxial bending in columns? a) By providing real-world context and applications; b) By simplifying theoretical concepts; c) By eliminating the need for codes; d) By reducing the need for calculations	[A]
20	What is the role of Microsoft Excel in the design process for biaxial bending? a) To provide visual representation of interaction diagrams; b) To replace engineering judgment; c) To verify designs against codes; d) To reduce the material cost	[A]

19/20

K.S.R.M. COLLEGE OF ENGINEERING (AUTONOMOUS), KADAPA-516003
DEPARTMENT OF CIVIL ENGINEERING
VALUE ADDED COURSE ON
"EXCEL SOLUTIONS FOR COMPRESSION MEMBER DESIGN" FROM 07/08/2023 to 04/09/2023

ASSESSMENT TEST

Roll Number: 209Y1A0177 **Name of the Student:** M. Abilash

Time: 20 Min **(Objective Questions)** **Max.Marks: 20**

Note: Answer the following Questions and each question carries **one** mark.

Q)	Description	Answer
1	What is the primary objective of the Limit State Method? a) To design structures to fail at service load; b) To ensure safety and serviceability of structures; c) To minimize the cost of construction; d) To maximize the aesthetic appeal of structures	[b] ✓
2	Which of the following is a limit state of collapse? a) Deflection; b) Durability; c) Buckling; d) Fire resistance	[b] ✗
3	What factors affect the limit state of serviceability? a) Load capacity and stability; b) Deflection and crack width; c) Load factor and material strength; d) Aesthetics and cost	[b] ✓
4	How does Microsoft Excel assist in engineering calculations? a) By providing aesthetic design options; b) By automating basic engineering calculations; c) By replacing engineering judgment; d) By offering material testing features	[b] ✓
5	Which code is typically used for designing axially loaded short columns in civil engineering? a) ACI 318; b) AISC; c) BS 8110; d) ASCE 7	[a] ✓
6	What is the main factor considered in the design of axially loaded short columns? a) Lateral load; b) Axial load capacity; c) Bending moment; d) Shear force	[B] ✓
7	In Microsoft Excel, which function is primarily used for calculating axial load capacity? a) SUM; b) VLOOKUP; c) IF; d) PMT	[a] ✓
8	What is the significance of verifying column designs against codes? a) To ensure aesthetic appeal; b) To meet safety and durability requirements; c) To reduce construction costs; d) To simplify the design process	[b] ✓
9	What is uniaxial bending in short columns? a) Bending about two axes simultaneously; b) Bending about a single axis; c) Axial compression without bending; d) Lateral displacement without bending	[b] ✓

10	Which formula is commonly used to calculate the moment capacity of a column with uniaxial bending? a) M=P·e; b) M=f·A; c) $M=P/A$; d) $M=I\cdot c$	[a] ✓
11	What does the term 'e' represent in the moment capacity formula $M=P\cdot e$? a) Axial load; b) Eccentricity; c) Bending moment; d) Area of cross-section	[b] ✓
12	In Excel, how can you model the interaction between axial load and uniaxial bending moment? a) Using pie charts; b) Using interaction diagrams; c) Using simple formulas only d) Using text annotations	[b] ✓
13	What distinguishes biaxial bending from uniaxial bending? a) Biaxial bending involves bending about one axis; b) Biaxial bending involves bending about two axes; c) Biaxial bending involves no bending; d) Biaxial bending is only theoretical	[b] ✓
14	Which of the following must be considered in the design of columns with biaxial bending? a) Bending about only one axis; b) Interaction of moments in both directions; c) Axial load capacity only; d) Shear force in one direction	[b] ✓
15	In Microsoft Excel, what tool can be used to analyze moments in two directions? a) Scatter plots; b) Pivot tables; c) Interaction diagrams; d) Bar charts	[c] ✓
16	What is the primary challenge in designing columns under biaxial bending? a) Ensuring aesthetic appeal; b) Simplifying the design process; c) Accounting for interaction of stresses; d) Reducing material cost	[c] ✓
17	Why is it important to verify designs against codes when dealing with biaxial bending? a) To reduce design time; b) To ensure safety and compliance; c) To increase profitability; d) To simplify the calculation process	[b] ✓
18	Which code provisions are typically used for the design of columns under biaxial bending? a) AISC; b) ACI 318; c) ASCE 7; d) BS 8110	[b] ✓
19	How can practical examples and case studies enhance the understanding of biaxial bending in columns? a) By providing real-world context and applications; b) By simplifying theoretical concepts; c) By eliminating the need for codes; d) By reducing the need for calculations	[a] ✓
20	What is the role of Microsoft Excel in the design process for biaxial bending? a) To provide visual representation of interaction diagrams; b) To replace engineering judgment; c) To verify designs against codes; d) To reduce the material cost	✓ [a]

Feedback form for Value Added Course "Excel Solutions for Compression Member Design" from 07/08/2023 to 04/09/2023

reddysrinu@ksrmce.ac.in Switch account

* Indicates required question

Email *

☐ Record **reddysrinu@ksrmce.ac.in** as the email to be included with my response

Roll Number *

Your answer

Name of the Student *

Your answer

The objectives of the Value Added Course were met (Objective) *

Excellent-5; Good-4; Average-3; Below Average-2; Poor-1

	1	2	3	4	5	
Poor	○	○	○	○	○	Excellent

The content of the course was organized and easy to follow (Delivery) *

Excellent-5; Good-4; Average-3; Below Average-2; Poor-1

	1	2	3	4	5	
Poor	○	○	○	○	○	Excellent

The Resource Persons were well prepared and able to answer any question (Interaction) *

Excellent-5; Good-4; Average-3; Below Average-2; Poor-1

	1	2	3	4	5	
Poor	○	○	○	○	○	Excellent

The exercises/role play were helpful and relevant (Syllabus Coverage) *

Excellent-5; Good-4; Average-3; Below Average-2; Poor-1

	1	2	3	4	5	
Poor	○	○	○	○	○	Excellent

The Course satisfy my expectation as a value added Programme (Course Satisfaction) *

Excellent-5; Good-4; Average-3; Below Average-2; Poor-1

	1	2	3	4	5	
Poor	○	○	○	○	○	Excellent

Submit Clear form

K.S.R.M. COLLEGE OF ENGINEERING
(UGC-AUTONOMOUS)
Kadapa, Andhra Pradesh, India– 516 003
Approved by AICTE, New Delhi & Affiliated to JNTUA, Ananthapuramu.
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DEPARTMENT OF CIVIL ENGINEERING

Feedback of Value Added Course on "Excel Solutions for Compression Member Design"

Sl. No.	Roll No.	Name	The objectives of the Value Added Course were met	The content of the course was organized and easy to follow	The Resource Person was well prepared and able to answer any question	The exercises/role play were helpful and relevant	The Course satisfy my expectation as a value added Programme
1	209Y1A0128	Kanta Eswar Sai	2	3	5	5	2
2	209Y1A0129	Kanuparthi Vishnu Vardhan	2	4	2	4	2
3	209Y1A0130	Kateeb Syed Noor Mohammed	3	3	2	3	5
4	209Y1A0131	Kethamreddy Praveen Kumar Reddy	3	5	3	3	5
5	209Y1A0133	Koppala Venkata Sampath	5	3	4	2	5
6	209Y1A0134	Kora Pavan Kumar Reddy	2	4	3	3	4
7	209Y1A0135	Kottam Ganesh	5	5	5	4	5
8	209Y1A0136	Kovuru Srivalli (W)	5	2	3	5	5

9	209Y1A0137	Madanapuri Abhilash	3	5	4	3	2
10	209Y1A0138	Maddur Suresh	5	5	5	4	3
11	209Y1A0139	Maddur Vishnu	3	4	2	4	2
12	209Y1A0140	Malisetty Vamsi Kumar	5	3	5	3	3
13	209Y1A0141	Malle Venkata Tharun	4	2	5	5	3
14	209Y1A0142	Mangali Madhu Krishna	3	4	2	3	2
15	209Y1A0143	Manigala Reddysai	3	3	5	2	5
16	209Y1A0144	Manyam Sai Teja Reddy	2	5	4	2	2
17	209Y1A0145	Meesala Subbarayudu	3	3	5	4	4
18	209Y1A0146	Meesala Venkata Sai	4	4	4	5	5
19	209Y1A0147	Mothukuri Rahul	5	5	4	3	5
20	209Y1A0148	Mothukuru Srinath	3	2	2	5	4
21	209Y1A0149	Mude Narendranaik	2	4	5	2	5
22	209Y1A0150	Nadivinti Saleem	3	5	4	4	2
23	209Y1A0151	Nakka Damodar	3	5	5	5	5

24	209Y1A0153	Nandyala Naga Siva Sai	2	3	5	5	2
25	209Y1A0155	Nerniki Valmeeki Sai Kiran	2	4	2	4	2
26	209Y1A0157	Pagadala Siva Sai Kumar	3	3	2	3	5
27	209Y1A0158	Palavala Lokanath	3	5	3	3	5

Coordinator

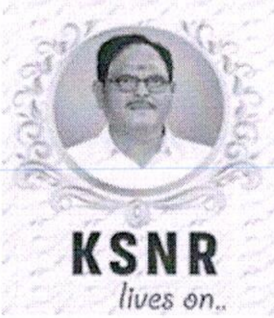
HOD

Head
Department of Civil Engineering
K.S.R.M. College of Engineering
(Autonomous)
KADAPA - 516 003. (A.P.)

K.S.R.M College of Engineering

(AUTONOMOUS)

KADAPA, ANDHRA PRADESH, INDIA-516003



DEPARTMENT OF CIVIL ENGINEERING

CERTIFICATE OF COURSE COMPLETION

This certificate is presented to

Kottam Ganesh (Reg. No. 209Y1A0135), Student of KSRM College of Engineering (Autonomous) for successful completion of value added course on "Excel Solutions for Compression Member Design" offered by Department of Civil Engineering, KSRMCE-Kadapa.

Course Duration: 39 Hours;
From: 7/8/2023 to 4/9/2023

Course Instructor:
Dr. N. Amaranatha Reddy,
Associate Professor, CE, KSRMCE-Kadapa

Coordinator

Head of the Department

Principal

K.S.R.M College of Engineering

(AUTONOMOUS)

KADAPA, ANDHRA PRADESH, INDIA-516003

DEPARTMENT OF CIVIL ENGINEERING

CERTIFICATE OF COURSE COMPLETION

This certificate is presented to

Maddur Suresh (Reg. No. 209Y1A0138), Student of KSRM College of Engineering (Autonomous) for successful completion of value added course on "Excel Solutions for Compression Member Design" offered by Department of Civil Engineering, KSRMCE-Kadapa.

Course Duration: 39 Hours;
From: 7/8/2023 to 4/9/2023

Course Instructor:
Dr. N. Amaranatha Reddy,
Associate Professor, CE, KSRMCE-Kadapa

Coordinator

Head of the Department

Principal

K.S.R.M College of Engineering

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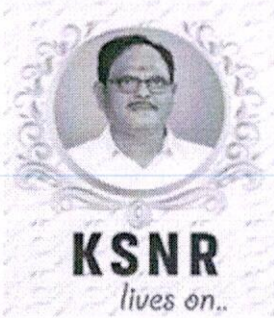

DEPARTMENT OF CIVIL ENGINEERING

CERTIFICATE OF COURSE COMPLETION

This certificate is presented to

M. Reddysai (Reg. No. 209Y1A0143), Student of KSRM College of Engineering (Autonomous) for successful completion of value added course on “Excel Solutions for Compression Member Design” offered by Department of Civil Engineering, KSRMCE-Kadapa.

Course Duration: 39 Hours;
From: 7/8/2023 to 4/9/2023

Course Instructor:
Dr. N. Amaranatha Reddy,
Associate Professor, CE, KSRMCE-Kadapa

Coordinator | **Head of the Department** | **Principal**

K.S.R.M College of Engineering

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KADAPA, ANDHRA PRADESH, INDIA-516003

DEPARTMENT OF CIVIL ENGINEERING

CERTIFICATE OF COURSE COMPLETION

This certificate is presented to

Nakka Damodar (Reg. No. 209Y1A0151), Student of KSRM College of Engineering (Autonomous) for successful completion of value added course on "Excel Solutions for Compression Member Design" offered by Department of Civil Engineering, KSRMCE-Kadapa.

Course Duration: 39 Hours;
From: 7/8/2023 to 4/9/2023

Course Instructor:
Dr. N. Amaranatha Reddy,
Associate Professor, CE, KSRMCE-Kadapa

Coordinator | **Head of the Department** | **Principal**

CERTIFICATE COURSE ON

Design of Compression members

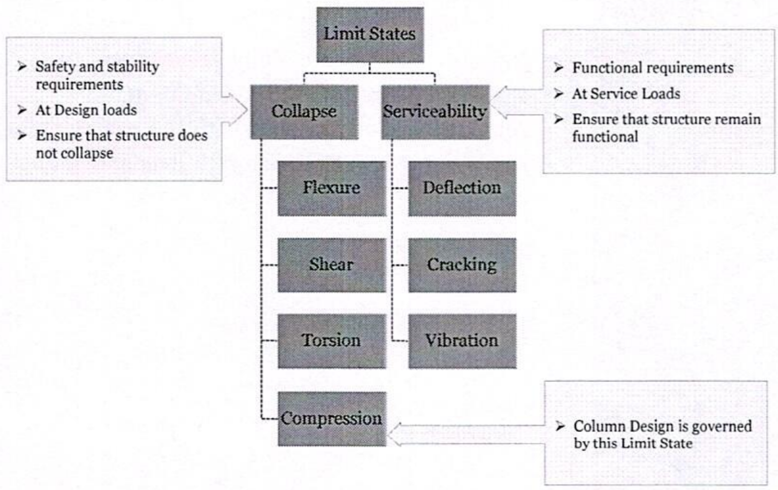
In This Workshop

- Review of Limit State Method
- Design of Short Axially Loaded Columns
- Analysis of Short Columns with Uniaxial Bending
- Analysis of Short Columns with Biaxial Bending

Review – What is a Limit State?

1. A Limit State is a state of impending failure, beyond which a structure ceases to perform its intended function in terms of safety and serviceability
2. On attainment of a Limit State a structure may either collapse or become unserviceable
3. Types of Limit States
   i. Limit States of Collapse
   ii. Limit States of Serviceability

Review – Types of Limit States



Review – Stress-Strain Diagrams for Fe415 Steel

Design Curve for Fe415

Stress Level	Elastic Strain	Inelastic Strain	Total Strain	Design Stress
0.800 $f_y/1.15$	0.00144	0.0000	0.00144	288.7
0.850 $f_y/1.15$	0.00153	0.0001	0.00163	306.7
0.900 $f_y/1.15$	0.00162	0.0003	0.00192	324.8
0.950 $f_y/1.15$	0.00171	0.0007	0.00241	342.8
0.975 $f_y/1.15$	0.00176	0.0010	0.00276	351.8
1.000 $f_y/1.15$	0.00180	0.0020	0.00380	360.9

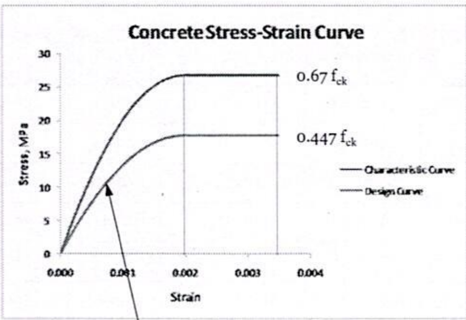
Review – Stress-Strain Diagrams for Fe500 Steel

Design Curve for Fe500

Stress Level	Elastic Strain	Inelastic Strain	Total Strain	Design Stress
0.800 $f_y/1.15$	0.00174	0.0000	0.00174	347.8
0.850 $f_y/1.15$	0.00185	0.0001	0.00195	369.6
0.900 $f_y/1.15$	0.00196	0.0003	0.00226	391.3
0.950 $f_y/1.15$	0.00207	0.0007	0.00277	413.0
0.975 $f_y/1.15$	0.00212	0.0010	0.00312	423.9
1.000 $f_y/1.15$	0.00217	0.0020	0.00417	434.8

Review – Stress-Strain Diagrams Concrete

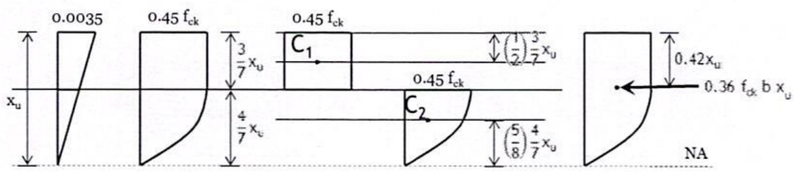
Characteristic and Design Curves



$$f_c = 0.447 f_{CK}\left[2\left(\frac{\varepsilon}{0.002}\right) - \left(\frac{\varepsilon}{0.002}\right)^2\right] \quad 0 \le \varepsilon \le 0.002$$

Review – Concrete (Full) Stress Block Parameters

Concrete Stress Block Parameters



Force $C_1 = b^* 0.45\, f_{ck}{}^* \frac{3}{7} x_u = 0.193\, f_{ck} b\, x_u$ acting at $\frac{3}{14} x_u$ from top

Force $C_2 = b^* \frac{2}{3}\,(0.45\, f_{ck})^* \frac{4}{7} x_u = 0.17\, f_{ck} b\, x_u$ acting at $\frac{20}{56} x_u$ from NA

Total $C = (0.193+0.170) f_{ck}\, b\, x_u = 0.36\, f_{ck}\, b\, x_u$

$$\text{Location of C from Top} = \frac{0.193\, f_{ck}\, b\, x_u\left(\frac{3}{14}x_u\right) + 0.17\, f_{ck} b\, x_u\left(x_u - \frac{20}{56}x_u\right)}{0.36\, f_{ck}\, b\, x_u} = 0.42\, x_u$$

By This Time...

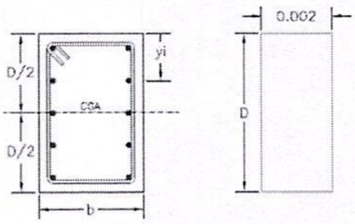
- ✓ Review of Limit State Method
- Design of Short Axially Loaded Columns
- Analysis of Short Columns with Uniaxial Bending
- Analysis of Short Columns with Biaxial Bending

Design of Axially Loaded Short Column

- A compression member is considered as short if slenderness ratio is less than 12 (§25.1.1)
- Maximum strain in axial compression is taken as 0.002 (§39.1.a)
- Minimum Eccentricity for design shall be (§25.4)
  - $e_{min} = l/500 + b/30$
  - $e_{min} = 20$ mm
- If $e_{min} < 0.05$ times lateral dimension, the design equation is given by §39.3

The member shall be designed by considering the assumptions given in 39.1 and the minimum eccentricity. When the minimum eccentricity as per 25.4 does not exceed 0.05 times the lateral dimension, the members may be designed by the following equation:

$$P_u = 0.4 f_{ck} . A_c + 0.67 f_y . A_{sc}$$



1. Pure Axial Compression (e=0)

Design of Axially Loaded Short Column

- For $\varepsilon = 0.002$, the design stresses are
  - For concrete : $0.447 f_{ck}$
  - For Fe250 : $0.870 f_y$
  - For Fe415 : $0.790 f_y$
  - For Fe500 : $0.746 f_y$
- Then Design strength is

  $P_u = 0.447 f_{ck} A_g + (f_{sc} - 0.447 f_{ck}) A_{sc}$

  $P_u = 0.447 f_{ck} A_c + f_{sc} A_{sc}$
- Code reduces the strength by about 10% and gives the Design strength as

  $P_u = 0.4 f_{ck} A_c + 0.67 f_y A_{sc}$
- The required condition is $e \le 0.05$ * lateral dimension

By This Time...

- ✓ Review of Limit State Method
- ✓ Design of Short Axially Loaded Columns
- Analysis of Short Columns with Uniaxial Bending
- Analysis of Short Columns with Biaxial Bending

Analysis of Short Column with Uniaxial Bending

Assumptions

- Plane sections normal to the axis remain plane after bending ⇒ strain varies linearly across the section
- The maximum strain in concrete (at highly compressed edge) is taken as

  $\varepsilon_{cu} = 0.0035$ if $x_u \leq D$ (⇒ section has both tension & compression)

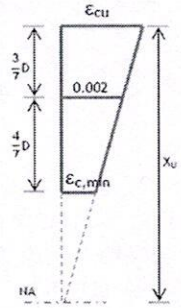
  $\varepsilon_{cu} = 0.0035 - 0.75\,\varepsilon_{c,min}$ if $x_u \geq D$ (⇒ total section is in compression)

The strain ε at any depth y from the most compressed edge is

$$\varepsilon = \varepsilon_{cu} - \frac{\varepsilon_{cu} - \varepsilon_{c,min}}{D}\, y$$

$$\varepsilon = \varepsilon_{cu} - \left[\frac{7}{3}\varepsilon_{cu} - \frac{4}{3}\, 0.0035\right]\frac{y}{D}$$

$$\varepsilon = 0.002 \;\; at \; y = \frac{3}{7}D$$



- Tensile strength of concrete is ignored
- Stress in steel is derives from its representative stress-strain curve

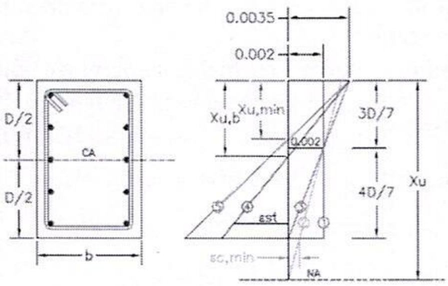
Analysis of Short Column with Uniaxial Bending

General Analysis Steps for a given Strain Profile

- Draw the stress diagram for concrete and find total compressive force C_u
- Calculate the moment M_{uc} of C_u about the centroidal axis
- From strain profile determine strain ε_i in all steel bars and read corresponding stress f_{si} for each of the bars
- Calculate the total force in steel bars as $\Sigma C_{si} = \Sigma(f_{si} - f_{ci})A_{si}$. f_{ci} is the stress in concrete at the level of steel bar i
- Calculate moment of forces in steel bars about centroidal axis as ΣM_{si}
- Ultimate axial load $P_u = C_u + \Sigma C_{si}$
- Ultimate moment is $M_u = M_{uc} + \Sigma M_{si}$

Analysis of Short Column with Uniaxial Bending

General Strain Profiles at Limit State

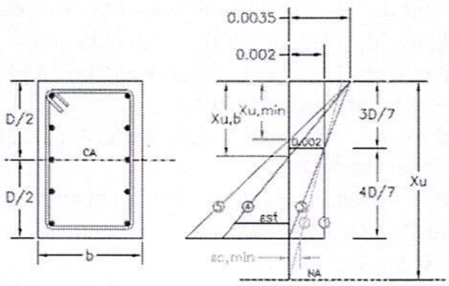


Case (1)

- Uniform compressive strain of ε_{cu} = 0.002 across the column section
- Eccentricity is zero (e = 0 and M_u = 0)
- Neutral axis is at infinity ($x_u = \infty$)

Analysis of Short Column with Uniaxial Bending

General Strain Profiles at Limit State

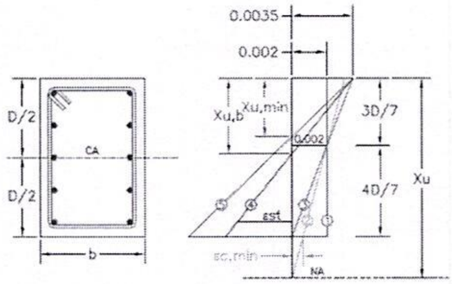


Case (2)

- General case of uniaxial compression ($M_u \neq 0$, $P_u \neq 0$)
- NA lies outside of section and $e_D < e < \infty$
- Strain varies linearly from ε_{cu} (<0.0035) to $\varepsilon_{c,min}$
- There is no tension in the column section

Analysis of Short Column with Uniaxial Bending

General Strain Profiles at Limit State

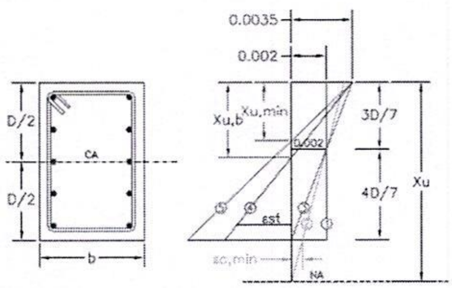


Case (3)

- NA coincides with the least compressed edge and $e = e_D$
- For $e > e_D$, entire section is under compression and NA lies outside of section
- For $e < e_D$, tension also exists, NA lies with the section and $\varepsilon_{cu} = 0.0035$

Analysis of Short Column with Uniaxial Bending

General Strain Profiles at Limit State

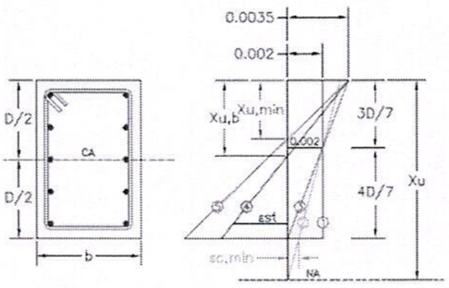


Case (4)

- Is called the balanced failure condition which is a tension failure
- NA depth is $x_{u,b} = d(\varepsilon_{cu}/(\varepsilon_{cu}+\varepsilon_{st}))$
- Maximum concrete strain $\varepsilon_{cu} = 0.0035$
- Maximum steel in steel $\varepsilon_{st} = \varepsilon_{yd}$

Analysis of Short Column with Uniaxial Bending

General Strain Profiles at Limit State

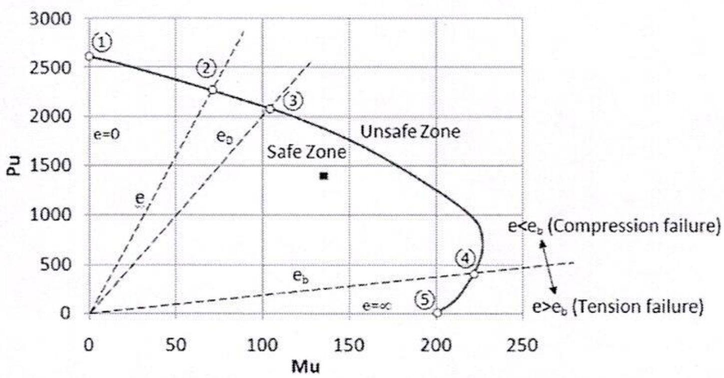


Case (5)

- Section is subjected to pure bending and axial load $P_u = 0$
- NA depth is minimum at $x_{u,min}$
- If $x_u < x_{u,min}$ then section is under axial tension and moment
- $x_{u,min}$ is found by trails

Analysis of Short Column with Uniaxial Bending

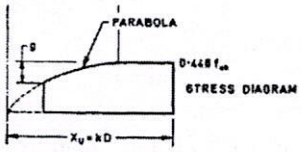
Interaction Curve



- Represents the design strength for a given column section
- If a design point (Mu, Pu) falls with in the design interaction, the section is safe; otherwise it is not

Analysis of Short Column with Uniaxial Bending

Stress Block Parameters for $x_u > D$



Let $x_u = kD$ and let g be the difference between the stress at the highly compressed edge and the stress at the least compressed edge. Considering the geometric properties of a parabola,

$$g = 0{\cdot}446 f_{ck} \left[\frac{\frac{4}{7}D}{kD - \frac{3}{7}D} \right]^2$$

$$= 0{\cdot}446 f_{ck} \left(\frac{4}{7k-3} \right)^2$$

Area of stress block

$$= 0{\cdot}446 f_{ck} D - \frac{g}{3}\left(\frac{4}{7} D\right)$$

$$= 0{\cdot}446 f_{ck} D - \frac{4}{21} g D$$

$$= 0{\cdot}446 f_{ck} D \left[1 - \frac{4}{21}\left(\frac{4}{7k-3}\right)^2\right]$$

The centroid of the stress block will be found by taking moments about the highly compressed edge.

Moment about the highly compressed edge

$$= 0{\cdot}446 f_{ck} D \left(\frac{D}{2}\right) - \frac{4}{21} g D \left[\frac{3}{7} D + \frac{3}{4}\left(\frac{4}{7} D\right)\right]$$

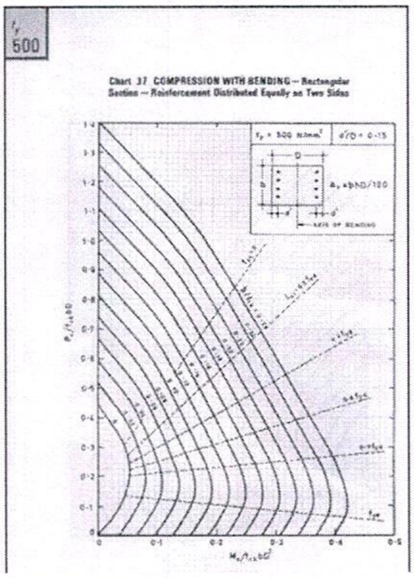
$$= 0{\cdot}446 f_{ck} \frac{D^2}{2} - \frac{8}{49} g D^2$$

The position of the centroid is obtained by dividing the moment by the area. For different values of k, the area of stress block and the position of its centroid are given in Table H.

Design of Short Column with Uniaxial Bending

Design of Section Using SP16

- Design charts are provided for rectangular and circular section
- Different configurations of steel placement for rectangular sections
- Charts for Fe250, Fe415 and Fe500
- Now-a-days computer programs are used for design



By This Time...

- ✓ Review of Limit State Method
- ✓ Design of Short Axially Loaded Columns
- ✓ Analysis of Short Columns with Uniaxial Bending
- Analysis of Short Columns with Biaxial Bending

Design of Short Column with Biaxial Bending

Simplified Code Procedure for Design

39.6 Members Subjected to Combined Axial Load and Biaxial Bending

The resistance of a member subjected to axial force and biaxial bending shall be obtained on the basis of assumptions given in **39.1** and **39.2** with neutral axis so chosen as to satisfy the equilibrium of load and moments about two axes. Alternatively such members may be designed by the following equation:

$$\left[\frac{M_{ux}}{M_{ux1}}\right]^{\alpha_n} + \left[\frac{M_{uy}}{M_{uy1}}\right]^{\alpha_n} \le 1.0$$

where

M_{ux}, M_{uy} = moments about x and y axes due to design loads,

M_{ux1}, M_{uy1} = maximum uniaxial moment capacity for an axial load of P_u, bending about x and y axes respectively, and

α_n is related to P_u/P_{uz}

where $P_{uz} = 0.45 f_{ck} \cdot A_c + 0.75 f_y \cdot A_{sc}$

For values of P_u/P_{uz} = 0.2 to 0.8, the values of α_n vary linearly from 1.0 to 2.0. For values less than 0.2, α_n is 1.0; for values greater than 0.8, α_n is 2.0.

By This Time...

- ✓ Review of Limit State Method
- ✓ Design of Short Axially Loaded Columns
- ✓ Analysis of Short Columns with Uniaxial Bending
- ✓ Analysis of Short Columns with Biaxial Bending

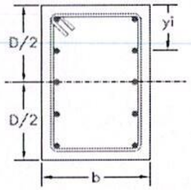
Discussion

Queries Please!!!

Workshop Concludes

Have A Nice Day

Analysis and Design of RCC Column
Case: Axial load with Uniaxial moment
Configuration: Equal on Two faces

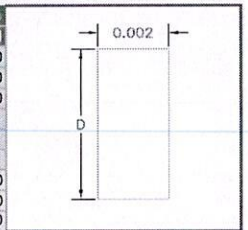


Section Properties			
Width	b=	300	mm
Depth	D=	500	mm
Clear Cover	c=	40	mm
Tie Diameter	Φv=	8	mm
Main Bar Diameter	Φ=	25	mm
Effective Cover	d'=	60.5	mm
Ratio	d'/D=	0.12	

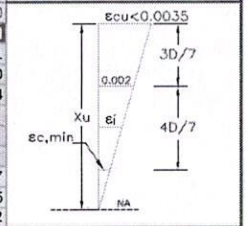
Materials and Design Loads			
Concrete Grade	fck=	25	MPa
Steel Grade	fy=	415	MPa
Factored Load	Pu=	1400	kN
Factored Moment	Mu=	135	kN
Eccentricity	e=	96	mm

Reinforcement			
% Steel	p=	1.90	%
No. of Layers	n=	3	
No. of Bars		6	

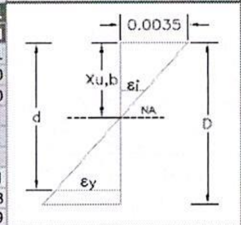
Case 1: Pure Axial Load Condition				xu=	∞	k=	∞
Layer	Yi	As	ε	fs	fc	P	M
1	60.5	950.0	0.002	327.7	11.2	300.7	57.0
2	250.0	950.0	0.002	327.7	11.2	300.7	0.0
3	439.5	950.0	0.002	327.7	11.2	300.7	-57.0
In Steel						902.2	0.0
In Concrete						1676.3	0.0
Total						2578.5	0.0



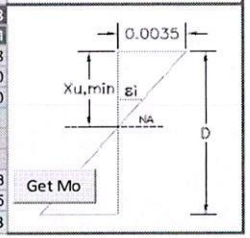
Case 2: NA outside section			xu=	650.0 mm	k=		1.300
Layer	Yi	As	ε	fs	fc	P	M
1	60.5	950.0	0.00271	350.4	11.2	322.3	61.1
2	250.0	950.0	0.00184	319.6	11.1	293.0	0.0
3	439.5	950.0	0.00097	193.7	8.2	176.2	-33.4
In Steel						791.6	27.7
In Concrete						1539.0	24.5
Total						2330.5	52.2



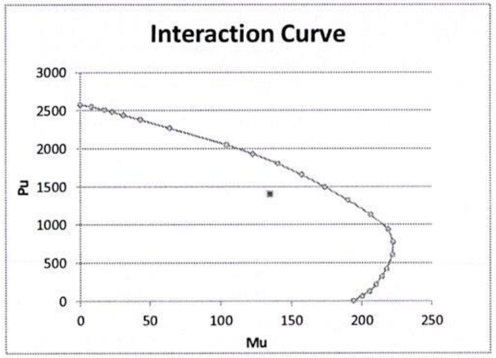
Case 4: Balanced Condition			xu,b=	210.6 mm		k=	0.421
Layer	Yi	As	ε	fs	fc	P	M
1	60.5	950.0	0.00249	345.0	11.2	317.1	60.1
2	250.0	950.0	-0.00066	-131.4	0.0	-124.8	0.0
3	439.5	950.0	-0.00381	-360.9	0.0	-342.9	65.0
In Steel						-150.6	125.1
In Concrete						571.7	92.8
Total						421.1	217.9



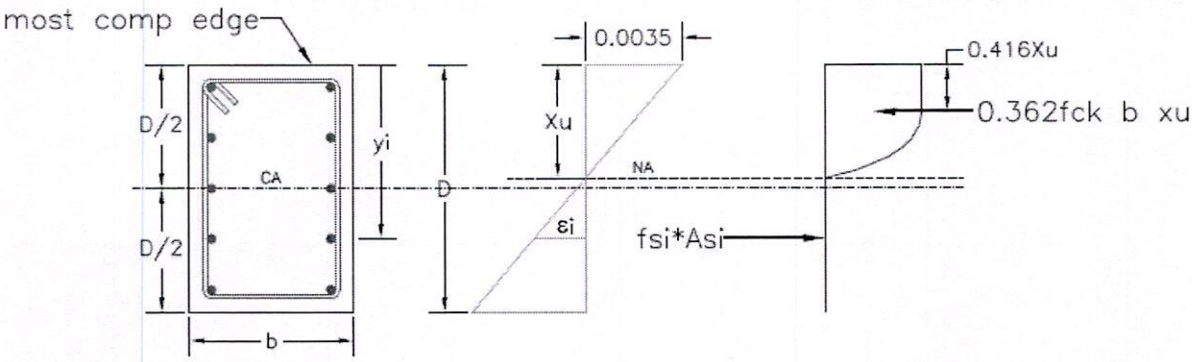
Case 5: Pure Flexure Condition			xu,min=	139.0 mm		k=	0.278
Layer	Yi	As	ε	fs	fc	P	M
1	60.5	950.0	0.00198	326.9	11.2	299.9	56.8
2	250.0	950.0	-0.00279	-352.1	0.0	-334.5	0.0
3	439.5	950.0	-0.00757	-360.9	0.0	-342.9	65.0
In Steel						-377.4	121.8
In Concrete						377.4	72.5
Total						0.0	194.3



Interaction Curve						
P	M	e	k	x	Remark	
0.0	194.3	∞	0.278	139.0	Flexure	Tension->
59.7	200.3	3352.3	0.307	153.3		
124.6	205.6	1649.9	0.335	167.6		
214.3	210.3	981.5	0.364	181.9		
322.8	214.4	664.4	0.393	196.3		
421.1	217.9	517.5	0.421	210.6	Balanced	
605.6	222.0	366.6	0.479	239.5		<-Compression
775.3	222.4	286.9	0.537	268.5		
938.5	219.0	233.4	0.595	297.4		
1128.2	206.5	183.0	0.653	326.3		
1320.8	190.1	143.9	0.711	355.3		
1496.3	173.8	116.2	0.768	384.2		
1658.4	157.4	94.9	0.826	413.2		
1801.4	140.3	77.9	0.884	442.1		
1929.1	122.9	63.7	0.942	471.1		
2048.4	104.3	50.9	1.000	500.0	e=eD	
2268.3	64.0	28.2	1.200	600.0		
2376.3	43.3	18.2	1.400	700.0		
2439.0	31.1	12.7	1.600	800.0		
2479.7	23.1	9.3	1.800	900.0		
2507.7	17.5	7.0	2.000	1000.0		
2550.6	7.9	3.1	3.000	1500.0		
2578.5	0.0	0.0	∞	∞	Axial	



Computations when the NA lies inside the section (k≤1)



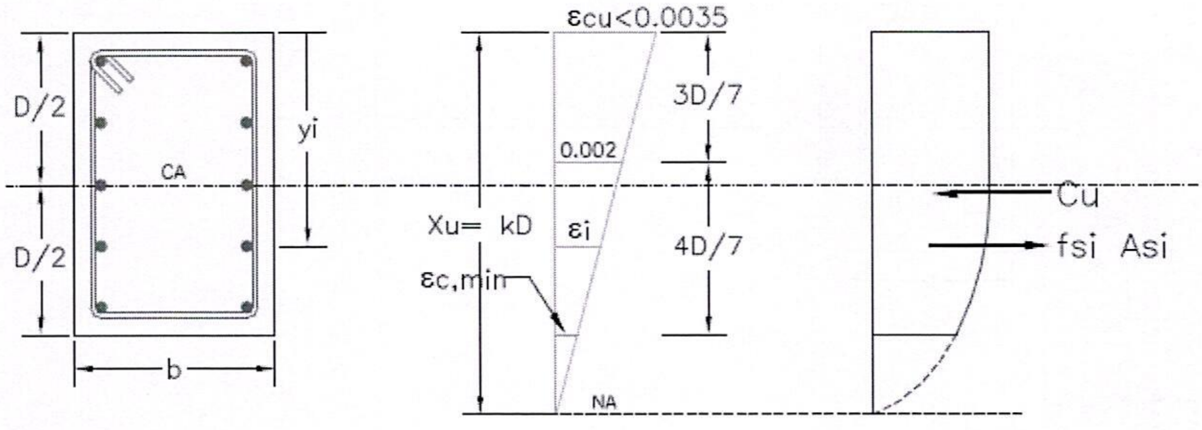
Neural Axis Inside the Section

For this case:

1. Both tension and compression exist in the section
2. Ratio $k = x_u/D \leq 1$
3. Maximum strain in concrete $\varepsilon_{CU} = 0.0035$
4. The condition $\varepsilon_{CU}=0.0035$ and maximum $\varepsilon_{Si} = 0.002+0.87f_y/E_S$ is balanced failure for which $X_U = (0.0035/(0.0055+0.87f_y/E_S)(D-c')$; c' is effective cover
5. $X_U \geq X_{UMIN}$, otherwise column will under tensile force. X_{MIN} is found by trials
6. The condition $X_U = X_{UMIN}$ is pure flexure failure $\Rightarrow P_U = 0$, $e = \infty$

Depth of NA	X_U (known or assumed)	
Force in concrete	$C_{UC} = 0.362\, f_{CK}\, b\, X_U$	
Moment of C_{uc} about CA	$M_{UC} = C_{UC}\,(½D - 0.416\, X_U)$	
Strain in concrete/steel in layer i	$\varepsilon_i = 0.0035\left(\dfrac{x_u - y_i}{x_u}\right)$	
Stress in concrete in layer i	$f_{Ci} = 0$	if $\varepsilon_i < 0$
	$f_{ci}=0.447f_{CK}\left[2\left(\dfrac{\varepsilon_i}{0.002}\right)-\left(\dfrac{\varepsilon_i}{0.002}\right)^2\right]$	if $0 \leq \varepsilon_i \leq 0.002$
	$f_{Ci} = 0.447\, f_{CK}$	if $\varepsilon_i > 0.002$
Stress in Steel in layer i	Read f_{Si} from corresponding stress-strain curve	
Force in Steel in layer i	$C_{Si} = (f_{Si} - f_{Ci})\, A_{Si}$	
Moment of C_{Si} about CA	$M_{Si} = C_{Si}\,(½D - y_i)$	
Ultimate Axial load capacity	$P_U = C_{UC} + \Sigma C_{Si}$	
Ultimate Moment capacity	$M_U = M_{UC} + \Sigma M_{Si}$	

Computations when the NA lies outside the section (k>1)



Neutral Axis Outside of Section (0<e<eD)

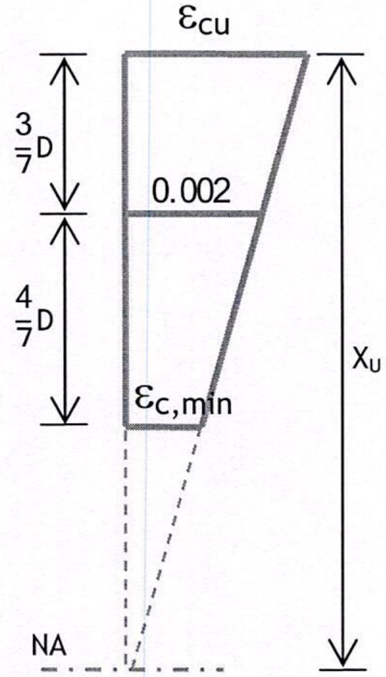
For this case:

1. Entire section is in compression
2. Ratio $k = x_u/D > 1$
3. Maximum strain ε_{CU} in concrete is such that $0.0020 \leq \varepsilon_{CU} \leq 0.0035$
4. The condition $\varepsilon_{CU} = 0.002$ is pure axial compression $\Rightarrow M_U = 0,\ e = 0\ \&\ X_U = \infty$

Description	Equation/Symbol
Factor	$k = X_U/D$
Force in concrete	$C_{UC}=0.447\left[1-\frac{4}{21}\left(\frac{4}{7k-3}\right)^2\right] f_{CK}bD$
Moment of C_{UC} about CA	$M_{UC}=C_{UC}\left[0.5-\frac{0.5-\frac{8}{49}\left(\frac{4}{7k-3}\right)^2}{1-\frac{4}{21}\left(\frac{4}{7k-3}\right)^2}\right]D$
Strain in concrete/steel in layer i	$\varepsilon_i=0.002\left(\frac{x_u-y_i}{x_u-\frac{3}{7}D}\right)$
Stress in concrete in layer i	$f_{ci} = 0$ if $\varepsilon_i < 0$
	$f_{ci}=0.447f_{CK}\left[2\left(\frac{\varepsilon_i}{0.002}\right)-\left(\frac{\varepsilon_i}{0.002}\right)^2\right]$ if $0 \leq \varepsilon_i \leq 0.002$
	$f_{ci} = 0.447\ f_{CK}$ if $\varepsilon_i > 0.002$
Stress in Steel in layer i	Read f_{Si} from corresponding stress-strain curve

Force in Steel in layer i	$C_{Si} = (f_{Si} - f_{Ci})\, A_{Si}$
Moment of C_{Si} about CA	$M_{Si} = C_{Si}\, (½D - y_i)$
Ultimate Axial load capacity	$P_U = C_{UC} + \Sigma C_{Si}$
Ultimate Moment capacity	$M_U = M_{UC} + \Sigma M_{Si}$

$$f_c = 0.447 f_{CK}\left[2\left(\frac{\varepsilon}{0.002}\right) - \left(\frac{\varepsilon}{0.002}\right)^2\right] \quad 0 \leq \varepsilon \leq 0.002$$

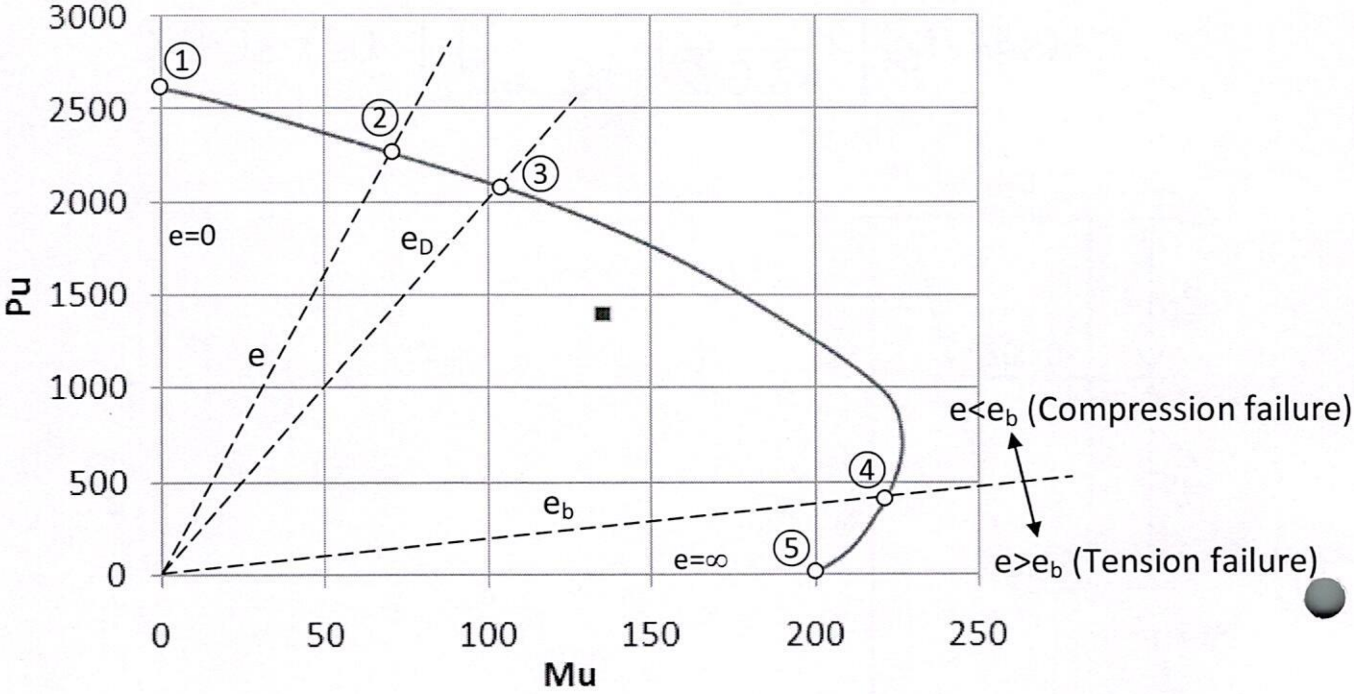


The strain ε at any depth y from the most compressed edge is

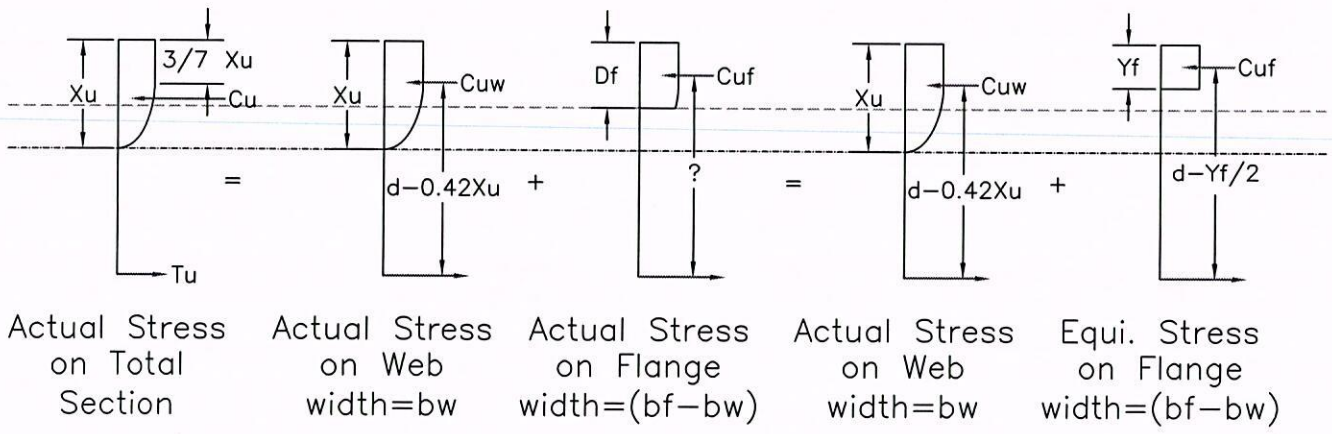
$$\varepsilon = \varepsilon_{cu} - \frac{\varepsilon_{cu} - \varepsilon_{c,min}}{D} y$$

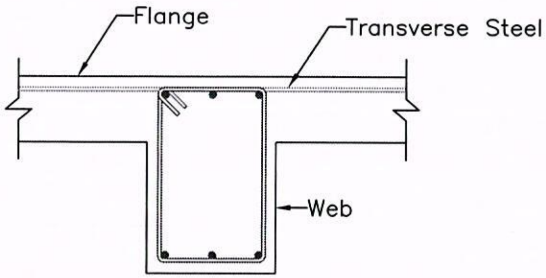
$$\varepsilon = \varepsilon_{cu} - \left[\frac{7}{3}\varepsilon_{cu} - \frac{4}{3}\,0.0035\right]\frac{y}{D}$$

$$\varepsilon = 0.002 \;\; at\; y = \frac{3}{7}D$$

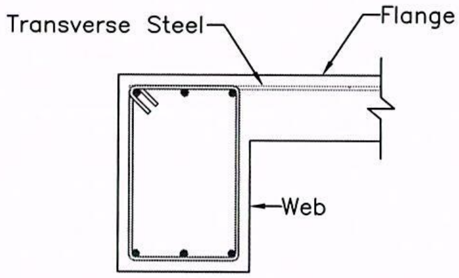


3000
2500
2000
1500
1000
500
0
0
50
100
150
200
250
Pu
Mu
①
②
③
④
⑤
e=0
e
e_D
e_b
e=∞
e<e_b (Compression failure)
e>e_b (Tension failure)

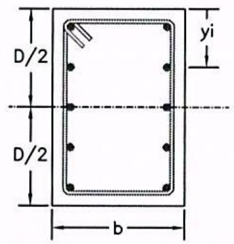


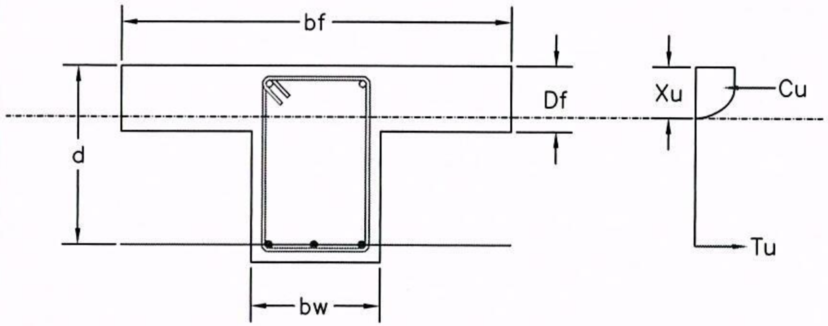


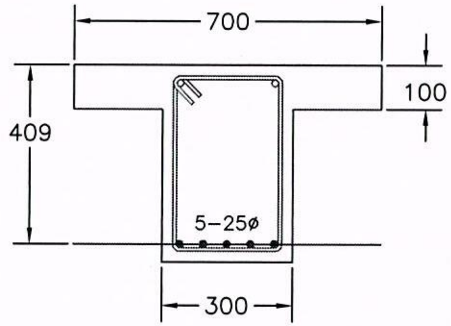
T−Section



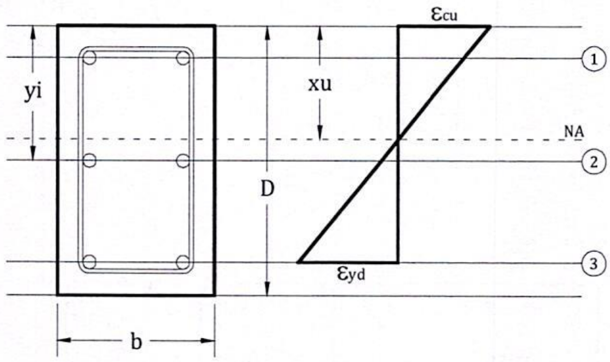
L−Section







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	=$\varepsilon_{st}=0.002+0.87f_y/E_s$	=	0.0038	
Depth to most tensile steel layer	=$d=D-c-\phi_T-\phi/2$	=	439.5	mm
Depth of neutral axis	=$x_u=d(\varepsilon_{cu}/(\varepsilon_{cu}+\varepsilon_{st}))$	=	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

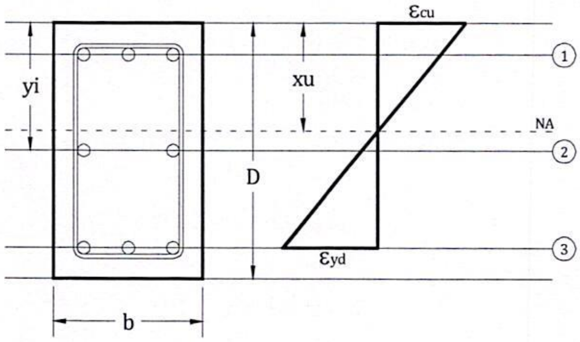
d. Balanced failure design forces

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 =

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

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

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

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

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

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

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

Steel force and moment =

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

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

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

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

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

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

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

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