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Department of Civil Engineering

B.Tech.

CE 202 - Mechanics of Materials

Dr. Visalakshi Talakokula, Professor

CE- 202: MECHANICS OF MATERIALS

B.Tech. - Civil Engineering

COURSE FILE

Spring Semester, 2020-21

Dr. Visalakshi Talakokula, Professor

Contents of the Course File

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CFA1- Details of the course

Details of the Course

Program : **B.Tech (Civil Engineering)**
Course Code : CE-202
Course Name : **Mechanics of Materials**
Credit Structure :

L	T	P	C
3	**1**	**0**	**4**

Pre-requisites : Engineering Mechanics
Co-requisites : None
Instructor's Weblink :
htt*https://www.mahindraecolecentrale.edu.in/faculty/visalakshi-talakokula*
Name of Instructor : **Dr. Visalakshi Talakokula**
Term : Spring 2020-21
Position : II Year – II Sem.
Batch : 2019 – 2023
Regulation : R18
No. of Students : 42
Instructor's email : visalakshi.talakokula@mahindrauniversity.edu.in
Contact Hours : Monday 8.25-9.20 AM
Thursday 9.25-10.20 AM
Friday 9.25-11.30AM

CFA2- Course Syllabus

Course Name:	**Mechanics of Materials**	**Course Code:**			CE 202
Department	Civil Engineering	**Type:**			Core
L-T-P Structure	**3-1-0**	**Credits**	**4**	**Pre-requisite:**	Engineering Mechanics

Course Content:

Module 1:
Stress-Strain behavior for uniaxial loading, Generalized Hooke's law, Elastic constants for isotropic materials, Notion of equilibrium, Free body diagrams, Deformation of axial members, Statically determinate and indeterminate problems, Truss structures – Stiffness methods.

Module 2:
Definition of stress, Different states of stress – uniaxial, biaxial, plane stress, Transformation of plane stress, Principal stresses and maximum shear stress, Mohr's circle.
Definition of strain – shear and normal strains, Transformation of plane strain, Principal strains.

Module 3:
Bending of beams: Relation between transverse loads, shear and bending moments, Shear and bending moment diagrams, Bending and Shear stresses in beams, ~~Deflections in beams~~.

Module 4:
Torsion: Torsional moment diagrams, Torsion formula for circular cross-sections, Maximum normal and shear stresses, Angle of twist, Power transmission through shafts.

Module 5:
Elastic stability: Notion of stability of equilibrium, Euler buckling.

Textbooks:

1. An Introduction to the Mechanics of Solids, Crandall S.H, Dahl N.C, McGraw-Hill.

2. Strength of Materials Vol. I by S P Timonshenko.
3. Engineering Mechanics of Solids by Egor P Popov

OBJECTIVE OF THE COURSE

- To understand different types of loading applied on engineering structures
- To understand response of engineering materials subjected to different stresses and strains.
- To develop a thorough understanding of the relations between the loads applied to a deformable body and the stresses produced in the body
- To enable students develop all necessary formulas in a rational and logical manner and to clearly indicate the conditions under which they may be safely applied to the analysis and design of actual engineering structures and machine components

EXPECTED LEARNING OUTCOMES: *At the end of the course, the learner will be able to:*

CO1. Understand and apply the principles of equilibrium and determine internal loadings in statically determinate structures, subjected to an external load viz. axial, transverse load, torsional and bending moment.

CO2. Evaluate normal and shear stress on plane and inclined sections and be able to determine the state of stress, principal stresses and maximum in-plane shear stresses.

CO3. Determine the internal forces developed in the beam due to transverse loading and able to draw the variation of these under different loading and support conditions.

CO4. Analyze the torsional stresses in shafts and calculate the power transmitted

CO5. Apply the concepts of stability and analyze buckling in columns

Pedagogy / Summary of Teaching and Learning

This course in mechanics of materials introduces the fundamental principles to study the mechanical behaviour of engineering materials subjected to slowly applied or steady state loading conditions. The course has one tutorial hour per week and hence weekly assignments are provided to students to aid in their learning activity. Two mid-term exams and one final exam was conducted for continuous assessment of students during the course.

Essential reading

Text Book/s

- R. C. Hibbeler; *Mechanics of Materials*, ISBN: 9789332518605, Pearson Education
- Beer, F. P., E. R. Johnston, and J. T. DeWolf. *Mechanics of materials*, 5th SI Edition.

Reference Books

- S. Timoshenko and J.N. Goodier; *Theory of elasticity*, McGraw Hill Publications.
- L.S. Srinath; *Advanced Mechanics of Solids*, Tata McGraw Hill Education Pvt Ltd., ISBN-10: 0070702608.

Detail Session Plan

Class #	Topic
1	Introduction into Mechanics of deformable solids.
2	Equilibrium of a deformable body
3	Stress, Average Normal Stress in an Axially Loaded Bar
4	Average Shear Stress
5	Allowable Stress Design
6	Deformation and Strain
7	Introduction to Mechanical Properties of Materials
8	Tension and Compression Test, Stress Strain Diagram, Stress Strain Behaviour of Ductile and Brittle Materials
9	Hooke´s law
10	Elastic constants for isotropic materials - Constants of elasticity: Young’s modulus, shear modulus, Poisson’s ratio
11	Elastic Deformation of axial members

12	Statically Indeterminate Axially Loaded Members
13	Thermal Stress
14	Different states of stress – uniaxial, biaxial, plane stress
15	Transformation of Plane Stress
16	Determination of principal stresses and principal planes
17	Determination of Maximum shear stress
18	Concept of Mohr's circle
19	Definition of strain – shear and normal strains
20	Transformation of plane strain, Principal strains
21	Introduction to Bending of beams, Flexure Formula, Assumptions in Basic Bending Theory
22	Relation between transverse loads, shear and bending moments
23	Differential equations of the deflection curve, computation of slope and deflection by integration
24	Shear and bending moment diagrams
25	Analysis of Various Types of Beams- Cantilever, Simply Supported, Propped Cantilever, Beams with Overhangs
26	Introduction to Transverse Shear
27	Shear in Straight Members
28	Derivation of the Shear Formula
29	Shear Flow in Built Up Members
30	Shear Flow in Thin Walled Members
31	Introduction to Torsion

32	Torsion formula for circular cross-sections
33	Polar moment of inertia
34	Maximum normal and shear stresses
35	Angle of twist, Power transmission through shafts
36	Introduction to Buckling
37	Elastic stability, Notion of stability of equilibrium
38	Euler buckling, Critical Load
39	Ideal Column with Pin Supports
40	Effect of end conditions on column buckling

Evaluation Components:

Mid semester Examination	20%
End Term Examination	30%
Project	20%
Presentations/seminar	10%
Assignments	10%
quizzes	10%

CFA3- Semester Timetable

Time Table

	08:25 – 9:20 a.m.	09:25 – 10:20 a.m.	10:35-11:30 a.m	11:35 am-12.30 pm	12:35 am-1.30 pm	2:35 -3:30 p.m.	3-4pm
Monday	Mechanics of Materials	Engineering Surveying	Concrete Technology	Fluid Mechanics		French	
Tuesday	Numerical Methods	Engineering Surveying	Concrete Technology	Surveing Lab		French	
Wednesday	Numerical Methods		Constructoction Techology and	Fluid Mechanics Lab			Matlab class
Thursday	Numerical Methods	Mechanics of Mateials	Constructoction Techology and	Fluid Mechanics	Drawing Session		
Friday	Fluid Mechanics	Mechanics of Mateials(Tut)	Mechanics of Materials	Concrete Technology Lab			
Saturday	Design Thinking						

CFB1- Student Details (Sr. no. ID No, Name, Gender)

List of Students enrolled

S. No.	HT No.	Name	Gender
1	19XJ1A0101	A DURGA GAYATRI VINUTHNA	Female
2	19XJ1A0102	A PRITIKA REDDY	Female
3	19XJ1A0103	ADITH KOMMALA REDDY	Male
4	19XJ1A0104	ANVITHA YADAMA	Female
5	19XJ1A0105	AITIPAMULA BHAVANI	Female
6	19XJ1A0106	AMAY SHUKLA	Male
7	19XJ1A0107	BONDADA CH ABHISHEK KUMAR	Male
8	19XJ1A0108	V.S.Ch.Dheeraj Kumar Bondada	Male
9	19XJ1A0109	CAROL RACHEL KAKILETI	Female
10	19XJ1A0110	DEVANSH BANSAL	Male
11	19XJ1A0111	DUGGIRALA SAI VAISHNAV	Male
12	19XJ1A0112	GATIKA ABHISTA SAI RISHI KUMAR	Male
13	19XJ1A0113	INDRANEEL REDDY BILLA	Male
14	19XJ1A0114	SHANTAN REDDY JANNUPREDDY	Male
15	19XJ1A0115	KADIRI BHUVANESH	Male
16	19XJ1A0116	KALAMSETTY VISWATEJA	Male
17	19XJ1A0117	KANIGIRI CHANDRAKANTH REDDY	Male
18	19XJ1A0118	BHUVAN ALLADI	Male
19	19XJ1A0119	MANVITHA THEEGALA	Female
20	19XJ1A0120	MOHAMMED KHURRAM HASSAN GHORI	Male
21	19XJ1A0121	MOHAMMED MUJTABA MOID	Male
22	19XJ1A0122	NAVARI SIDDARTH REDDY	Male
23	19XJ1A0123	NEERUDI YESHWANTH	Male
24	19XJ1A0124	PENUMATSA GOWTHAM VARMA	Male
25	19XJ1A0125	SAKETHRAM REDDYGARI	Male
26	19XJ1A0126	SAKSHAM RAJPUT	Male
27	19XJ1A0127	SHERI SAKETH REDDY	Male
28	19XJ1A0128	SIRI REDDY PANNALA	Female
29	19XJ1A0129	SREE VANSH BUDDINENI	Male
30	19XJ1A0130	TARUN SAGAR REDDY BOMMIREDDY	Male
31	19XJ1A0131	VANGA AMULYA REDDY	Female

32	19XJ1A0132	VENKAT RISHI BADIGA	Male
33	19XJ1A0133	VUNGARALA YASHWANTH RAO SUBASH	Male
34	19XJ1A0134	Y RIDHIMA REDDY	Female
35	19XJ1A0135	AMITH CHANDRA KODALI	Male
36	19XJ1A0136	DEVIREDDY SOWMYA	Female
37	19XJ1A0137	GOPU VENKATA SIVA SAI SAMEER	Male
38	19XJ1A0138	SLOKA GAMPA	Female
39	19XJ1A0139	SYNTHIA MAIYUKHI KOTAMRAJU	Male
40	19XJ1A0140	NAINENI RAGHU CHANDER	Male
41	19XJ1A0141	P VISHWAAJITH	Male
42	19XJ1A0142	Sumedh	Male
43	19XJ1A0143	Sourab Vokkalkar	Male
44	19XJ1A0144	Semanth Reddy	Male

CFB2- Attendance Record (Lectures, Tutorials and Labs)

S. No.	HT No.	Name	Total Classes attended
1	19XJ1A0101	A DURGA GAYATRI VINUTHNA	37
2	19XJ1A0102	A PRITIKA REDDY	38
3	19XJ1A0103	ADITH KOMMALA REDDY	35
4	19XJ1A0104	ANVITHA YADAMA	19
5	19XJ1A0105	AITIPAMULA BHAVANI	35
6	19XJ1A0106	AMAY SHUKLA	24
7	19XJ1A0107	BONDADA CH ABHISHEK KUMAR	37
8	19XJ1A0108	V.S.Ch.Dheeraj Kumar Bondada	34
9	19XJ1A0109	CAROL RACHEL KAKILETI	27
10	19XJ1A0110	DEVANSH BANSAL	34
11	19XJ1A0111	DUGGIRALA SAI VAISHNAV	32
12	19XJ1A0112	GATIKA ABHISTA SAI RISHI KUMAR	10
13	19XJ1A0113	INDRANEEL REDDY BILLA	15
14	19XJ1A0114	SHANTAN REDDY JANNUPREDDY	14
15	19XJ1A0115	KADIRI BHUVANESH	8
16	19XJ1A0116	KALAMSETTY VISWATEJA	5
17	19XJ1A0117	KANIGIRI CHANDRAKANTH REDDY	34
18	19XJ1A0118	BHUVAN ALLADI	16
19	19XJ1A0119	MANVITHA THEEGALA	37
20	19XJ1A0120	MOHAMMED KHURRAM HASSAN GHORI	13
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42	19XJ1A0142	Sumedh	35
43	19XJ1A0143	Sourab Vokkalkar	4
44	19XJ1A0144	Semanth Reddy	34

CFC1- Summary of COs and evaluation criteria

No	Course Outcomes
CO1	Understand and apply the principles of equilibrium and determine internal loadings in statically determinate structures, subjected to an external load viz. axial, transverse load, torsional and bending moment
CO2	Evaluate normal and shear stress on plane and inclined sections and be able to determine the state of stress, principal stresses and maximum in-plane shear stresses.
CO3	Determine the internal forces developed in the beam due to transverse loading and able to draw the variation of these under different loading and support conditions.
CO4	Analyze the torsional stresses in shafts and calculate the power tramsmitted
CO5	Apply the concepts of stability and analyze buckling in columns

Evaluation Components:

Evaluation Components	**Weight age**	**Mapping Course Outcomes**
Mid semester Examination	20%	4,5
End Term Examination	30%	1,2,3,4,5
Project	20%	1,2
Presentations/seminar	10%	1,2
Assignments	10%	1,2,3,4,5
quizzes	10%	1,2,3,4,5

CFC3- Team Projects (w/- CO mapping, if applicable) + Model Key

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Winter Semester, 2021
B.Tech. (Civil Engineering), Semester-IV
CE-202: Mechanics of Materials
Team Project

Course Coordinator: Visalakshi Talakokula **Date of submission: 15 May** 2021

TITLE: To determine the ultimate strength of different materials

PROJECT OVERVIEW:

Students learn about the variety of materials used by engineers in the design and construction of structures. They also find out about the material properties important to the construction and consider the advantages and disadvantages of steel and concrete as common bridge-building materials and other materials to handle compressive and tensile forces

Goals & Objectives:

To observe the stress-strain behavior of different materials
Understand the behavior of brittle and ductile materials and classify them
To determine the ultimate strength of different building materials

Learning Objectives

After completing the project, students should be able to:

List several common materials used the design and construction of structures.
Describe several factors that engineers consider when selecting materials for the design of a bridge.
Explain the advantages and disadvantages of common materials used in engineering structures (steel and concrete)

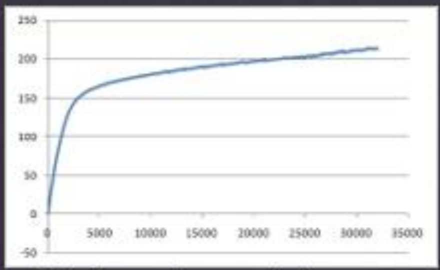
MAHINDRA UNIVERSITY
CIVIL DEPARTMENT
TENSILE TEST FOR ALUMINIUM

Objective: 1. To observe how a given material behaves when it is subjected to tensile loads.
2. To draw the stress-strain curve.
3. To observe different salient features from the stress-strain curve.

Methodology

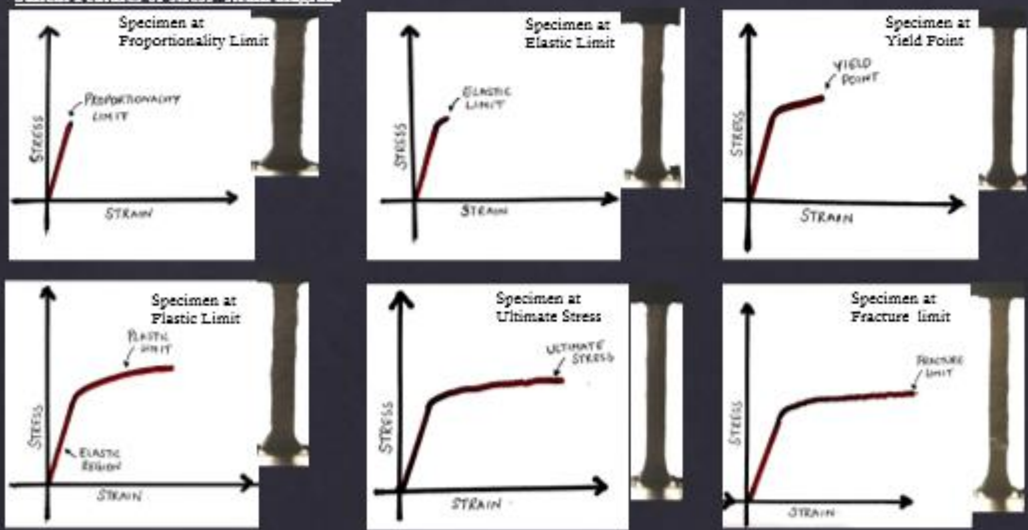
1. We Collected the raw material, the material was cut and properly filed into a dog-bone shape with correct dimensions which fit perfectly into the testing apparatus.
2. Then we started doing the test by applying suitable tensile load.
3. At a certain point, we observed an elongation in the specimen and at a later level, it started to fail. Then we collected the data that we got throughout the experiment.
4. With the obtained data, we drew graphs and observed the different salient features from the stress-strain curve.

Results : From the data obtained, we got the below stress strain curve and observed some salient features from the curve.



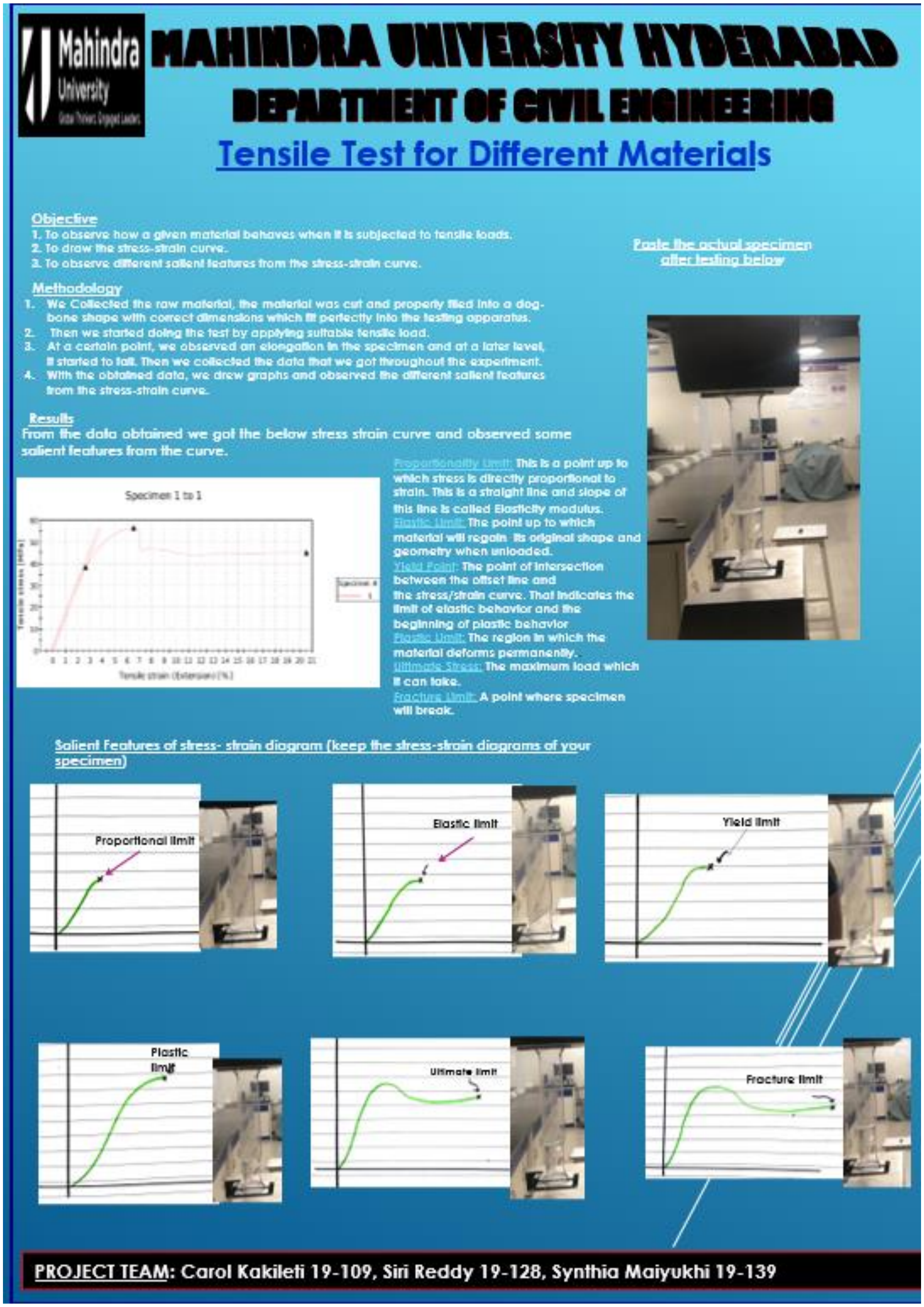
Proportionality Limit: This is a point up to which stress is directly proportional to strain. This is a straight line and slope of this line is called Elasticity modulus.
Elastic Limit: The point up to which material will regain its original shape and geometry when unloaded.
Yield Point: The point of intersection between the offset line and the stress/strain curve. That indicates the limit of elastic behavior and the beginning of plastic behavior
Plastic Limit: The region in which the material deforms permanently.
Ultimate Stress: The maximum load which it can take.
Fracture Limit: A point where specimen will break.

Salient Features of stress- strain diagram



One drive link:- https://mahindraecolecentrale-my.sharepoint.com/:f:/g/personal/abhishek19107_mechyd_ac_in/[illegible]

PROJECT TEAM: Pritika Reddy(19102), Abhishek Kumar(19107), Siddarth Reddy(19122)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MAHINDRA UNIVERSITY HYDERABAD
DEPARTMENT OF CIVIL ENGINEERING
Tensile Test for Different Materials
Objective
1. To observe how a given material behaves when it is subjected to tensile loads.
2. To draw the stress-strain curve.
3. To observe different salient features from the stress-strain curve.
Methodology
1. We Collected the raw material, the material was cut and properly filed into a dog-bone shape with correct dimensions which fit perfectly into the testing apparatus.
2. Then we started doing the test by applying suitable tensile load.
3. At a certain point, we observed an elongation in the specimen and at a later level, it started to fall. Then we collected the data that we got throughout the experiment.
4. With the obtained data, we drew graphs and observed the different salient features from the stress-strain curve.
Paste the actual specimen after testing below
Results
From the data obtained we got the below stress strain curve and observed some salient features from the curve.
Specimen 1 to 1
Proportionality Limit: This is a point up to which stress is directly proportional to strain. This is a straight line and slope of this line is called Elasticity modulus.
Elastic Limit: The point up to which material will regain its original shape and geometry when unloaded.
Yield Point: The point of intersection between the offset line and the stress/strain curve. That indicates the limit of elastic behavior and the beginning of plastic behavior
Plastic Limit: The region in which the material deforms permanently.
Ultimate Stress: The maximum load which it can take.
Fracture Limit: A point where specimen will break.
Salient Features of stress- strain diagram (keep the stress-strain diagrams of your specimen)
Proportional limit
Elastic limit
Yield limit
Plastic limit
Ultimate limit
Fracture limit
PROJECT TEAM: Carol Kakileti 19-109, Siri Reddy 19-128, Synthia Maiyukhi 19-139

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MAHINDRA UNIVERSITY

Department of civil engineering

Tensile Test for Different Materials

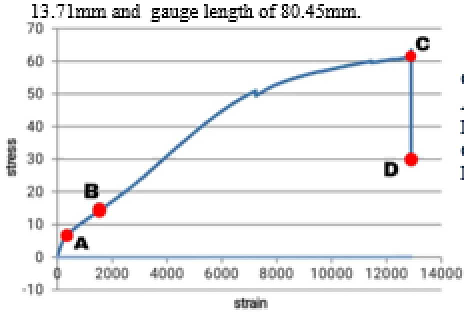
Objective:-

To study the behaviour of wood under the application of tensile stress using a universal Testing Machine And to obtain a stress stain curve for the given specimen of wood.

Methodology:-

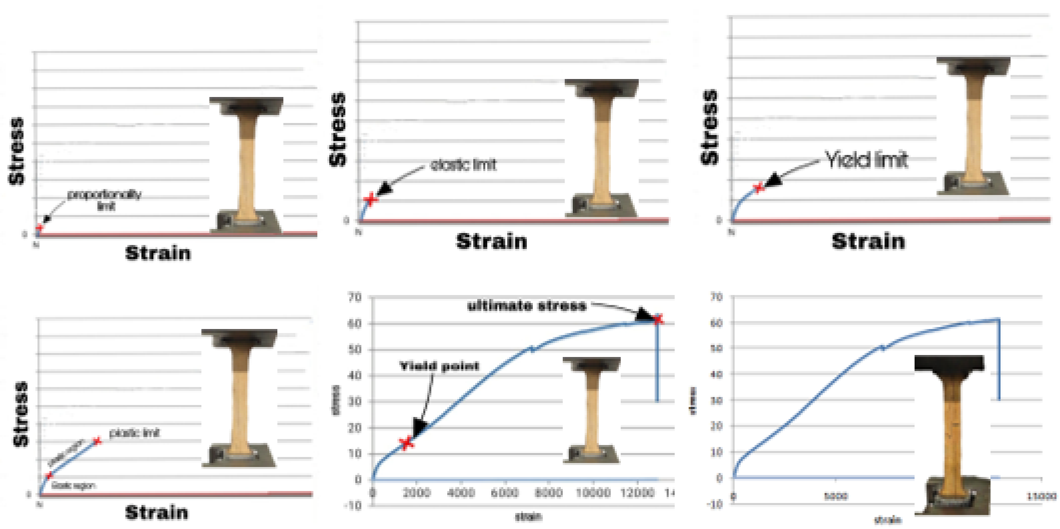
1) First we obtain the specimens in cuboidal shape from the present resources.
2)Then we cut these specimens using cutting machines in Dog bone shape.
3)After this, we use files and make the edges of the specimen as straight as possible.
4)Then we place the specimen in universal testing machine and then we adjusted the rate of loading on the specimen.
5)We Observe the behavior of the specimen till it fails.
6) We note down the respective load values and extension values from the software.

The given specimen of wood had a thickness of 9.47mm,width of 13.71mm and gauge length of 80.45mm.



OA:-proportional limit
A:- Elastic limit
B:-Yield stress point
C:- Ultimate stress point
D:-Breaking or rupture point

Salient features of stress-strain diagram



By : Dheeraj kumar Bondada(19108), Semanth B(19-144), Amith kodali(19-135)

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Department of civil engineering

Tensile Test for Different Materials

Objective:-

To study the behaviour of wood under the application of tensile stress using a universal Testing Machine And to obtain a stress stain curve for the given specimen of wood.

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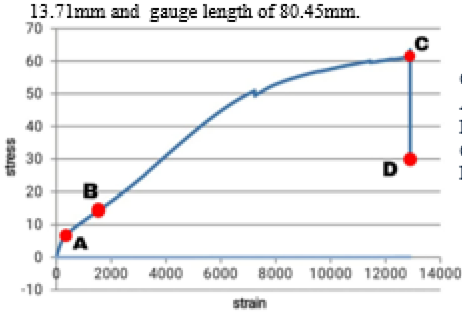
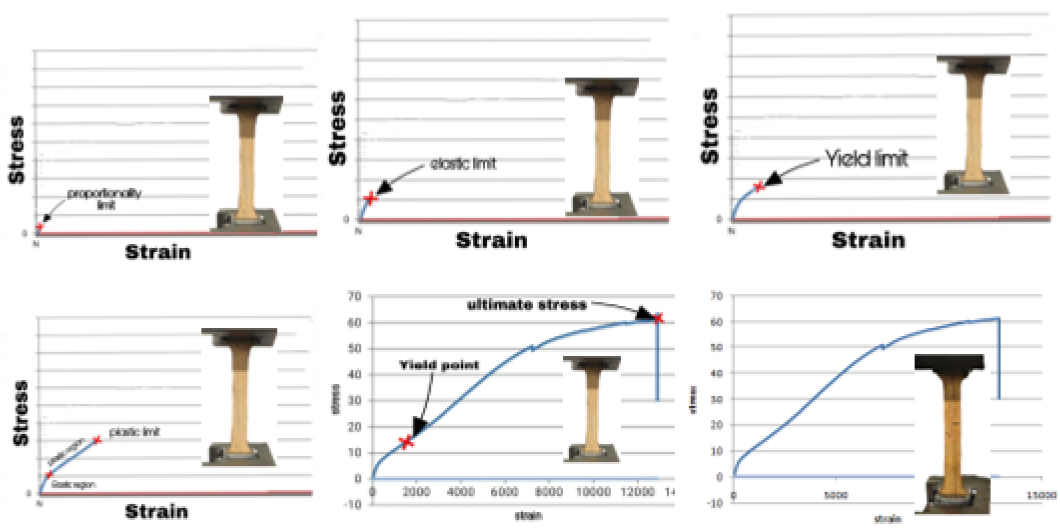


OA:-proportional limit
A:- Elastic limit
B:-Yield stress point
C:- Ultimate stress point
D:-Breaking or rupture point

Salient features of stress-strain diagram



By : Dheeraj kumar Bondada(19108), Semanth B(19-144), Amith kodali(19-135)

CFC3- Quiz (w/- CO mapping, if applicable) + Model Key

Winter Semester, 2021
B.Tech. (Civil Engineering), Semester-IV
CE-202: Mechanics of Materials
Quiz No: 1

Quizz no.1 Beams

Hi Visalakshi, when you submit this form, the owner will be able to see your name and email address.

Required

1.A beam which extends beyond it supports can be termed as _________

(1 Point)

- a) Over hang beam
- b) Over span beam
- c) Isolated beams
- d) Tee beams

2.Example for cantilever beam is _____

(1 Point)

- c) Bridges
- d) Railway sleepers
- a) Portico slabs
- b) Roof slab

3.What is beam?

(1 Point)

- a) structural member subjected to transverse loads
- b) structural member subjected to axial loads only
- c) structural member subjected to seismic loads only
- d) structural member subjected to transverse loads only

4.Which of the following statement is correct?

(1 Point)

- a) beams are termed as fixed beams when end condition do not carry end moments
- b) beams are termed as simply supported beams when ends are rigidly connected to other members
- c) beams are termed as fixed beams when ends are rigidly connected to other members

- d) beams are termed as continuous beams when they do not extend across more than two support

5.what are the reaction forces developed in the beam

(1 Point)

- Axial, shear, torsion and dending forces
- Horizontal force, verical force and moment
- Axial, and ahear
- axial force, shear force and bending force

6.What are the reaction forces developed at support when a beam is subjected to ecentric point load "p"with distances a & b from left and right supports respectively

(1 Point)

- P each
- P/2 each
- Pa/b and pb/a
- pa/l and pb/l

7.How many reaction forces are developed for a roller support with rolls provided inclined at 30 degrees

(1 Point)

- Only horizontal
- Only vertical
- Both horizontal and vertical
- None of the above

8.Load transfer by a beam is primarily by

(1 Point)

- c) bending and shear
- d) neither bending nor shear
- b) shear only
- a) bending only

9.Continuous beams are ________

(1 Point)

- b) Statically indeterminate beams
- a) Statically determinate beams
- c) Statically gravity beams

- d) Framed beams

10.Reactions at support develop only when

(1 Point)

- When it is free to displace
- There is a constraint in the displacement
- Both a & B
- None of the above

Winter Semester, 2021
B.Tech. (Civil Engineering), Semester-IV
CE-202: Mechanics of Materials
Quiz No: 2

Beams 2

Mandatory

1.What happens to shear force diagram at point where vertical force acts
(1 Point)

- Will be flat
- will be inclined
- A sudden step is seen
- none of the above

2.The value of the sudden increase in SF at a point where vertical force acts is equal to
(1 Point)

3.Mention different types of transverse loads applied on a beam

4.Sign convention for Shear force calculations
(1 Point)

5.Sign COnvention for bending moment calcualtion
(1 Point)

Quiz.4: Beam Bending

Hi Visalakshi, when you submit this form, the owner will be able to see your name and email address.

1.Neutral axis of the beam is the axis of
(1 Point)

- (a) Zero stresses
- (b) maximum stress
- (c) negative stress
- (d) positive stress

2.In a simply supported beam loaded with U.D.L over the whole section, the bending stress is .... at top and .... at bottom.

(1 Point)

- (a) Compressive, tensile
- (b) Tensile, compressive
- (c) Tensile, zero
- (d) Compressive, zero

3.When a beam is subjected to a bending moment the strain in a layer is ....the distance from the neutral axis.

(1 Point)

- (a) Independent of
- (b) Directly proportional to
- (c) Inversely proportional to
- (d) None of these

4.The plane section remains plane assumption in bending theory implies

(1 Point)

- a) Strain profile is linear
- b) Stress profile is linear
- c) Both profile are linear
- d) Shear deformation is neglected

5.In a simple bending theory, one of the assumption is that the material of the beam is isotropic. This assumption means that the

(1 Point)

- A. normal stress remains constant in all directions
- B. normal stress varies linearly in the material
- C. elastic constants are same in all the directions
- D. elastic constants varies linearly in the material
- Option 2

Winter Semester, 2021
B.Tech. (Civil Engineering), Semester-IV
CE-202: Mechanics of Materials
Quiz No: 3

Beams 3(10 Points)

Mandatory

1

A cantilever beam curved in plane is subjected to lateral loads will develop at any section
(1 Point)

- Bending moment and shearing force
- Bending moment and twisting moment
- Twisting moment and shearing force
- Bending moment, twisting moment and shearing force

2

If the shear force at a section of beam under bending is equal to zero then the bending moment at the section is
(1 Point)

- zero
- Maximum
- Minimum
- Constant

3

Two people weighing W each are sitting on a plank of length L floating on the water at L/4 from either ends. Neglecting the weight of the plank, the bending moment at the center of the plank is
(1 Point)

- wl/32
- wl/8

- 0
- wl/16

4

For A simply supported beam of length L, subjected to a uniformly distributed moment "M",the bending moment at the mid span of beam is
(1 Point)

- 0
- M
- ML
- M/L

5

A simply supported beam is subjected to a uniformly distributed load .Which one of the following statement is true?
(1 Point)

- Maximum or minimum shear force occurs where the curvature is zero
- Maximum or minimum bending moment occurs where shear force is zero
- Maximum or minimum bending moment occurs where the curvature is zero
- Maximum bending moment and maximum shear force occur at the same section

6

The shape of the bending moment diagram over the length of a beam, carrying a uniformly varying load is always
(1 Point)

- Linear
- Parabola
- Cubic Parabola
- Constant

7

The figure given below is the SFD for
(1 Point)

- Cantilever
- Simply Supported
- Over Hang

- None

8

A sudden increase or decrease in shear force diagram between any two points indicates that there is
(1 Point)

- No loading between the two points
- Point loads between the two points
- U.D.L. between the two points
- None of these

9

The slope of SFD at any point is equal to
(1 Point)

- Slope of BM
- BM
- Intensity of load
- None

10

Change in BMD between two points is equal to
(1 Point)

- Area of SFD in between the same points
- Area of Load in between the same points
- Intensity of Load
- None

Mahindra University
ÉCOLE CENTRALE SCHOOL OF ENGINEERING

Winter Semester, 2021
B.Tech. (Civil Engineering), Semester-IV
CE-202: Mechanics of Materials
Quiz No: 4

Quiz.4: Beam Bending

Hi Visalakshi, when you submit this form, the owner will be able to see your name and email address.

1.In a simply supported beam loaded with U.D.L over the whole section, the bending stress is .... at top and .... at bottom.

(1 Point)

- (a) Compressive, tensile
- (b) Tensile, compressive
- (c) Tensile, zero
- (d) Compressive, zero

2.The plane section remains plane assumption in bending theory implies

(1 Point)

- a) Strain profile is linear
- b) Stress profile is linear
- c) Both profile are linear
- d) Shear deformation is neglected

3.In a simple bending theory, one of the assumption is that the material of the beam is isotropic. This assumption means that the

(1 Point)

- A. normal stress remains constant in all directions
- B. normal stress varies linearly in the material
- C. elastic constants are same in all the directions
- D. elastic constants varies linearly in the material
- Option 2

4.Neutral axis of the beam is the axis of

(1 Point)

- (a) Zero stresses

- (b) maximum stress
- (c) negative stress
- (d) positive stress

5.When a beam is subjected to a bending moment the strain in a layer is ....the distance from the neutral axis.

(1 Point)

- (a) Independent of
- (b) Directly proportional to
- (c) Inversely proportional to
- (d) None of these

ÉCOLE CENTRALE
SCHOOL OF ENGINEERING

Winter Semester, 2021
B.Tech. (Civil Engineering), Semester-IV
CE-202: Mechanics of Materials
Quiz No: 5

Page 1

1	**Q.1.** variation of share stress along the depth of rectangular beam is	1.0

Page 2

2	**Q.3.** Shear stresses are induced due to	1.0

Page 3

3	**Q.2.** The max shear stress for a circular c/s of beam is 4/3 times the average shear stress	1.0

Page 4

4	**Q.4.** How can you say share stress vary parabolically along the depth of beam?	1.0
5	**Q.5.** What are complimentary shear stresses?	1.0

Page 1

1	**Q.1.** When a torque is applied, what happens to the c/s at the end of shaft	1.0

Page 2

2	**Q.2.** The variation of shear stresses due to torsion vary linearly along the radius with maximum at center at ze...	1.0

Page 3

3	**Q.3.** Torsional rigidity is	1.0

Page 4

4	**Q.4.** Shaft subjected to pure torsion means	1.0

Page 5

5	**Q.5.** The twist along the shaft is uniform	1.0

Page 1

1	**Q.1.** Short column fail due to buckling/cripling	1.0

Page 2

2	**Q.2.** Define Static equilibrium and give the equation	1.0

Page 3

3	**Q.3.** An ideal column is	1.0

Page 4

4	**Q.4.** Which of the fallowing are economical sections a) Hollow section b) solid section c) Wide flange section ...	1.0

Page 5

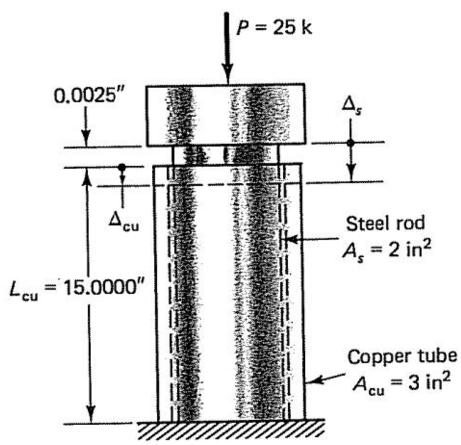
5	**Q.5.** Column buckles about the principal axis of C/S having least moment of inertia give reasons.	1.0

CFC3- Assignments (w/- CO mapping, if applicable) + Model Key

Winter Semester, 2021
B.Tech. (Civil Engineering), Semester-IV
CE-202: Mechanics of Materials
Assignment No: 1

Course Coordinator: Visalakshi Talakokula **Date of submission:** 24 Feb 2021

1. A steel rod with a cross-sectional area of 2 in^2 and a length of 15.0025 in. is loosely inserted into a copper tube, as shown in Fig. The copper tube has a cross-sectional area of 3 in^2 and is 15.0000 in. long. If an axial force P = 25 kips is applied through a rigid cap, what stresses will develop in the two materials? Assume that the elastic moduli of steel and copper are E_s = 30 x 10^6 psi and E_{cu}= 17 x 10^6 psi, respectively.

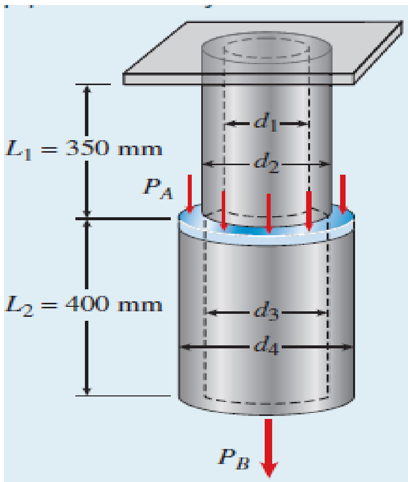


2. A hollow circular nylon pipe supports a load P_A = 7800 N, which is uniformly distributed around a cap plate at the top of the lower pipe. A second load P_B is applied at the bottom. The inner and outer diameters of the upper and lower parts of the pipe are d_1 = 5 mm, d_2 = 60 mm, d_3 = 57 mm, and d_4 = 63 mm, respectively. The upper pipe has a length L_1 = 350 mm; the lower pipe length is L_2 = 400 mm. Neglect the self-weight of the pipes.

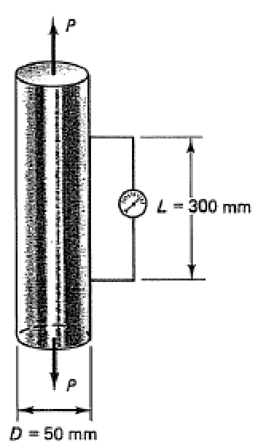
a) Find P_B so that the tensile stress in upper part is 14.5 MPa. What is the resulting stress in the lower part?

b) If P_A remains unchanged, find the new value of P_B so that upper and lower parts have same tensile stress.

c) Find the tensile strains in the upper and lower pipe segments for the loads in part (b) if the elongation of the upper pipe segment is known to be 3.56 mm and the downward displacement of the bottom of the pipe is 7.63 mm.

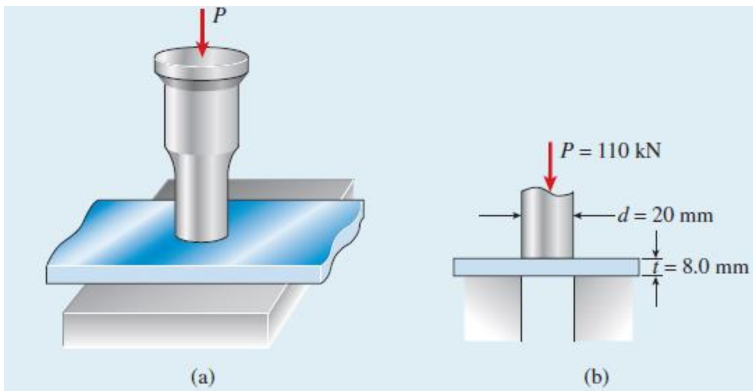


3. Consider a carefully conducted experiment where an aluminium bar of 50 mm diameter is stressed in a testing machine, as shown in Fig. 2-27. At a certain instant the applied force P is 100 KN, while the measured elongation of the rod is 0.219 mm in a 300 mm gage length, and the diameter's dimension is decreased by 0.01215 mm. Calculate the two physical constants μ and E of the material.



4. A 50 mm cube of steel is subjected to a uniform pressure of 200 MPa acting on all faces. Determine the change in dimension between two parallel faces of the cube. Let E = 200 GPa and μ= 0.25.

5. A punch for making holes in steel plates is shown in Fig. a. Assume that a punch having diameter d =20 mm is used to punch a hole in an 8 mm plate, as shown in the cross-sectional view . If a force P =110 kN is required to create the hole, what is the average shear stress in the plate and the average compressive stress in the punch?

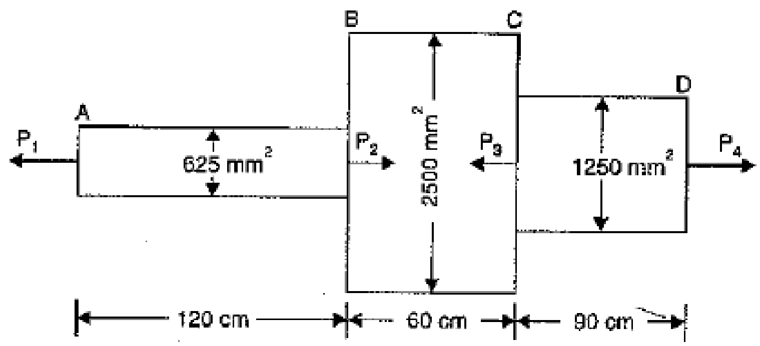


6. A tensile test was conducted on a mild steel bar. The following data was obtained from the test:

a)	Diameter of the steel bar	= 3cm
b)	Gauge length of the bar	= 20 cm
c)	Load at elastic limit	= 250 KN
d)	Extension at a load of 150 KN	= 0.21 mm
e)	Maximum load	= 380 KN
f)	Total extension	= 60 mm
g)	Diameter of the rod at failure	= 2.25 cm

Determine: a) the young's modulus, b) the stress at elastic limit
c) the percentage elongation, d) the percentage decrease

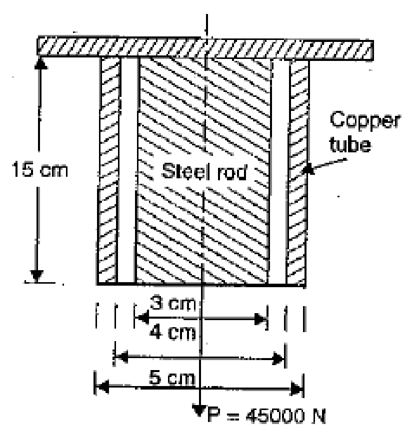
7. A member ABCD is subjected to point loads P_1, P_2 , P_3 and P_4 as shown in figure.



Calculate the force P_2 necessary for equilibrium, if $P_1 = 45\ KN$, P_3 = 450 KN, and P_4= 130 KN. Determine the total elongation of the member, assuming the modulus of elasticity to be 2.1×10^5 N/mm^2.

8. A steel rod of 3cm diameter is enclosed centrally in a hollow copper tube of external diameter 5cm and internal diameter of 4cm. The composite bar is then subjected toan axial pull of 45000 N. If the length of each bar is equal to 15cm, determine:
   a) Stresses in the rod and tube and
   b) Load carried by each bar

   Take E for steel = 2.1×10^5 N/mm^2 and for copper = 1.1×10^5 N/mm^2.



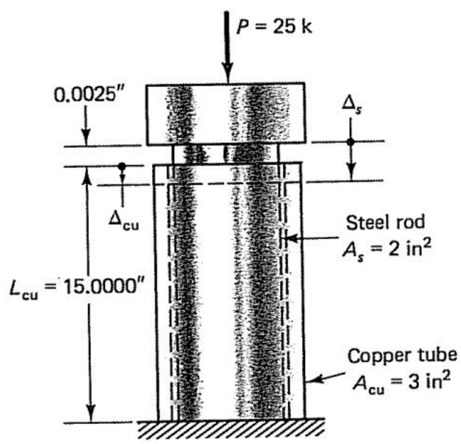
9. Calculate the modulus of Rigidity and bulk modulus of a cylindrical bar of diameter 30mm and of length 1.5m if the longitudinal strain in a bar during a tensile stress is four times the

lateral strain. Find the change in volume, when the bar is subjected to a hydrostatic pressure of 100 N/mm^2. Take E= 1×10^5 N/mm^2.

10. The ultimate stress for a hollow steel column which carries an axial steel load of 1.9 MN is 480 N/mm^2. If the external diameter of the column is 200mm, determine the internal diameter. Take the factor of safety as 4.

Winter Semester, 2021
B.Tech. (Civil Engineering), Semester-IV
CE-202: Mechanics of Materials
Solution-Assignment No: 1

1. A steel rod with a cross-sectional area of 2 in^2 and a length of 15.0025 in. is loosely inserted into a copper tube, as shown in Fig. The copper tube has a cross-sectional area of 3 in^2 and is 15.0000 in. long. If an axial force P = 25 kips is applied through a rigid cap, what stresses will develop in the two materials? Assume that the elastic moduli of steel and copper are E_s = 30 x 10^6 psi and E_{cu}= 17 x 10^6 psi, respectively.



Solution:

If the applied force P is sufficiently large to close the small gap, a force P_s will be developed in the steel rod and a force P_{cu}, in the copper tube. Moreover, upon loading, the steel rod will compress axially Δ_s, which is as much as the axial deformation Δ_{cu}, of the copper tube plus the initial gap. Hence, From statics:

$$P_s + P_{cu} = 25{,}000 \text{ lb}$$

From compatibility:

$$\Delta_s = \Delta_{cu} + 0.0025$$

Δ = PL/AE, Substituting, and simplifying,

$$\frac{P_S L_S}{A_S E_S} = \frac{P_{cu}\, L_{cu}}{A_{cu} E_{cu}} + 0.0025$$

$$\frac{15.0025}{2\times30\times10^6} P_s - \frac{15}{3\times17\times10^6} P_{cu} = 0.0025$$

$$P_s - 1.176 P_{cu} = 10{,}000 \text{ lb}$$

Solving the two equations simultaneously,

$$P_{cu} = 6900 \text{ lb and } P_s = 18{,}100 \text{ lb}$$

and dividing these forces by the respective cross-sectional areas gives

$$\sigma_{cu} = 6900/3 = 2300 \text{ psi and } \sigma_s = 18{,}100/2 = 9050 \text{ psi}$$

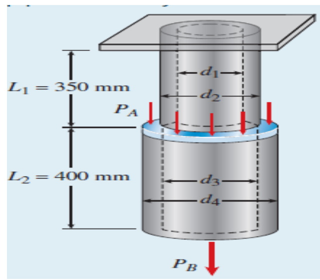
If either of these stresses were above the proportional limit of its material or if the applied force was too small to close the gap, the above solution would not be valid. Also note that since the deformations considered are small, it is sufficiently accurate to use $L_s = L_{cu}$.

2. A hollow circular nylon pipe supports a load P_A = 7800 N, which is uniformly distributed around a cap plate at the top of the lower pipe. A second load P_B is applied at the bottom. The inner and outer diameters of the upper and lower parts of the pipe are d_1 = 5 mm, d_2 = 60 mm, d_3 = 57 mm, and d_4 = 63 mm, respectively. The upper pipe has a length L_1 = 350 mm; the lower pipe length is L_2 = 400 mm. Neglect the self-weight of the pipes.

d) Find P_B so that the tensile stress in upper part is 14.5 MPa. What is the resulting stress in the lower part?

e) **If P_A remains unchanged, find the new value of P_B so that upper and lower parts have same tensile stress.**

f) **Find the tensile strains in the upper and lower pipe segments for the loads in part (b) if the elongation of the upper pipe segment is known to be 3.56 mm and the downward displacement of the bottom of the pipe is 7.63 mm.**



Solution: Numerical data:

$d_3 = 57$ mm, $d_4 = 63$ mm, $d_1 = 51$ mm, $d_2 = 60$ mm,
$P_A = 7800$ N, $L_1 = 350$ mm, $L_2 = 400$ mm

a) Find PB so that the stress in the upper part is 14.5 MPa. What is the resulting stress in the lower part? Neglect self-weight in all calculations.

Use the given dimensions to compute the cross-sectional areas of the upper (segment 1) and lower (segment 2) pipes (we note that A_1 is 1.39 times A_2). The stress in segment 1 is known to be 14.5 MPa.

$A_1 = \frac{\pi}{4} \times (d_2^2 - d_1^2) = 784.613 \text{ mm}^2$, $A_2 = \frac{\pi}{4} \times (d_4^2 - d_3^2) = 565.487 \text{ mm}^2$

The axial tensile force in the upper pipe is the sum of loads P_A and P_B. Write an expression for σ_1 in terms of both loads, then solve for P_B:

$$\sigma_1 = \frac{P_A + P_B}{A_1}$$

Where, $\sigma_1 = 14.5$ MPa so $P_B = \sigma_1 A_1 - P_A = 3577$ N

With P_B now known, the axial tensile stress in the lower segment can be computed as

$$\sigma_2 = \frac{P_B}{A_2} = 6.33 \text{ MPa}$$

b) If P_A remains unchanged, find the new value of P_B so that upper and lower parts have same tensile stress.

So P_A = 7800 N. Write expressions for the normal stresses in the upper and lower segments, equate these expressions, and then solve for P_B.

Tensile normal stress in upper segment:

$$\sigma_1 = \frac{P_A + P_B}{A_1}$$

Tensile normal stress in lower segment:

$$\sigma 2 = \frac{P_B}{A_2}$$

Equate these expressions for stresses $\sigma 1$ and $\sigma 2$ and solve for the required *PB*:

$$P_B = \frac{\frac{P_A}{A_1}}{\frac{1}{A_2} - \frac{1}{A_1}} = 20{,}129 \text{ N}$$

So for the stresses to be equal in the upper and lower pipe segments, the new value of load *PB* is 2.58 times the value of load *PA*.

(c) Find the tensile strains in the upper and lower pipe segments for the loads in part (b).

The *elongation* of the upper pipe segment is $\delta 1$ _ 3.56 mm. So the tensile strain in the upper pipe segment is

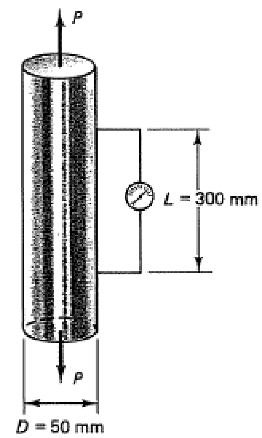
$$\varepsilon_1 = \frac{\delta_1}{L_1} = 1.017 \times 10^{-2}$$

The downward *displacement* of the bottom of the pipe is δ =7.63 mm. So the *net elongation* of the lower pipe segment is $\delta 2 = \delta - \delta 1$ = 4.07 mm and the tensile strain in the lower pipe segment is

$$\varepsilon_2 = \frac{\delta_2}{L_2} = 1.017 \times 10^{-2}$$

Note: As explained earlier, strain is a dimensionless quantity and no units are needed. For clarity, however, units are often given. In this example, ε could be written as 1017 $\times 10^{-6}$m/m or 1017 μm/m.

3. Consider a carefully conducted experiment where an aluminium bar of 50 mm diameter is stressed in a testing machine, as shown in Fig. At a certain instant the applied force P is 100 KN, while the measured elongation of the rod is 0.219 mm in a 300 mm gage length, and the diameter's dimension is decreased by 0.01215 mm. Calculate the two physical constants μ and E of the material.



Solution:

Transverse or lateral strain:

$$\varepsilon_r = \frac{\Delta_r}{D} = -\frac{0.01215}{50} = -\ 0.000243 \text{ mm/mm}$$

In this case, the lateral strain et is negative, since the diameter of the bar decreases by Δ_r

Axial strain:

$$\varepsilon_a = \frac{\Delta}{L} = +\frac{0.219}{300} = 0.00073 \text{ mm/mm}$$

Poisson's ratio:

$$\mu = -\frac{\varepsilon_r}{\varepsilon_a} = -\frac{(-0.000243)}{0.00073} = 0.333$$

Next, since the area of the rod A = $\frac{\pi}{4} \times 50^2 = 1960$ mm^2

$$E = \frac{PL}{A\Delta} = \frac{100\times10^3\times300}{1960\times0.219} = 70\times10^3 \text{ N/mm}^2 = 70 \text{ Gpa}$$

In practice, when a study of physical quantities, such as E and v, is being made, it is best to work with the corresponding stress-strain diagram to be assured that the quantities determined are associated with the elastic range of the material behaviour. Also note that it makes no difference whether the initial or the final lengths are used in computing strains, since the deformations are very small.

4. A 50 mm cube of steel is subjected to a uniform pressure of 200 MPa acting on all faces. Determine the change in dimension between two parallel faces of the cube. Let E = 200 GPa and μ= 0.25.

Solution:

Note that pressure is a compressive stress.

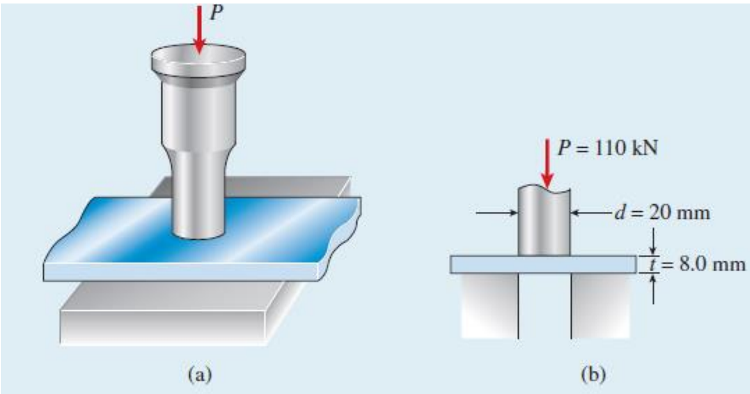
$$\varepsilon_x = \frac{(-200)}{200 \times 10^3} - \left(\frac{1}{4}\right)\frac{(-200)}{200 \times 10^3} - \left(\frac{1}{4}\right)\frac{(-200)}{200 \times 10^3}$$

$$= -5 \times 10^{-4} \text{ mm/mm}$$

$$\Delta_x = \varepsilon_x L_x = -5 \times 10^{-4} \times 50 = -0.025 \text{ mm (contraction)}$$

In this case $\Delta_x = \Delta_y = \Delta_z$.

5. A punch for making holes in steel plates is shown in Fig. a. Assume that a punch having diameter *d* =20 mm is used to punch a hole in an 8 mm plate, as shown in the cross-sectional view . If a force *P* =110 kN is required to create the hole, what is the average shear stress in the plate and the average compressive stress in the punch?



Solution:

The average shear stress in the plate is obtained by dividing the force *P* by the shear area of the plate. The shear area *As* is equal to the circumference of the hole times the thickness of the plate, or

$$A_s = \pi dt = \pi(20\text{ mm})(8.0\text{ mm}) = 502.7\text{ mm}^2$$

in which *d* is the diameter of the punch and *t* is the thickness of the plate.

Therefore, the average shear stress in the plate is

$$\tau_{avg} = \frac{P}{A_s} = \frac{110\text{ KN}}{502.7\text{ mm}^2} = 219\text{ MPa}$$

The average compressive stress in the punch is

$$\sigma_c = \frac{P}{A_{Punch}} = \frac{P}{\pi d^2/4} = \frac{110KN}{\pi(20mm)^2/4} = 350\text{ MPa}$$

in which A_{punch} is the cross-sectional area of the punch.

6. A tensile test was conducted on a mild steel bar. The following data was obtained from the test:

h) Diameter of the steel bar = 3cm

i) Gauge length of the bar = 20 cm

j) Load at elastic limit = 250 KN

k) Extension at a load of 150 KN = 0.21 mm

l) Maximum load = 380 KN

m) Total extension = 60 mm

n) Diameter of the rod at failure = 2.25 cm

Determine: a) the young's modulus, b) the stress at elastic limit c) the percentage elongation, d) the percentage decrease

Solution:

Area of the rod, A $= \frac{\pi}{4} \times D^2 = = \frac{\pi}{4} \times 3^2$ cm^2

$$= 7.0685\text{ cm}^2 = 7.0685 \times 10^{-4}\ m^2$$

a) Youngs modulus:

Stress $= \frac{load}{area} = \frac{150 \times 1000}{7.0685 \times 10^{-4}}\ N/m^2$

$$= 21220.9 \times 10^4\ N/m^2$$

Strain = $\frac{0.21\,mm}{20\times10\,mm} = 0.00105$

Therefore, youngs modulus, E = $\frac{stress}{strain} = \frac{21220.9\times10^4}{0.00105} = 2.02\times 10^5$ N/mm^2

b) The stress at elastic limit:

Stress = $\frac{load\ at\ elastic\ limit}{area} = \frac{250\times1000}{7.0685\times10^{-4}}$

= 353.64 N/mm^2

c) The percentage elongation:

percentage elongation = $\frac{Total\ increase\ in\ length}{Original\ length} \times 100$

$\frac{60\,mm}{20\times10\,mm}\times 100 = 30\%$

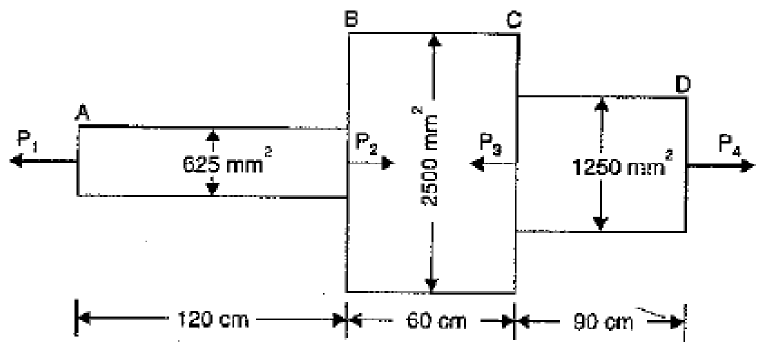
d) The percentage decrease in area:

Percentage decrease in area = $\frac{(Original\ area - Area\ at\ failure)}{Original\ area} \times 100$

$= \frac{\left(\frac{\pi}{4}\times3^2 - \frac{\pi}{4}\times2.25^2\right)}{\frac{\pi}{4}\times3^2} \times 100$

= 43.75%

7. A member ABCD is subjected to point loads P_1, P_2, P_3 and P_4 as shown in figure.



Calculate the force P_2 necessary for equilibrium, if $P_1 = 45\ KN$, P_3 = 450 KN, and P_4= 130 KN. Determine the total elongation of the member, assuming the modulus of elasticity to be 2.1× 10^5 N/mm^2.

Solution:

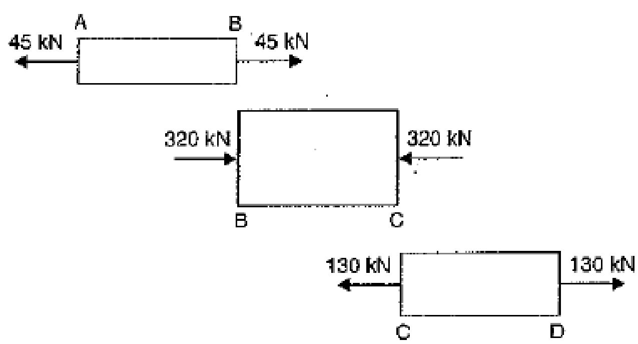
Value of P_2 necessary for equilibrium

Resolving the forces on the rod along its axis, we get

$$P_1 + P_3 = P_2 + P_4$$

$$45+450 = P_2 + 130$$

$$P_2 = 365\ KN$$



Hence for part AB, there will be increase in length, for part BC there will be decrease in length and for part CD there will be increase in length.

Increase in length of AB = $\frac{P}{A_1 E} \times L_1 = \frac{45000}{625 \times 2.1 \times 10^5} \times 1200$

= 0.4114 mm.

Decrease in length of BC = $\frac{P}{A_2 E} \times L_2 = \frac{320,000}{2500 \times 2.1 \times 10^5} \times 600$

= 0.3657 mm

Increase in length of CD = $\frac{P}{A_3 E} \times L_3 = \frac{130,000}{1250 \times 2.1 \times 10^5} \times 900$

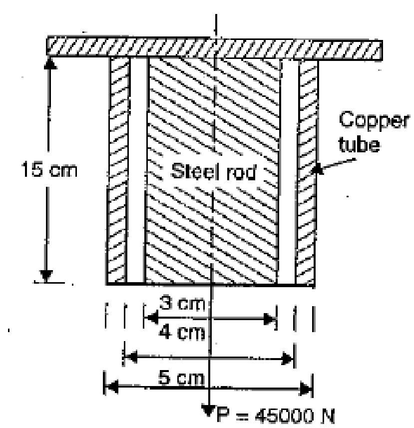
= 0.4457 mm

Total change in the length of the member = 0.4114−0.3657+0.4457

= **0.4914 mm** (extension)

8. **A steel rod of 3cm diameter is enclosed centrally in a hollow copper tube of external diameter 5cm and internal diameter of 4cm. The composite bar is then subjected toan axial pull of 45000 N. If the length of each bar is equal to 15cm, determine:**
   c) **Stresses in the rod and tube and**
   d) **Load carried by each bar**

   Take E for steel = 2.1× 10^5 N/mm² and for copper = 1.1× 10^5 N/mm².



Solution: Given:

Dia. Of steel rod = 3cm = 30 mm

Area of steel rod, $A_S = \frac{\pi}{4} \times 30^2$ =706.86 mm²

External dia. Of copper rod = 5 cm = 50 mm

Internal dia. Of copper tube = 4 cm= 40mm

Area of copper tube, $A_c = \frac{\pi}{4}(50^2 - 40^2) = 706.86\ mm^2$

Axial pull on the composite bar, P = 45000N

Length of each bar, L = 15cm

Youngs modulus of steel, $E_s = 2.1\times 10^5\ N/mm^2$

Youngs modulus of copper, $E_c = 1.1\times 10^5\ N/mm^2$

a) The stress in the rod and tube:

Strain in steel = strain in copper

$$\sigma_s = \frac{E_S}{E_C} \times \sigma_c = \frac{2.1\times10^5}{1.1\times10^5} \times \sigma_c = 1.909\sigma_c \text{ ------------ (i)}$$

Load on steel + load on copper = Total load

$$(\sigma_s A_s) + (\sigma_c A_c) = P$$

$$(1.909\sigma_c \times 706.86) + (\sigma_c \times 706.86) = 45000$$

$$\boldsymbol{\sigma_c = 21.88\ N/mm^2}$$

Substituting the value of σ_c in eq. (i), we get

$$\sigma_s = 1.909 \times 21.88$$

$$\boldsymbol{\sigma_s = 41.77\ N/mm^2}$$

b) Load carried by each bar:

Load carried by steel rod, $P_s = \sigma_s A_s$

= 41.77×706.86 = **29525.5 N**

Load carried by Copper tube, P_c = 45000-29525.5

=**15474.5 N**

9. Calculate the modulus of Rigidity and bulk modulus of a cylindrical bar of diameter 30mm and of length 1.5m if the longitudinal strain in a bar during a tensile stress is four times the lateral strain. Find the change in volume, when the bar is subjected to a hydrostatic pressure of 100 N/mm^2. Take E= 1×10^5 N/mm^2.

Solution: Given:

Diameter of the bar, d = 30 mm

Length of the bar, L = 1.5 m = 1500 mm

Therefore, volume of the bar, $V=\frac{\pi}{4}d^2 \times L = \frac{\pi}{4}\times 30^2 \times 1500$

$= 1060287.52 \text{ mm}^3$

Longitudinal strain = 4×Lateral strain

Therefore, $\frac{Lateral\ strain}{Longitudinal\ strain} = \frac{1}{4} = 0.25$

We know that, $E = 2C\,(1+\mu)$

$1\times 10^5 = 2C\,(1+0.25)$

$\mathbf{C = 4\times 10^4}$ **N/mm^2**

For bulk modulus, we know that

$E = 3K\,(1-2\mu)$

$1\times 10^5 = 3K\,(1-2\times 0.25)$

$\mathbf{K = 0.667\times 10^5}$ **N/mm^2**

We know that $K=\frac{P}{\left(\frac{dV}{V}\right)}$

$0.667\times 10^5 = \frac{100}{\left(\frac{dV}{V}\right)}$

$\left(\frac{dV}{V}\right) = 1.5\times 10^{-3}$

$dV = V\times 1.5\times 10^{-3} = 1060287.52\times 1.5\times 10^{-3}$

dV = 1590.43 mm^3

10. The ultimate stress for a hollow steel column which carries an axial steel load of 1.9 MN is 480 N/mm^2. If the external diameter of the column is 200mm, determine the internal diameter. Take the factor of safety as 4.

Solution: Given:

Ultimate stress =480 N/mm^2

Axial load, P = 1.9 MN = 1.9$\times 10^6$ N

External dia. D= 200mm

Factor of safety, F= 4

Area of cross-section of the column,

$$A = \frac{\pi}{4} \times (D^2 - d^2) = \frac{\pi}{4} \times (200^2 - d^2)$$

We know that factor of safety = $\frac{Ultimate\ stress}{working\ stress}$

Working stress = $\frac{480}{4}$ = 120 N/mm^2

σ =120 N/mm^2

We know that stress, $\sigma = \frac{P}{A}$

$$120 = \frac{1900000}{\frac{\pi}{4}\times(200^2 - d^2)}$$

d= 140.85 mm

Winter Semester, 2021
B.Tech. (Civil Engineering), Semester-IV
CE-202: Mechanics of Materials
Assignment No: 2

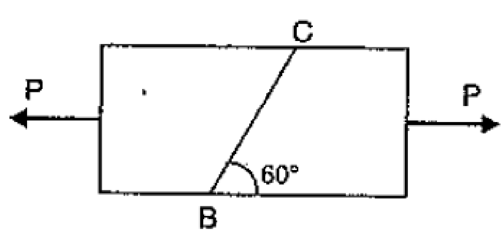
Course Coordinator: Visalakshi Talakokula **Date of submission:** 15 March 2021

1. A rod of 2m long at a temperature of 10°C. Find the expansion of the rod, when the temperature is raised to 80°C. If this expansion is prevented, find the stress induced in the material of the rod. Take 1.0×10^5 MN/m^2 and $\alpha = 0.000012$ per degree centigrade.
2. A steel rod of 3cm diameter and 5m long is connected to two grips and the rod is maintained at a temperature of 95°C. Determine the stress and pull exerted when the temperature falls to 30°C, if

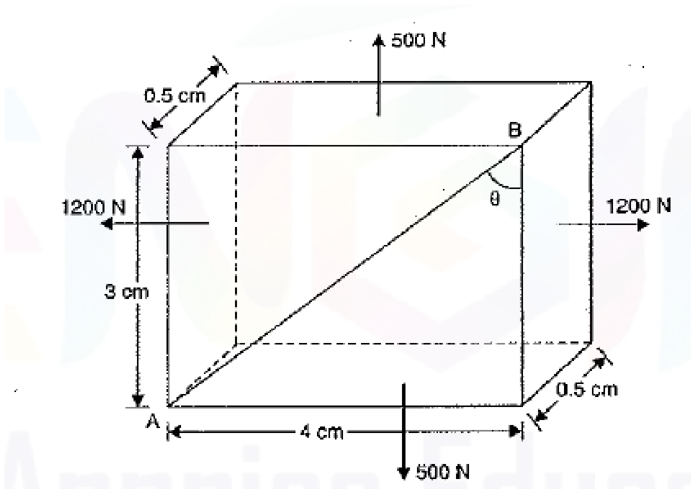
   (i) the ends do not yield and

   (ii) the ends yield by 0.12 cm

   Take E = 2×10^5 MN/m^2 and $\alpha = 12 \times 10^{-6}$ /°C.
3. A steel rod of 20mm diameter passes centrally through a copper tube of 50mm external diameter and 40mm internal diameter. The tube is closed at each end by rigid plates of negligible thickness. If the temperature of the assembly is raised by 50°C, calculate the stress developed in copper and steel. Take E for steel and copper as 200 GN/m^2 and 100 GN/m^2 and α for steel and copper as 12×10^{-6} /°C and 18×10^{-6} /°C.
4. A rectangular bar of cross-sectional area of 11000mm^2 is subjected to a tensile load P as shown in figure. The permissible normal and shear stresses on the oblique plane BC are given as 7 N/mm^2 and 3.5 N/mm^2 respectively. Determine the safe value of P.



5. The stresses at a point in a bar are 200 N/mm^2 (tensile) and 100 N/mm^2 (compressive). Determine the resultant stress in magnitude and direction on a plane inclined at 60° to the axis of the major stress. Also determine the maximum intensity of shear stress in the material at the point.
6. A small block is 4 cm long, 3 cm high and 0.5 cm thick. It is subjected to uniformly distributed tensile forces of resultants 1200N and 500 N as shown in figure. Compute the normal and shear stresses developed along the diagonal AB.



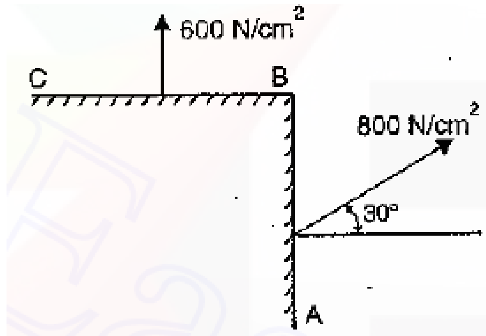
7. A rectangular block of material is subjected to tensile stress of 110 N/mm^2 on one plane and a tensile stress of 47 N/mm^2 on the plane at right angles to the former. Each of the above stresses is accompanied by a shear stress of 63 N/mm^2 and that associated with the former tensile stress tends to rotate the block anticlockwise. Find:
(i) the direction and magnitude of each of the principal stress and
(ii) magnitude of the greatest shear stress

8. The intensity of resultant stress on a plane AB as shown in figure at a point in a material under stress is 800 N/cm^2 and it is inclined at 30° to the normal to that plane. The normal component of stress on another plane BC at right angles to plane AB is 600 N/cm^2.

Determine the following:

a) The resultant stress on the plane BC,
b) The principal stresses and their directions and

c) The maximum shear stresses.



9. The stresses at a point in a bar are 200 N/mm^2 (tensile) and 100 N/mm^2 (compressive). Determine the resultant stress in magnitude and direction on a plane inclined at 60° to the axis of the major stress. Solve by using Mohr's circle method.
10. At a certain point in a strained material, the intensities of stresses on two planes at right angles to each other are 20 N/mm^2 and 10 N/mm^2 both tensile. They are accompanied by a shear stress of magnitude 10 N/mm^2. Find graphically the location of principal planes and evaluate the principal stresses.

Winter Semester, 2021
B.Tech. (Civil Engineering), Semester-IV
CE-202: Mechanics of Materials
Solution-Assignment No: 2

11. A rod of 2m long at a temperature of 10℃. Find the expansion of the rod, when the temperature is raised to 80℃. If this expansion is prevented, find the stress induced in the material of the rod. Take E = 1.0$\times 10^5$ MN/m^2 and $\alpha = 0.000012$ per degree centigrade.

Solution: **<u>Given:</u>**

Length of the rod, L =2m = 2000mm

Initial temperature, T_1 = 10°C

Final temperature, T_2 = 80°C

∴ Rise in temperature, $T_2 - T_1$ =70°C

Youngs modulus, E = 1.0$\times 10^5$ MN/m^2 = 1.0$\times 10^5$ N/mm^2

Coefficient of linear expansion, $\alpha = 0.000012$ /℃

(i) Expansion of the rod due to temperature rise:

Expansion of the rod = αTL

= $0.000012 \times 70 \times 2000$

= **1.68 mm**

(ii) The stress induced in the material of the rod, if expansion prevented:

Thermal stress, $\sigma = \alpha$TE

= $0.000012 \times 70 \times 1.0 \times 10^5$

= **84 N/mm^2**

2) A steel rod of 3cm diameter and 5m long is connected to two grips and the rod is maintained at a temperature of 95℃. Determine the stress and pull exerted when the temperature falls to 30℃, if

(i) the ends do not yield and

(ii) the ends yield by 0.12 cm

Take E = 2× 10^5 MN/m² and $\alpha = 12 \times 10^{-6}$ /℃.

Solution: **Given:**

Dia. Of the rod, d = 3 cm= 30 mm

∴ Area of the rod, A = $\frac{\pi}{4} \times 30^2$ = 706.85 mm^2

Length of the rod, L = 5m = 5000 mm

Initial temperature, T_1 = 95℃

Final temperature, T_2 = 30℃

Fall in temperature, T = $T_1 - T_2$ = 95-30 = 65℃

Youngs modulus, E =2× 10^5 MN/m²= 2× 10^5 N/mm²

Coefficient of linear expansion, $\alpha = 12 \times 10^{-6}$/℃

(i) When the ends do not yield:

Thermal stress, $\sigma = \alpha$TE

$= 12 \times 10^{-6} \times 65 \times 2 \times 10^5$

= 156 N/mm²

Pull in the rod = stress × Area

= 156 × 706.85

= 110269.9 N

(ii) When the ends yield by 0.12 cm

$$\delta = 0.12 \text{ cm} = 1.2 \text{ mm}$$

The stress when the ends yield is given by

$$= \frac{\alpha TL - \delta}{L} \times E$$

$$= \frac{(12\times10^{-6}\times65\times5000)-1.2}{5000} \times 2\times 10^{5}$$

$$\mathbf{= 108\ N/mm^2}$$

Pull in the rod $= \text{stress} \times \text{Area}$

$= 108 \times 706.85$

$=$ **76340 N**

3) **A steel rod of 20mm diameter passes centrally through a copper tube of 50mm external diameter and 40mm internal diameter. The tube is closed at each end by rigid plates of negligible thickness. If the temperature of the assembly is raised by 50℃, calculate the stress developed in copper and steel. Take E for steel and copper as 200 GN/m^2 and 100 GN/m^2 and $\boldsymbol{\alpha}$ for steel and copper as $\mathbf{12 \times 10^{-6}}$ /℃ and $\mathbf{18 \times 10^{-6}}$ /℃.**

Solution: **<u>Given:</u>**

Dia. Of the steel rod = 20mm

∴ Area of the steel rod, $A_s = \frac{\pi}{4} \times 20^2 = 314.15 \text{ mm}^2$

Area of the copper tube, $A_C = \frac{\pi}{4} \times (50^2 - 40^2) = 706.85 \text{ mm}^2$

Rise of temperature, T = 50℃

E for steel, $E_s = 200 \text{ GN}/m^2 = 2 \times 10^5 \text{ N}/mm^2$

E for copper, $E_C = 100 \text{ GN}/m^2 = 1 \times 10^5 \text{ N}/mm^2$

$\alpha_s = 12\times 10^{-6}$ per ℃

α_c =18$\times 10^{-6}$ per ℃

For equilibrium of the system, Tensile load on steel = Compressive load on copper

$$\sigma_s A_s = \sigma_c A_c$$

$$\sigma_s = \sigma_c \frac{A_c}{A_s}$$

$$\sigma_s = 2.25 \times \sigma_c \text{-------------------- (i)}$$

Now, Actual expansion of steel = Free expansion of steel + Expansion due to tensile stress

$$= \alpha_s TL + \frac{\sigma_s}{E_s} \times L$$

And actual expansion of copper = Free expansion of copper – contraction due to compressive stress

$$\alpha_c TL - \frac{\sigma_c}{E_c} \times L$$

But Actual expansion of steel = Actual expansion of copper

$$\alpha_s TL + \frac{\sigma_s}{E_s} \times L = \alpha_c TL - \frac{\sigma_c}{E_c} \times L$$

$$\alpha_s T + \frac{\sigma_s}{E_s} = \alpha_c T - \frac{\sigma_c}{E_c}$$

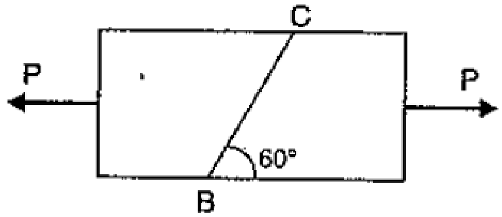
$$12 \times 10^{-6} \times 50 + \frac{2.25\sigma_c}{2 \times 10^5} = 18 \times 10^{-6} \times 50 - \frac{\sigma_c}{1 \times 10^5}$$

$$\boldsymbol{\sigma_c = 14.117\ \mathrm{N}/mm^2}$$

Substituting this value in eq. (i), we get

$$\boldsymbol{\sigma_s} = 2.25 \times 14.117 = \mathbf{31.76\ N}/\boldsymbol{mm^2}$$

4) A rectangular bar of cross-sectional area of 11000mm^2 is subjected to a tensile load P as shown in figure. The permissible normal and shear stresses on the oblique plane BC are given as 7 N/mm^2 and 3.5 N/mm^2 respectively. Determine the safe value of P.



Solution: **Given:**

Area of cross-section, A = 11000mm^2

Normal stress, $\sigma_n = 7$ N/mm^2

Shear stress, $\sigma_t = 3.5$ N/mm^2

Angle of oblique plane with the axis of the bar = 60°

∴ Angle of oblique plane BC with the normal cross-section of the bar,

$$\theta = 90° - 60° = 30°$$

We know that, $\sigma_n = \sigma \cos \theta^2$

$\sigma_n = 9.334$ N/mm^2

$\sigma_t = \frac{\sigma}{2} \sin 2\theta$

$3.5 = \frac{\sigma}{2} \sin 2 \times 30°$

$\sigma = 8.083$ N/mm^2

The safe stress is the least of the two values.

∴ Safe value of the axial pull, P = safe stress× area of cross-section

= 8.083 ×11000

= **88913 N**

5) **The stresses at a point in a bar are 200 N/mm^2 (tensile) and 100 N/mm^2 (compressive). Determine the resultant stress in magnitude and direction on a plane inclined at 60° to the axis of the major stress. Also determine the maximum intensity of shear stress in the material at the point.**

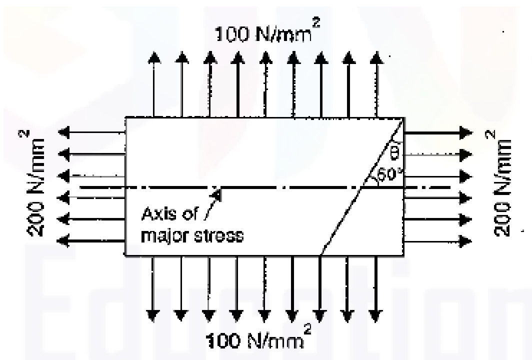
Solution: <u>Given:</u>

Major stress, $\sigma_1 = 200$ N/mm^2

Minor stress, $\sigma_2 = -100$ N/mm^2

Angle of the plane, which it makes with the major stress = 60°

∴ Angle, $\theta = 90° - 60° = 30°$



Resultant stress in magnitude and direction:

Normal stress, $\sigma_n = \frac{\sigma_1+\sigma_2}{2} + \frac{\sigma_1-\sigma_2}{2}\cos 2\theta$

$$= \frac{200+(-100)}{2} + \frac{200-(-100)}{2}\cos 2\times 30°$$

= **125 N/mm^2**

Tangential stress, $\sigma_t = \frac{\sigma_1-\sigma_2}{2}\sin 2\theta$

$= \frac{200-(-100)}{2} \sin 2 \times 30°$

= **129.9 N/mm²**

∴ Resultant stress, $\sigma_R = \sqrt{\sigma_n^2 + \sigma_t^2} = \sqrt{125^2 + 129.9^2}$

= **180.27 N/mm²**

The inclination of the resultant stress with the normal of the inclined plane is given by

$\tan \emptyset = \frac{\sigma_t}{\sigma_n} = \frac{129.9}{125} = 1.04$

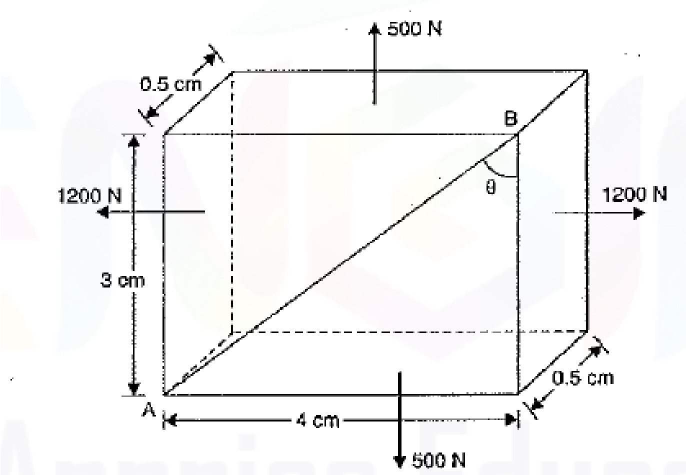
$\therefore \emptyset = 46.6°$

Maximum shear stress:

$\sigma_{t_{max}} = \frac{\sigma_1 - \sigma_2}{2} = \frac{200-(-100)}{2}$

= 150 N/mm²

6) **A small block is 4 cm long, 3 cm high and 0.5 cm thick. It is subjected to uniformly distributed tensile forces of resultants 1200N and 500 N as shown in figure. Compute the normal and shear stresses developed along the diagonal AB.**



Solution: <u>Given:</u>

Length = 4cm = 40 mm

Height = 3 cm = 30 mm

Width = 0.5 cm = 5 mm

Force along x- axis = 1200 N

Force along y-axis = 500 N

Area of cross-section normal to x-axis = $30\times 5 = 150\ mm^2$

Area of cross-section normal to y-axis = $40\times 5 = 200\ mm^2$

∴ Stress along x-axis, $\sigma_1 = \frac{Force\ along\ x-axis}{Area\ normal\ to\ x-axis}$

$$= \frac{1200}{150} = 8 \text{ N/mm}^2$$

Stress along y-axis, $\sigma_2 = \frac{Force\ along\ y-axis}{Area\ normal\ to\ y-axis}$

$$= \frac{500}{200} = 2.5 \text{ N/mm}^2$$

And $\tan\theta = \frac{4}{3} = 1.33$

$$\theta = 53.06°$$

Normal stress on diagonal AB, $\sigma_n = \frac{\sigma_1+\sigma_2}{2} + \frac{\sigma_1-\sigma_2}{2}\cos 2\theta$

$$= \frac{8+2.5}{2} + \frac{8-2.5}{2}\cos 2\times 53.06°$$

$$= 4.48 \text{ N/mm}^2$$

Shear stress on diagonal AB, $\sigma_t = \frac{\sigma_1-\sigma_2}{2}\sin 2\theta$

$$= \frac{8-2.5}{2}\sin 2\times 53.06°$$

= 2.64 N/mm^2

7) **A rectangular block of material is subjected to tensile stress of 110 N/mm^2 on one plane and a tensile stress of 47 N/mm^2 on the plane at right angles to the former. Each of the above stresses is accompanied by a shear stress of 63 N/mm^2 and that associated with the former tensile stress tends to rotate the block anticlockwise. Find**:

(i) the direction and magnitude of each of the principal stress and

(ii) magnitude of the greatest shear stress

Solution: <u>Given:</u>

Major tensile stress, $\sigma_1 = 110$ N/mm^2

Minor tensile stress, $\sigma_2 = 47$ N/mm^2

Shear stress, $\tau = 63$ N/mm^2

(i) Major principal stress:

$$\text{Major principal stress} = \frac{\sigma_1+\sigma_2}{2} + \sqrt{\left(\frac{\sigma_1-\sigma_2}{2}\right)^2 + \tau^2}$$

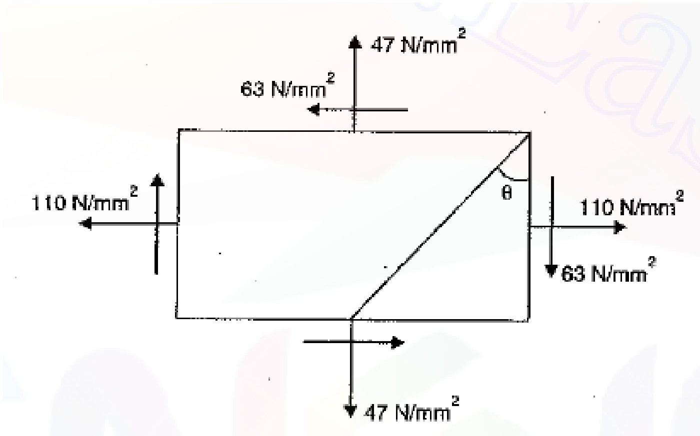
$$= \frac{110+47}{2} + \sqrt{\left(\frac{110-47}{2}\right)^2 + 63^2}$$

= 148.9 N/mm^2

$$\text{Minor principal stress} = \frac{\sigma_1+\sigma_2}{2} - \sqrt{\left(\frac{\sigma_1-\sigma_2}{2}\right)^2 + \tau^2}$$

$$= \frac{110+47}{2} - \sqrt{\left(\frac{110-47}{2}\right)^2 + 63^2}$$

= 8.064 N/mm^2



The directions of principal stresses are given by

$$\tan 2\theta = \frac{2\tau}{\sigma_1 - \sigma_2} = \frac{2 \times 63}{110 - 47}$$

$$= 2$$

$$\boldsymbol{\theta = 31.43° \; or \; 121.43°}$$

(ii) Magnitude of the greatest shear stress:

$$\tau_{max} = \frac{1}{2}\sqrt{(\sigma_1 - \sigma_2)^2 + 4\tau^2}$$

$$= \frac{1}{2}\sqrt{(110 - 47)^2 + 4 \times 63^2}$$

$$\mathbf{= 70.436\ N/mm^2}$$

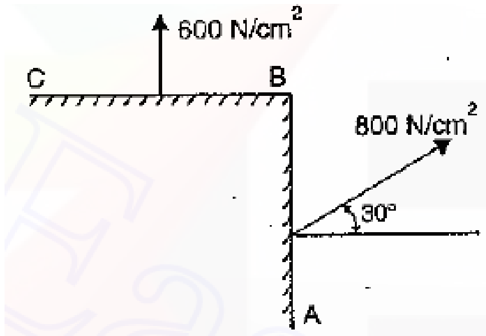
8) **The intensity of resultant stress on a plane AB as shown in figure at a point in a material under stress is 800 N/cm^2 and it is inclined at 30° to the normal to that plane. The normal component of stress on another plane BC at right angles to plane AB is 600 N/cm^2.**

Determine the following:

(i) The resultant stress on the plane BC,

(ii) The principal stresses and their directions and

(iii) The maximum shear stresses



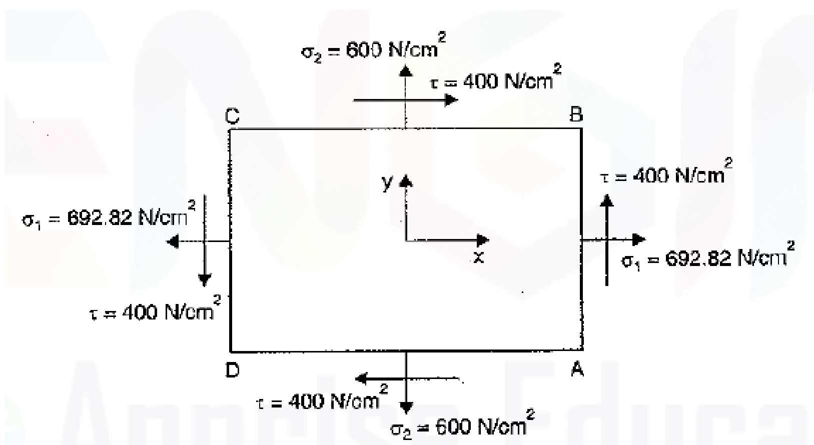
Solution: Given:

Resultant stress on plane AB = 800 N/cm^2

Angle of inclination of the above stress = 30°

Normal stress on plane BC = 600 N/cm^2

The resultant stress 800 N/cm^2 on plane AB is resolved into normal stress and tangential stress.



The normal stress on plane AB = 800 × cos 30° = 692.82 N/cm^2 = 6.92 N/mm^2

The tangential stress on plane AB = 800 × sin 30° = 400 N/cm^2 = 4 N/mm^2

(i) The resultant stress on the plane BC:

Resultant stress on the plane BC = $\sqrt{\sigma_2^2 - \tau^2} = \sqrt{6^2 - 4^2}$ = 7.21 N/mm^2

The resultant will be inclined at an angle θ with the horizontal is given by

$$\tan\theta = \frac{\sigma_2}{\tau} = \frac{6}{4} = 1.5$$

$$\boldsymbol{\theta = 56.3°}$$

(ii) Principal stresses and their directions:

$$\text{Major principal stress} = \frac{\sigma_1+\sigma_2}{2} + \sqrt{\left(\frac{\sigma_1-\sigma_2}{2}\right)^2 + \tau^2}$$

$$= \frac{6.92+6}{2} + \sqrt{\left(\frac{6.92-6}{2}\right)^2 + 4^2}$$

= 10.49 N/mm^2 (tensile)

$$\text{Minor principal stress} = \frac{\sigma_1+\sigma_2}{2} - \sqrt{\left(\frac{\sigma_1-\sigma_2}{2}\right)^2 + \tau^2}$$

$$= \frac{6.92+6}{2} - \sqrt{\left(\frac{6.92-6}{2}\right)^2 + 4^2}$$

= 2.43 N/mm^2

The directions of principal stresses are given by

$$\tan 2\theta = \frac{2\tau}{\sigma_1-\sigma_2} = \frac{2\times4}{6.92-6} = 8.6$$

$$\theta = 41.49° \ or \ 131.99°$$

(iii) The maximum shear stress:

$$\tau_{max} = \frac{1}{2}\sqrt{(\sigma_1-\sigma_2)^2 + 4\tau^2}$$

$$= \frac{1}{2}\sqrt{(6.92-6)^2 + 4\times4^2}$$

= 4.02 N/mm^2

9) The stresses at a point in a bar are 200 N/mm^2 (tensile) and 100 N/mm^2 (compressive). Determine the resultant stress in magnitude and direction on a plane inclined at 60° to the axis of the major stress. Solve by using Mohrs circle method.

Solution: <u>Given</u>:

Major stress, $\sigma_1 = 200$ N/mm^2

Minor stress, $\sigma_2 =$ - 100 N/mm^2

Angle of the plane, which it makes with the major stress = 60°

∴ Angle, θ =90° −60° = 30°

Take 1 cm = 20 N/mm^2

Then, $\sigma_1 = \frac{200}{20} = 10\ cm$ and $\sigma_2 = \frac{-100}{20} = -5\ cm$

(i) Take any point A and draw a horizontal line trough A on both sides.

(ii) Take AB = $\sigma_1 = 10\ cm$ towards right of A and AC = $\sigma_2 = -5\ cm$ towards left of A.

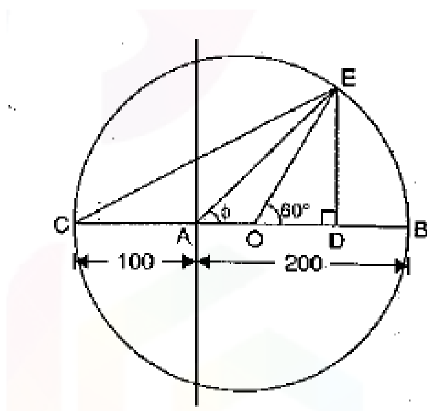
(iii) Bisect BC at O.

(iv) With O as centre and radius equal to CO or OB,draw a circle.

(v) Through O, draw a line OE, making an angle 2θ $(2\times 30° = 60°)$ with OB.

(vi) From E, draw ED perpendicular to AB. Join AE and CE.

Then AE represents the resultant stress and angle ∅ represents the obliquity.



By measurement from figure, we have

Length AE = 9 cm

Length AD = 6.25 cm and length ED = 6.5 cm

Angle made by the resultant stress with the normal of the inclined plane, $\emptyset = 46°$

∴ Resultant stress = length AE × $scale$ = 9× 20

= 180 N/mm^2

Normal stress = length AD $\times$ 20 = 6.25 $\times$ 20

= 125 N/mm^2

Shear stress = length ED$\times$ 20 = 6.5 $\times$ 20

= 130 N/mm^2

10) At a certain point in a strained material,the intensities of stresses on two planes at right angles to each other are 20 N/mm^2 and 10 N/mm^2 both tensile. They are accompanied by a shear stress of magnitude 10 N/mm^2. Find graphically the location of principal planes and evaluate the principal stresses.

Solution: **<u>Given:</u>**

Major principal stress, $\sigma_1 = 20$ N/mm^2

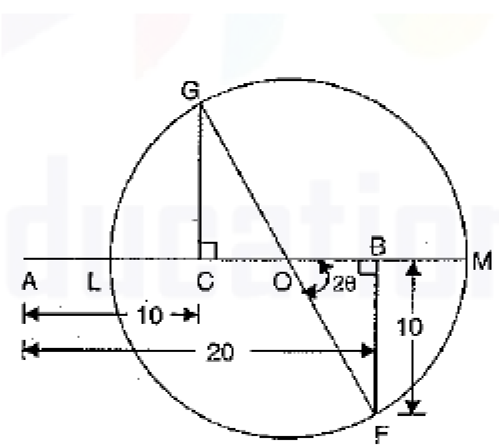
Minor principal stress, $\sigma_2 = 10$ N/mm^2

Shear stress, $\tau = 10$ N/mm^2

Take 1 cm = 2 N/mm^2

Then, $\sigma_1 = \frac{20}{2} = 10\ cm$ and $\sigma_2 = \frac{10}{2} = 5\ cm$

$\tau = \frac{10}{2} = 5\ cm$



1) Take any point A and draw a horizontal line trough A on both sides.

2) Take AB = $\sigma_1 = 10\ cm$ towards right of A and AC = $\sigma_2 = 5\ cm$ towards left of A.
3) Draw perpendicular at B and C and cutoff BF = CG = $\tau = 5\ cm$. Bisect BC at O.
4) With O as centre and radius equal to OG or OF, draw a circle cutting the horizontal line through A, at L and M as shown in figure.
5) Then AM and AL represents the major and minor principal stresses.

By measurements, we have

Length AM = 13.1 cm and length AL = 1.91 cm

Major principal stress = length AM $\times$ scale

$= 13.1 \times 2 = 26.2\ N/mm^2$

Minor principal stress = length AL $\times$ scale

$= 1.91 \times 2 = 3.82\ N/mm^2$

Location of principal planes:

$$\text{Angle FOB} = 2\theta = 63.7°$$

$$\theta = 31.85°$$

The second principal plane is given by

$$\theta + 90° = 31.85° + 90° = 121.85°$$

Mahindra University | ÉCOLE CENTRALE SCHOOL OF ENGINEERING

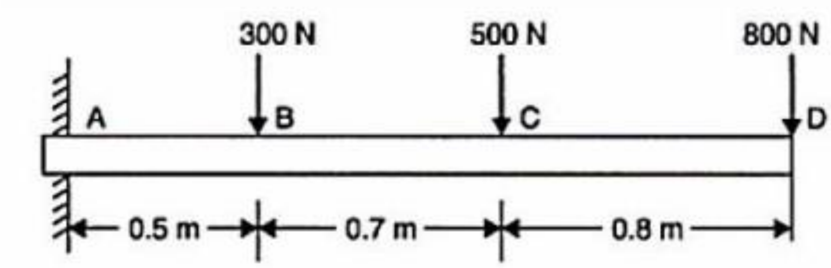
Winter Semester, 2021
B.Tech. (Civil Engineering), Semester-IV
CE-202: Mechanics of Materials Assignment No: 3

Course Coordinator: Dr. Visalakshi Talakokula **Date of submission: 03 May 2021**

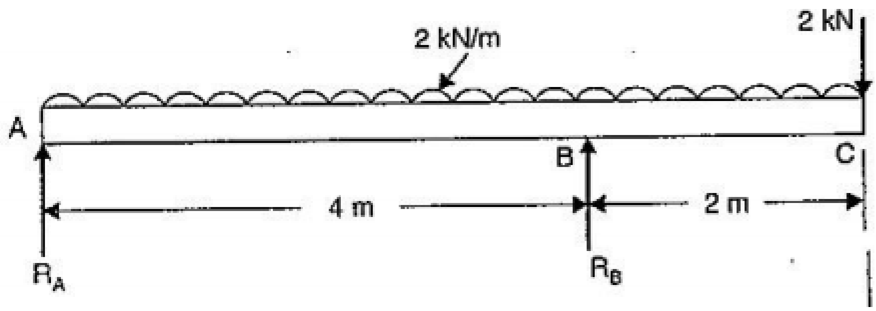
Note: Pl. read the instruction below carefully

To change the loads/length/distances take any values suitable
Total students are divided in to 7 groups
Details of group:
Group 1: Roll no 19XJ1A0101 to 19XJ1A0106 (change the load of each beam of the below problems and analyse)
Group 2: Roll no 19XJ1A0107 to 19XJ1A0112 (change the distance between the loads of each beam and analyse)
Group 3: Roll no 19XJ1A013 to 19XJ1A0119 (Change the length of the each beam and analyse)
Group 4: Roll no 19XJ1A0120 to 19XJ1A0125 (change the support conditions of each beam and analyse)
Group 5: Roll no 19XJ1A0126 to 19XJ1A0131 (Use the same problem given below and analyse)
Group 6: Roll no 19XJ1A032 to 19XJ1A0137 (Change both loads and distance between loads of all beams and analyse)
Group 7: Roll no 19XJ1A0138 to 19XJ1A0144 (change both length of the beams and magnitude of loads on each beam and analyse)

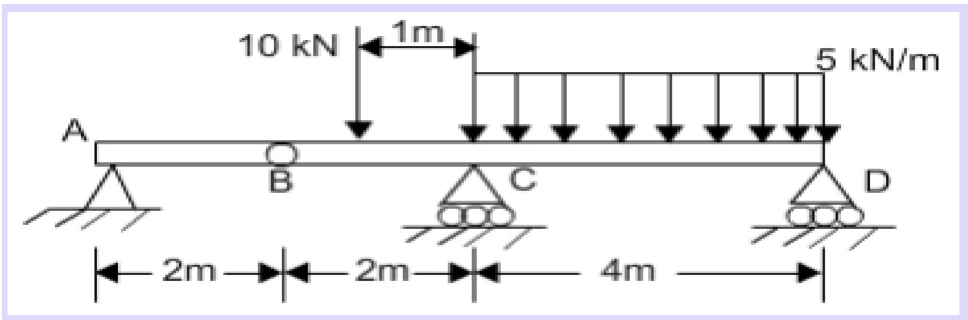
1 A cantilever beam of length 2 m carries the point loads as shown in Fig. Draw the shear force and B.M.diagrams



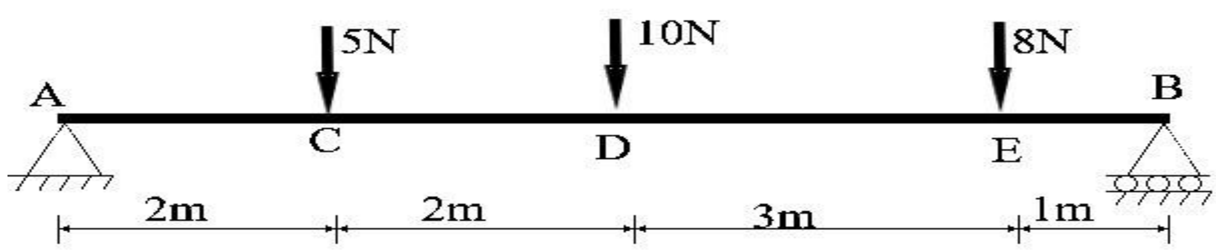
2 Draw the S.F. and BM. diagrams for the overhanging beam carrying uniformly distributed load of 2 kN/m over the entire length and a point load of 2 kN as shown in Fig. Locate the point of contra-flexure.



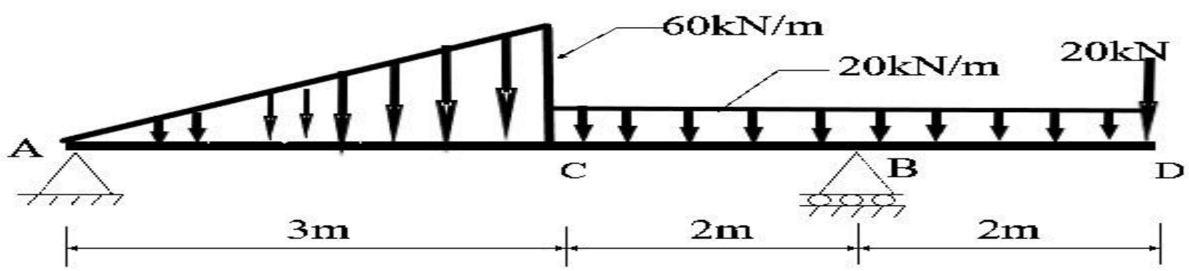
3 A beam with a hinge is loaded as below. Draw the shear force and bending moment diagram.



4 Draw shear force and bending moment diagrams [SFD and BMD] for a simply supported beam subjected to three point loads as shown in the Fig. given below.

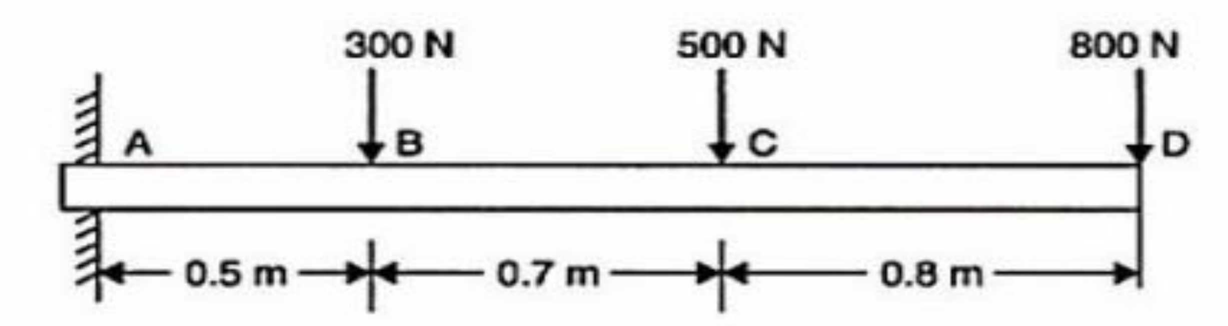


5. Draw SFD and BMD for the single side overhanging beam subjected to loading as shown below. Mark salient points on SFD and BMD.



Winter Semester, 2021
B.Tech. (Civil Engineering), Semester-IV
CE-202: Mechanics of Materials
Solution-Assignment No: 3

Question 1 A cantilever beam of length 2 m carries the point loads as shown in Fig. Draw the shear force and B.M. Diagrams for the cantilever beam.



Solution 1

Step 1 Calculate the Reaction Force

RA= 300+500+800
=1600N

Taking moments of all forces about A

MA= 300x0.5+500x1.2+800x2
= 2350N-M

Step 2 Determine the Shear Force (SF)

S.F. at D, FD = + 800 N

S.F. at C, Fc = + 800 + 500 = + 1300 N

S.F. at B, FB = + 800 + 500 + 300 = 1600 N

S.F. at A, FA = + 1600 N.

Step 3 Determine the Bending Moment (BM)

The bending moment at D is zero

B.M. at C, MC = - 800 x 0.8 = - 640 Nm.

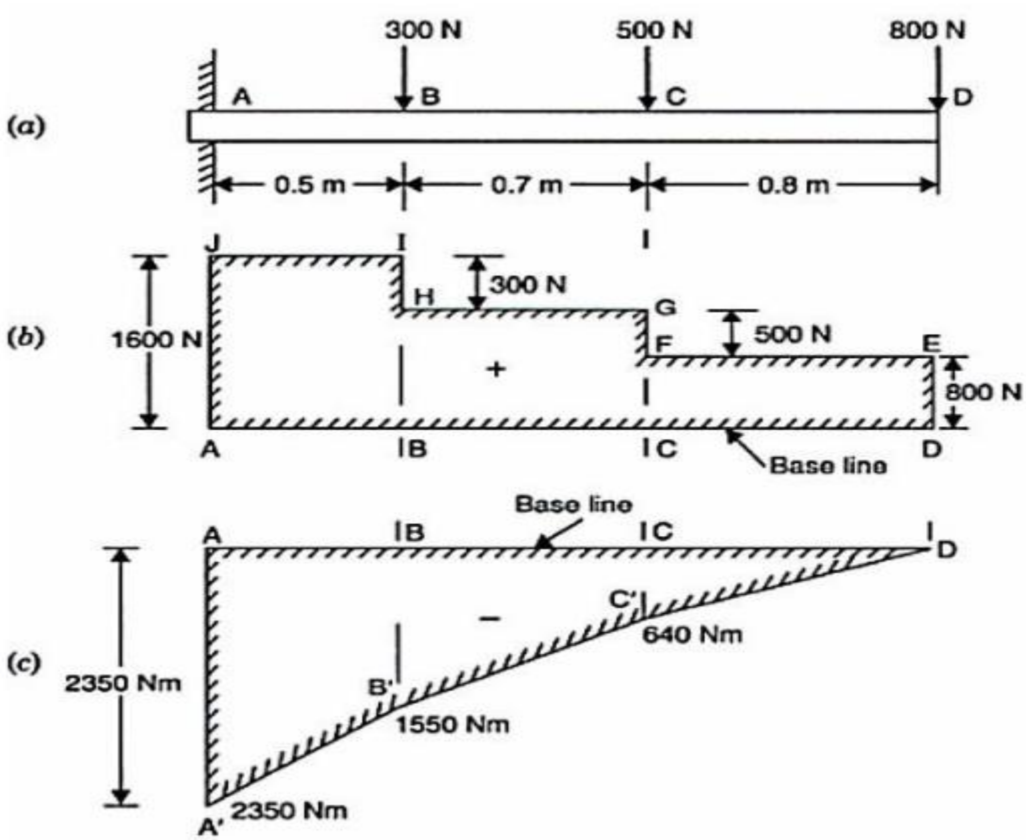
B.M. at B, MB = - 800 x 1.5 - 500 (1.5 - 0.8)

= 1200 - 350 = - 1550 Nm.

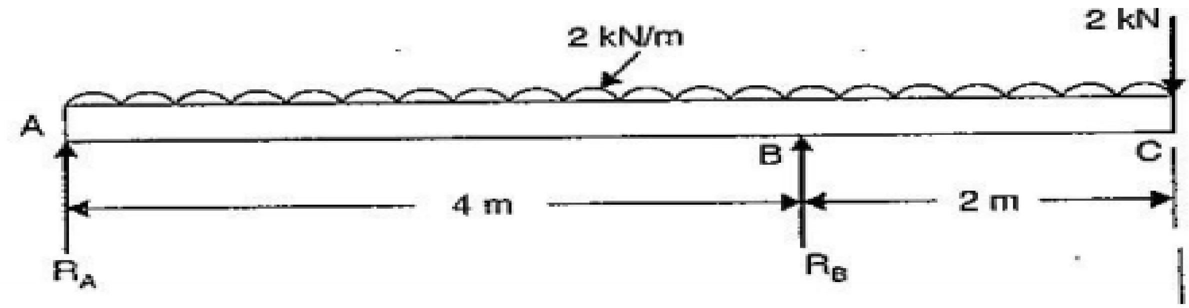
The B.M. at A, MA = - 800 x 2 - 500 (2 - 0.8) - 300 (2 - 1.5)

= - 800 x 2 - 500 x 1.2 - 300 x 0.5

= - 1600 - 600 - 150 = - 2350 Nm.



Question 2 Draw the S.F. and BM. diagrams for the overhanging beam carrying uniformly distributed load of 2 kN/m over the entire length and a point load of 2 kN as shown in Fig. Locate the point of contra-flexure



Solution 2

Step 1 Calculate the reactions RA and RB.

Upward forces = Downward forces

RA + RB = 2 X 6 +2 = 14 kN

Taking moments of all forces about A,

we get

RB x 4 = 2 x 6 x 3 + 2 x 6 = 48 k Nm

RB = 12 kN ; RA = 2 kN

Step 2 Determine the Bending Moment

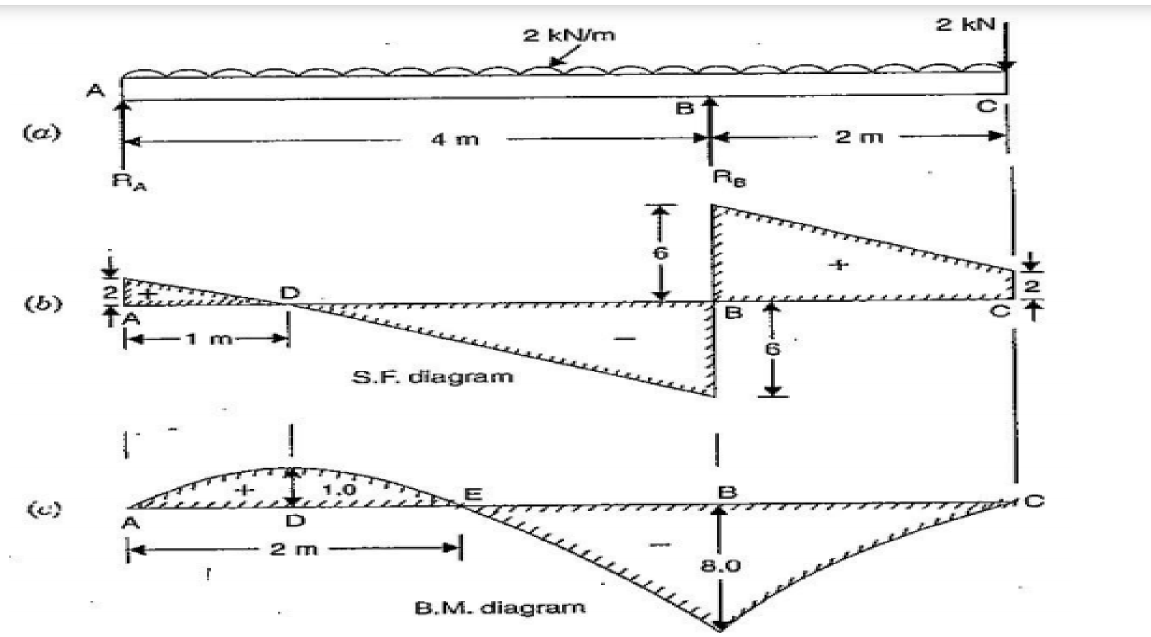
MA = 0

MB = -(2 x 2) x 1 – 2 x 2 = -8kN-m

MC = 0

Step 3 Determine the Shear force

	Left of section	**Right of section**
AT point A		2x6 + 2 – 12 = 2Kn
AT point B	2 – 2 x 4 = -6 kN	2 x 2 +2 = 6 kN
AT point C	2 + 12 – 2 x 6 = 2 kN	



To find maximum bending moment:

WKT, bending moment is maximum where shear force is zero.

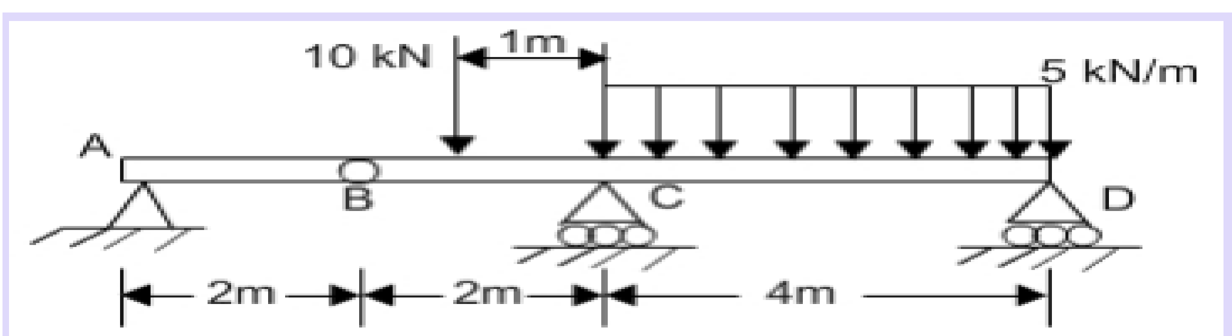
Therefore,

FD = 0 = RA -2 x (x) ;

x=1m

MD = 2 x 1 – 2 x 1 x 0.5 = 1 kN-m

Question 3 A beam with a hinge is loaded as below. Draw the shear force and bending moment diagram.



Solution 3

Step 1 Calculating the Reaction Force

A hinge can transfer axial force and shear force but not bending moment. So, bending moment at the hinge location is zero.
Also, without the hinge, the system is statically indeterminate (to a degree 1). The hinge imposes an extra condition thus rendering the system determinate.

$$M_b = 0$$
$$R_a \times 2 = 0$$
$$R_a = 0$$

Taking moment at D

Md=0
10 x 5+5x 4x 2=Rc x 4
Rc =22.5KN
10 +5 x 4 - 22.5 =Rd
Rd=7.5KN

Step 2 Calculate the shear force

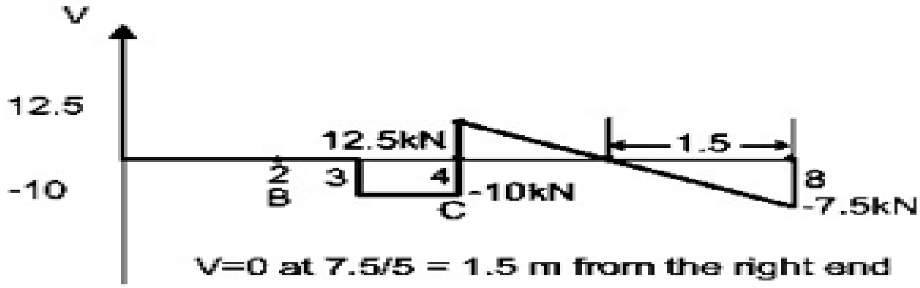
Shear force Diagram The shear force remains zero till the 10kN load is reached. It is then constant and equal to -10 kN till it reaches the point C where it jumps up by the value of Rcy. From C to D it decreases linearly at 5kN/m. From above considerations, the shear force diagram is as below.

Vd= -7.5KN

Vc-l =20-7.5 =12.5KN

Vc-r =20-7.5-22.5=-10KN

V_b=-10+10=0



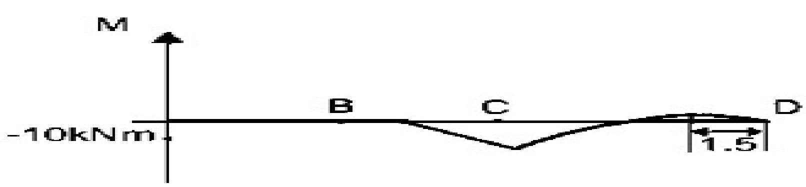
Step 2 Determine the Bending Moment at each point

Let us draw the bending moment diagram from the shear force diagram, keeping in mind the fact that the slope of bending moment diagram at any point must be equal to the shear at that point. Further, we know that the bending moment is zero at end supports. The bending moment remains zero till the 10kN force, as shear is zero. It then decreases linearly at 10 kNm/m up to the point C. From the point C, it is parabolic till it finally reaches zero at the right support D. Further, it reaches a maximum where shear is zero, keeping these in mind, the BM diagram is as below.

BM at point c = - (5 x 4 x 2) +30

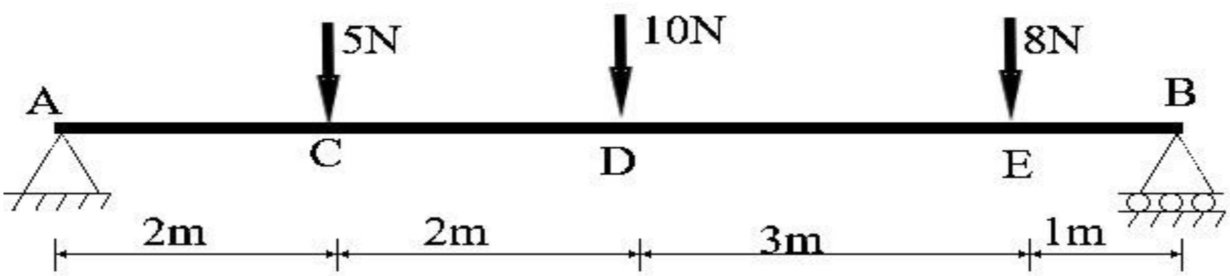
= -10kn-m

BM at D = 0



$$M_{max} = 7.5 \times 1.5 - 5 \times 1.5 \times \frac{1.5}{2} = 5.625 \text{ kNm}$$

Question 4 Draw shear force and bending moment diagrams [SFD and BMD] for a simply supported beam subjected to three point loads as shown in the Fig. given below.



Solution 4

Step 1 Determine the reaction forces RA and RB

Using the condition: $\Sigma M_A = 0$

$- R_B \times 8 + 8 \times 7 + 10 \times 4 + 5 \times 2 = 0$

$\mathbf{R_B = 13.25\ N}$

Using the condition: $\Sigma F_y = 0$

$R_A + 13.25 = 5 + 10 + 8$

$\mathbf{R_A = 9.75\ N}$

Step 2 Determine the Shear Force at the section 1-1 is denoted as $V_{1\text{-}1}$

Shear Force at the section 2-2 is denoted as $V_{2\text{-}2}$ and so on...

$V_{0\text{-}0} = 0$; $= +9.75$ N

$V_{2\text{-}2} = +9.75$ N

$V_{3\text{-}3} = +9.75 - 5 = 4.75$ N

$V_{4\text{-}4} = +4.75$ N

$V_{5\text{-}5} = +4.75 - 10 = -5.25$ N

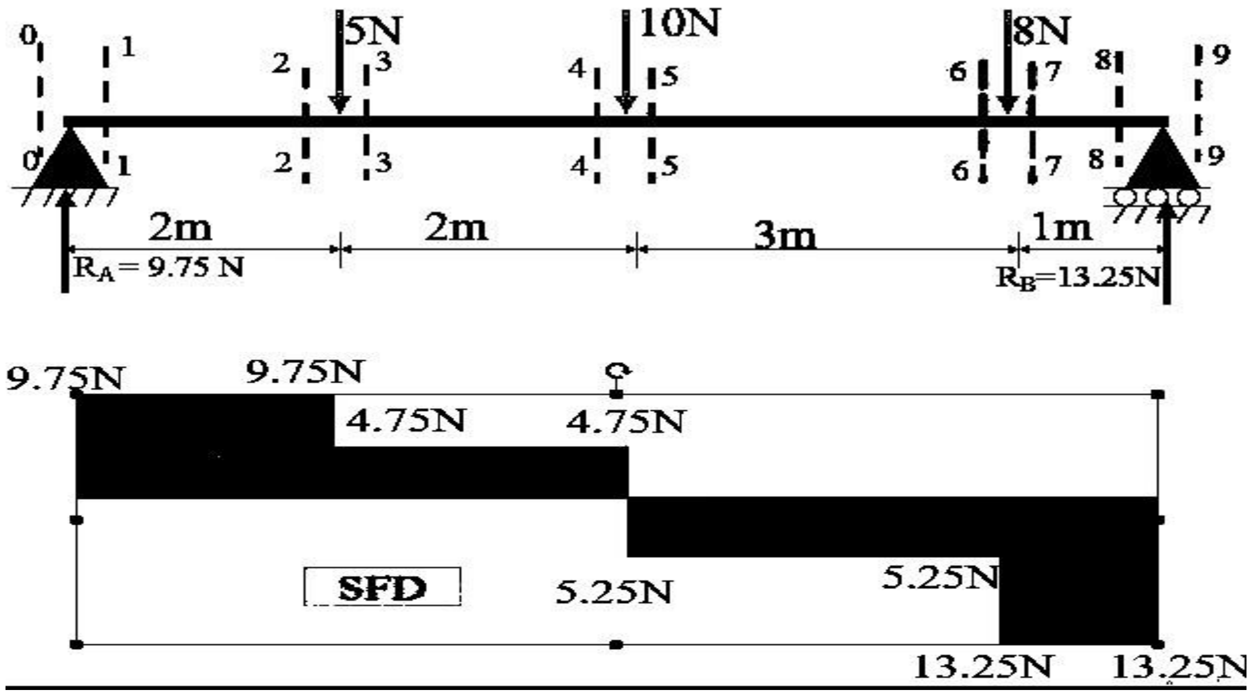
$V_{6\text{-}6} = -5.25$ N

$V_{7\text{-}7} = 5.25 - 8 = -13.25$ N

$V_{8\text{-}8} = -13.25$

$V_{9\text{-}9} = -13.25 + 13.25 = 0$

(Check)



Step 3 Determine the Bending moment of beam

Bending moment at A is denoted as M_A

Bending moment at B is denoted as M_B

and so on…

$M_A = 0$ [since it is simply supported]

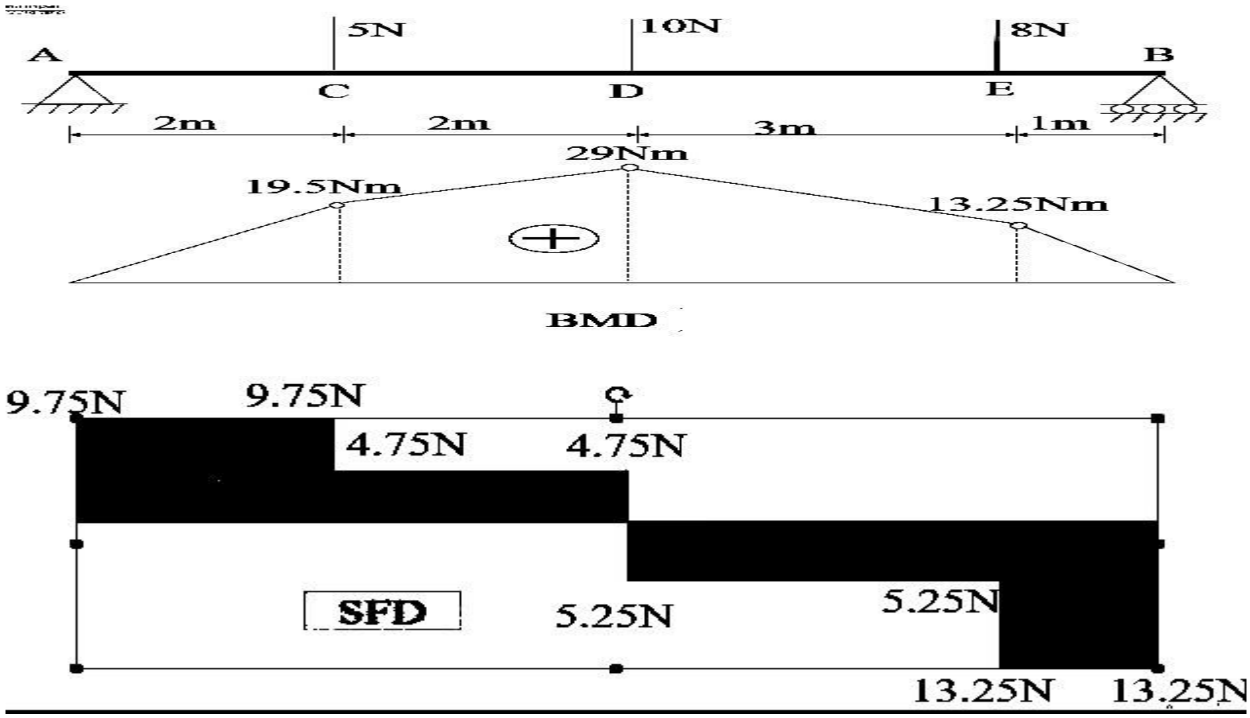
$M_C = 9.75 \times 2 = 19.5$ Nm

$M_D = 9.75 \times 4 - 5 \times 2 = 29$ Nm

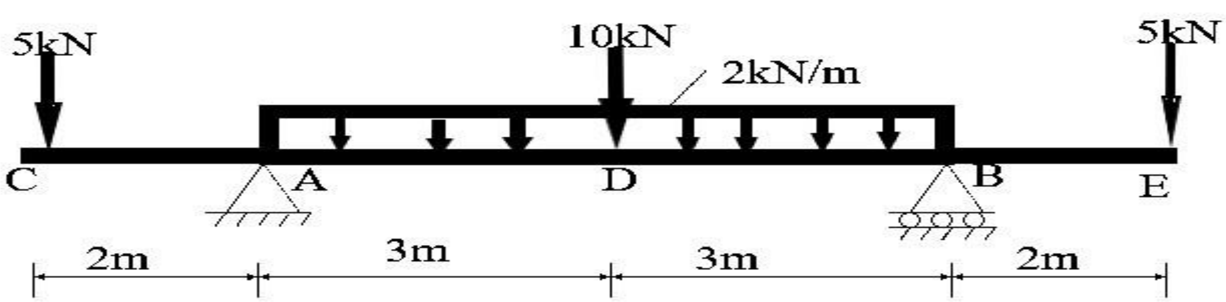
$M_E = 9.75 \times 7 - 5 \times 5 - 10 \times 3 = 13.25$ Nm

$M_B = 9.75 \times 8 - 5 \times 6 - 10 \times 4 - 8 \times 1 = 0$

or $M_B = 0$ [since it is simply supported]



Question 5 Draw SFD and BMD for the double side overhanging beam subjected to loading as shown below. Locate points of contraflexure if any.



Solution 5

Step 1 Calculation of Reactions RA and RB

Due to symmetry of the beam, loading and boundary conditions, reactions at both supports are equal.

∴ RA = RB = ½(5+10+5+2 × 6) = 16 kN

Step 2 Determine the Shear Force Calculation: $V_{0\text{-}0} = 0$

$V_{1\text{-}1} = -5\text{kN}$

$V_{2\text{-}2} = -5\text{kN}$

$V_{3\text{-}3} = -5 + 16 = 11\text{ kN}$

$V_{4\text{-}4} = 11 - 2 \times 3 = +5\text{ kN}$

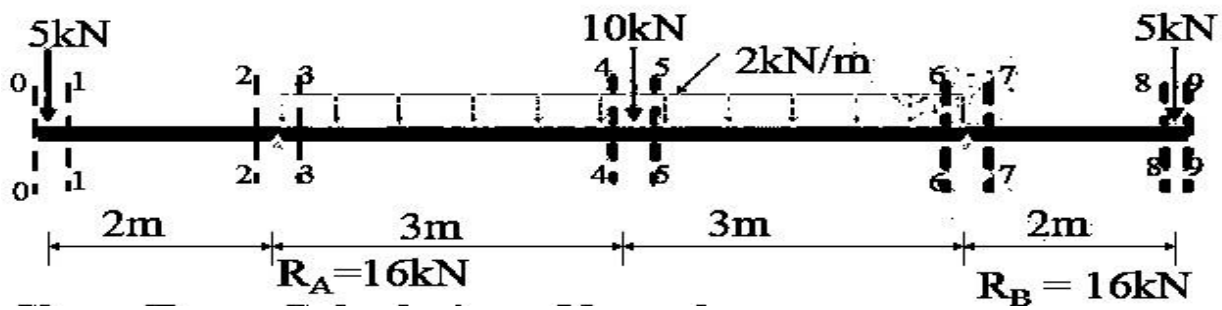
$V_{5\text{-}5} = 5 - 10 = -5\text{kN}$

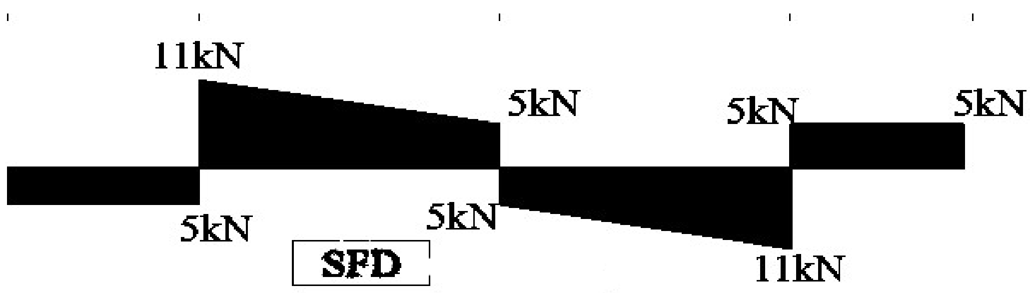
$V_{6\text{-}6} = -5 - 6 = -11\text{kN}$

$V_{7\text{-}7} = -11 + 16 = 5\text{kN}$

$V_{8\text{-}8} = 5\text{ kN}$

$V_{9\text{-}9} = 5 - 5 = 0$ (Check)



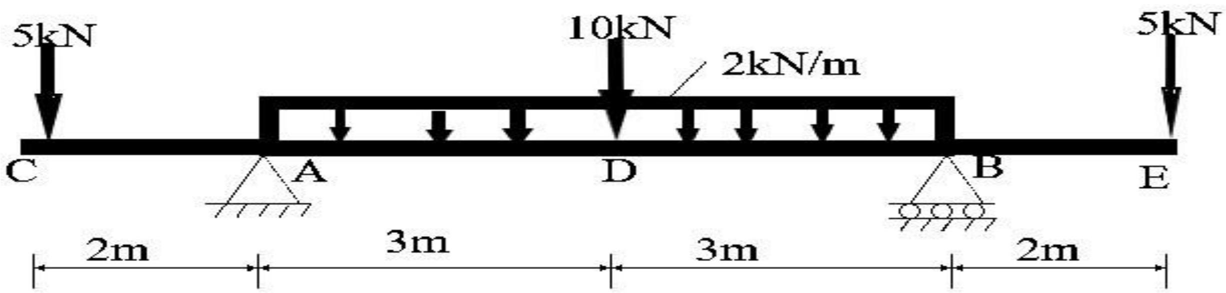


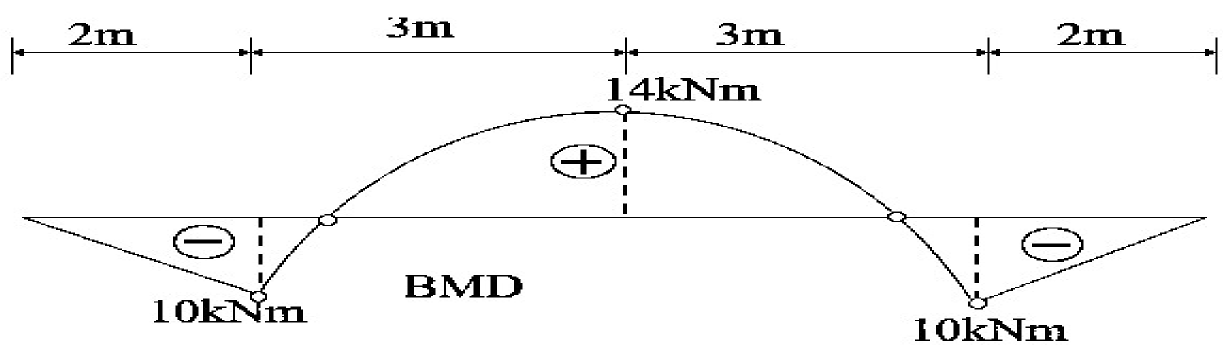
Step 3 calculation of Bending Moment

$M_C = M_E = 0$ [Because Bending moment at free end is zero]

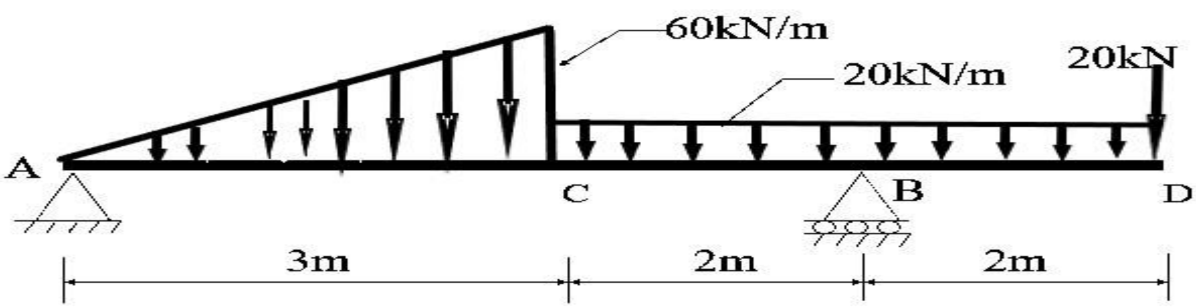
$M_A = M_B = -5 \times 2 = -10\text{ kNm}$

$M_D = -5 \times 5 + 16 \times 3 - 2 \times 3 \times 1.5 = +14\text{ kNm}$





Question 6 Draw SFD and BMD for the single side overhanging beam subjected to loading as shown below. Mark salient points on SFD and BMD.



Solution 6

Step 1 Calculation of Reactions:

$\Sigma MA = 0$

- $R_B \times 5 + ½ \times 3 \times 60 \times (2/3) \times 3 + 20 \times 4 \times 5 + 20 \times 7 = 0$ ➔ $R_B = 144kN$

$\Sigma Fy = 0$

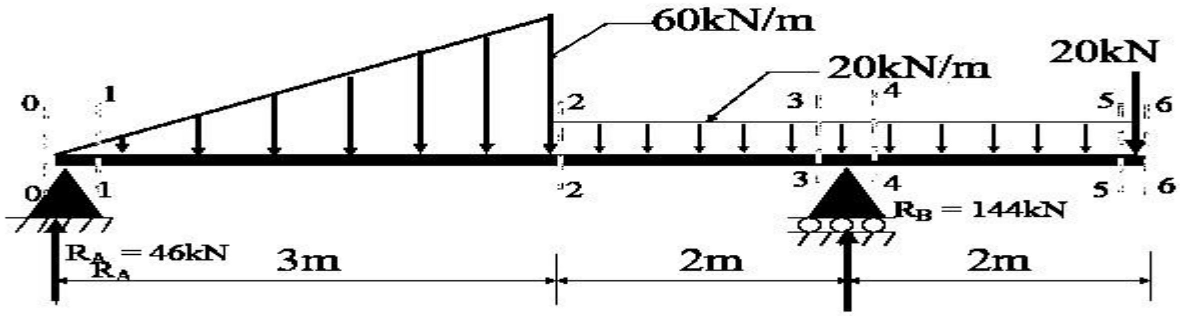
$R_A + 144 - \frac{1}{2} \times 3 \times 60 - 20 \times 4 - 20 = 0 \rightarrow R_A = 46kN$

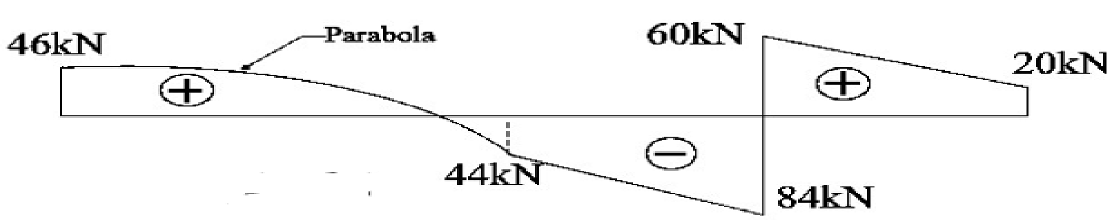
Step 2 Shear Force Calculations:

$V_{0\text{-}0} = 0$; $V_{1\text{-}1} = +46$ kN $\quad$ $V_{4\text{-}4} = -84 + 144 = +60$kN

$V_{2\text{-}2} = +46 - \frac{1}{2} \times 3 \times 60 = -44$ kN $\quad$ $V_{5\text{-}5} = +60 - 20 \times 2 = +20$ kN

$V_{3\text{-}3} = -44 - 20 \times 2 = -84$ kN $\quad$ $V_{6\text{-}6} = 20 - 20 = 0$ (Check)



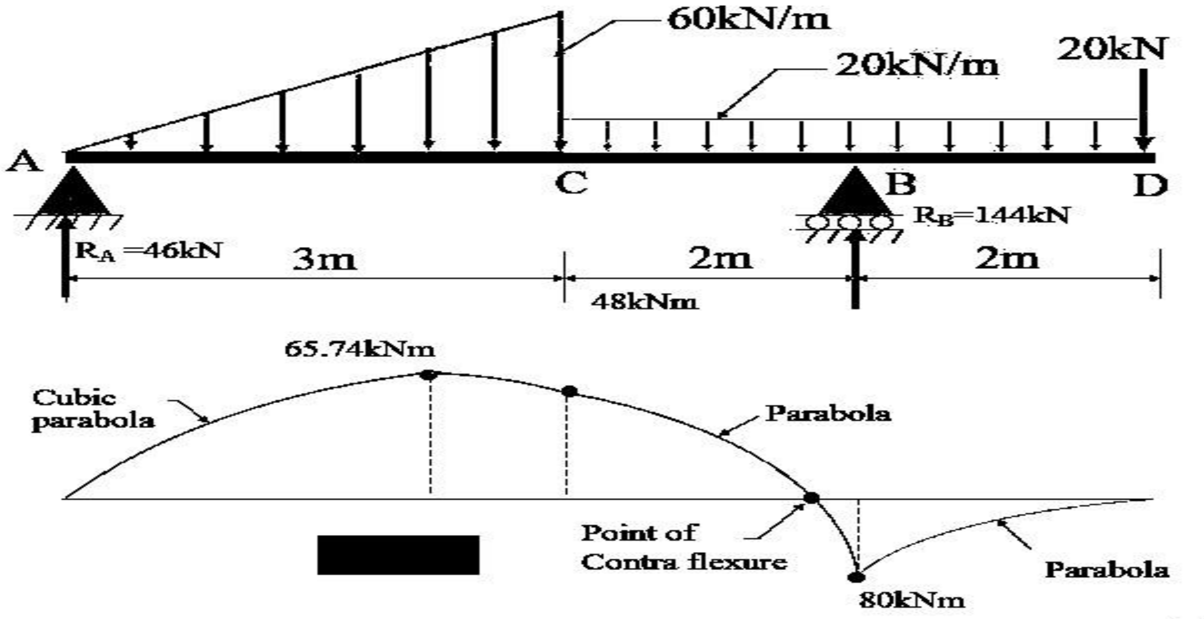


Step 3 Calculation of bending moments

$M_A = M_D = 0$

$M_C = 46 \times 3 - \frac{1}{2} \times 3 \times 60 \times (1/3 \times 3) = 48$ kNm[Considering LHS of section]

$M_B = -20 \times 2 - 20 \times 2 \times 1 = -80$ kNm [Considering RHS of section]



Absolute Maximum Bending Moment,

Mmax = 46 × 2.145 – ½ × 2.145 ×(2.145 × 60/3) × (1/3 × 2.145)

= 65.74 kNm

Calculations of Absolute Maximum Bending Moment:

Max. bending moment will occur at the section where the shear force is zero. The SFD shows that the section having zero shear force is available in the portion AC. Let that section be X-X, considered at a distance ‘x’ from support A as shown above. The shear force expression at that section should be equated to zero. i.e.,

Vx-x = 46 – ½ .x. (60/3)x = 0 ➔ x = 2.145 m

BM at X- X ,

M max = 46 × 2.145 – ½ × 2.145 ×(2.145 × 60/3) × (1/3 × 2.145)

=65.74kn-m

Winter Semester, 2021
B.Tech. (Civil Engineering), Semester-IV
CE-202: Mechanics of Materials
Assignment No: 4

Course Coordinator: Dr. Visalakshi Talakokula **Date of submission: 18 May 2021**

Note: Pl. read the instruction below carefully

To change the loads/length/distances take any values suitable

Total students are divided in to 7 groups

Details of group:

Group 1: Roll no 19XJ1A0101 to 19XJ1A0106 (change the load of each beam of the below problems and analyse)

Group 2: Roll no 19XJ1A0107 to 19XJ1A0112 (change the distance between the loads of each beam and analyse except question 5 and 6)

Group 3: Roll no 19XJ1A013 to 19XJ1A0119 (Change the length of the each beam and analyze).In question no 6 change the length of pipe.

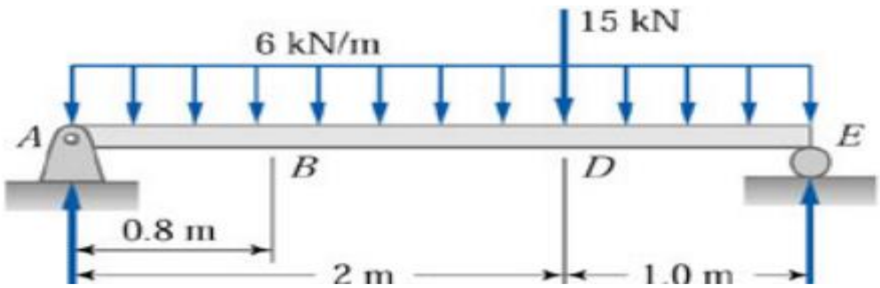
Group 4: Roll no 19XJ1A0120 to 19XJ1A0125 (change the cross-section dimension of each beam and analyse except in question no 6 change the diameter of pipe)

Group 5: Roll no 19XJ1A0126 to 19XJ1A0131 (Use the same problem given below and analyse)

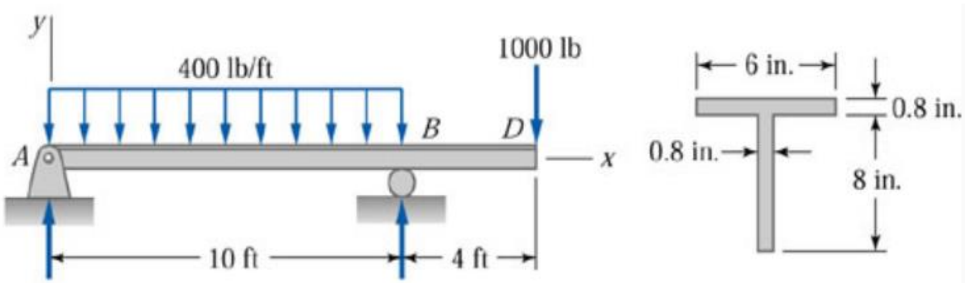
Group 6: Roll no 19XJ1A032 to 19XJ1A0137 (Change both loads and distance between loads of all beams and analyse).In question 5 and 6 only magnitude of loads should be changed.

Group 7: Roll no 19XJ1A0138 to 19XJ1A0144 (change both length of the beams and magnitude of loads on each beam and analyse).In question no 6 change the length of pipe.

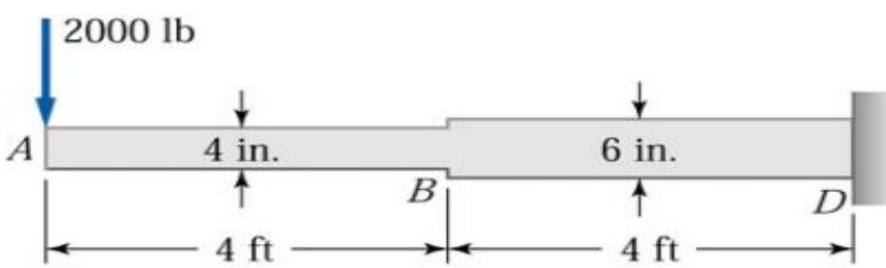
1) The simply supported beam in has a rectangular cross section 120 mm wide and 200 mm high. (1) Compute the maximum bending stress in the beam. (2) Sketch the bending stress distribution over the cross section on which the maximum bending stress occurs. (3) Compute the bending stress at a point on section B that is 25 mm below the top of the beam.



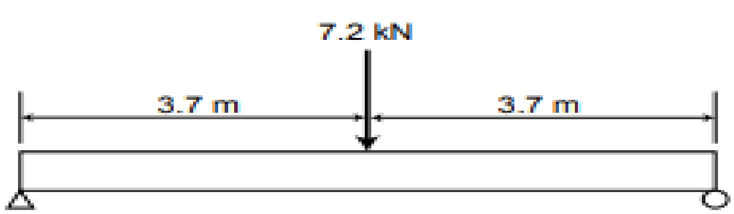
2 The simply supported beam in Fig has the T-shaped cross section shown. Determine the values and locations of the maximum tensile and compressive bending stresses.



3 The cantilever beam in below Fig is composed of two segments with rectangular cross sections. The width of the each section is 2 in., but the depths are different, as shown in the figure. Determine the maximum bending stress in the beam.



4 A 89 mm×300 mm beam has a length of 7.4 m and supports a concentrated load of 7.2 kN, as illustrated below. Draw shear force and bending moment diagrams for the beam. Find the maximum maximum shear stress and the maximum bending stress.

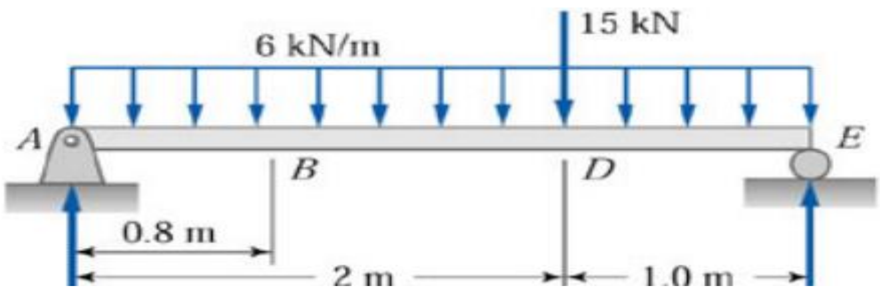


5 A rectangular beam 200mm deep and 300mm wide is simply supported over the span of 8m. What uniformly distributed load per metre the beam may carry, if the bending stress is not exceed 120N/mm2.

6 Calculate the maximum stress induced in a cast iron pipe of external diameter 40mm, of internal diameter 20mm and length 4m when the pipe is supported at its ends and carries a point load of 80N at its centre.

Winter Semester, 2021
B.Tech. (Civil Engineering), Semester-IV
CE-202:Mechanics of Materials
Solution-Assignment No: 4

Q.1) The simply supported beam in has a rectangular cross section 120 mm wide and 200 mm high. (1) Compute the maximum bending stress in the beam. (2) Sketch the bending stress distribution over the cross section on which the maximum bending stress occurs. (3) Compute the bending stress at a point on section B that is 25 mm below the top of the beam.



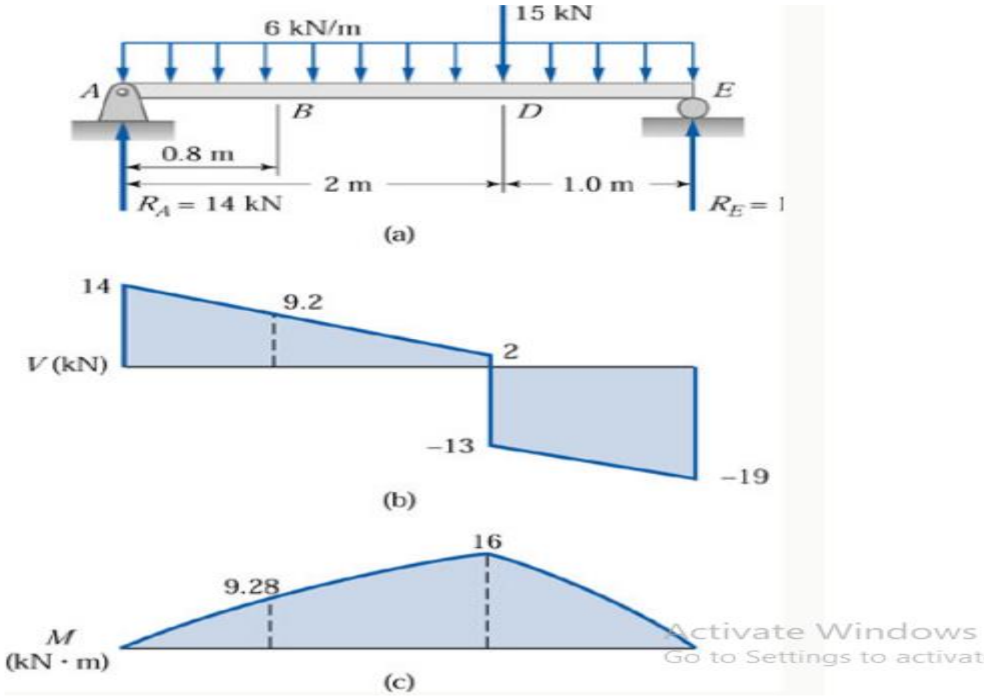
Solution

Preliminary Calculations

The shear force and bending moment diagrams. M max = +16 kN·m, occurring at D. The neutral axis (NA) is an axis of symmetry of the cross section. The moment of inertia of the cross section about the neutral axis is

I=bd^3/12
= 0.12 x (0.2)^3/12
=800e-6m^4

and the distance c between the neutral axis and the top (or bottom) of the cross section is c = 100 mm = 0.1 m.



Part 1

The maximum bending stress in the beam on the cross section that carries the largest bending moment, which is the section at D.

σ =M*C/I
=16e-3x0.1/80e-6
=20.0Mpa

Part 2

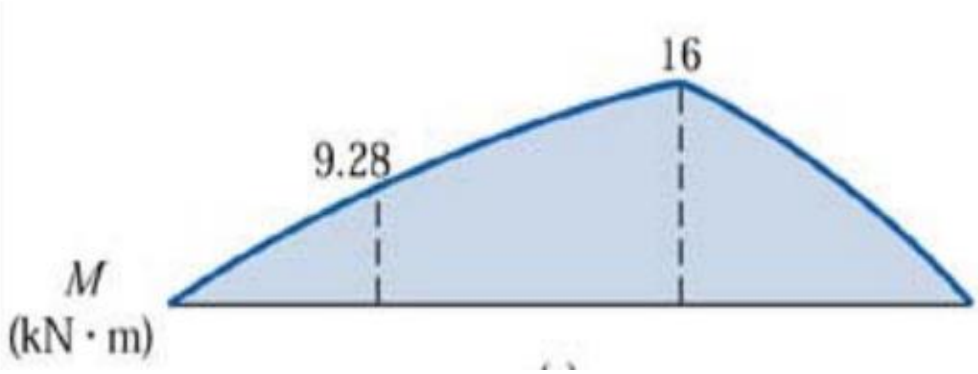
The stress distribution on the cross section is i.e
(i) The bending stress varies linearly with distance from the neutral axis
(ii) Because M max is positive, the top half of the cross section is in compression and the bottom half is in tension.
(iii)Due to symmetry of the cross section about the neutral axis, the maximum tensile and compressive stresses are equal in magnitude.

Part 3

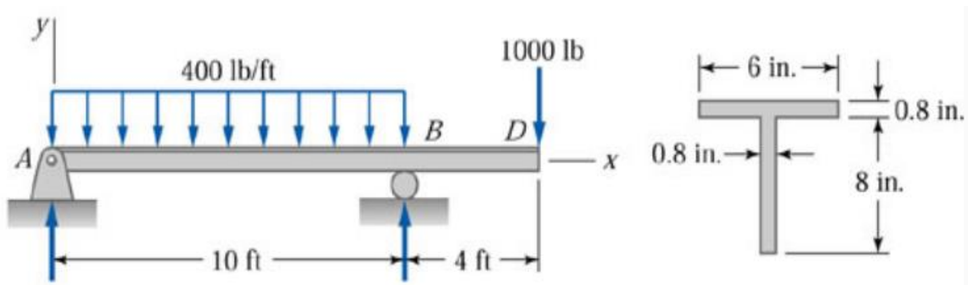
we see that the bending moment at section B is M = + 9.28 kN·m. The y-coordinate of the point that lies 25 mm below the top of the beam is y = 100 -25 = 75 mm = 0.075 m.

σ = MY/I
= 9.28e3x0.075/80e-6
= -8.7e6 pa

The negative sign indicates that this bending stress is compressive, which is expected because the bending moment is positive and the point of interest lie above the neutral axis.



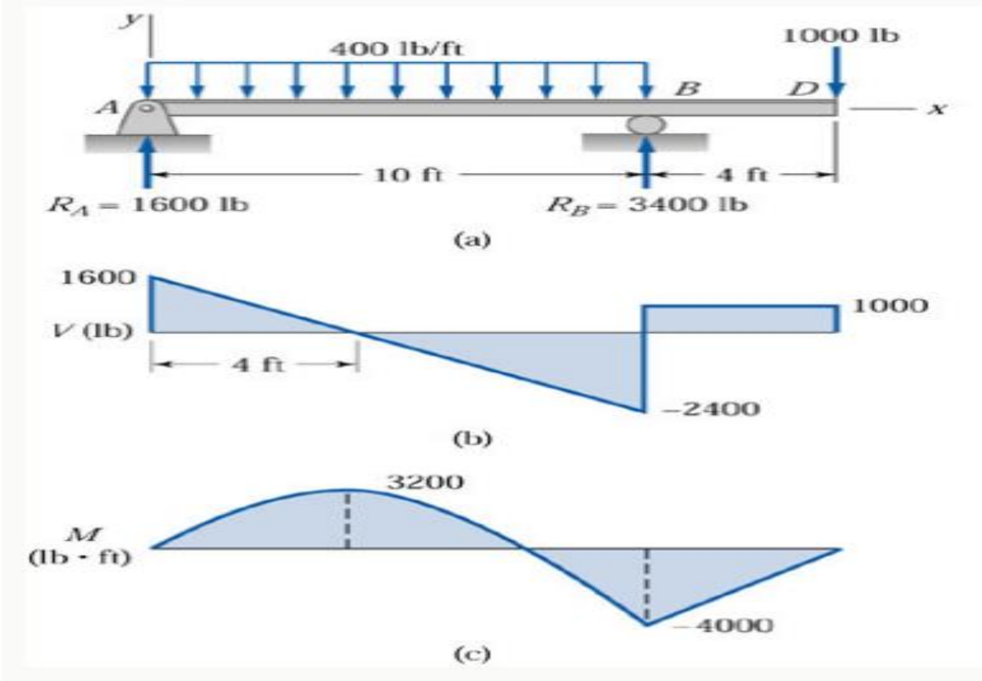
Q.2) The simply supported beam in Fig has the T-shaped cross section shown. Determine the values and locations of the maximum tensile and compressive bending stresses.



Solution

Preliminary Calculations

Find the largest positive and negative bending moment. The results are shown in Fig. (a) -(c). From Fig.(c), the largest positive and negative bending moment are 3200 lb·ft and 4000 lb·ft respectively.



As shown in Fig the cross section to be composed of the two rectangles with areas

A1 = 0.8(8) = 6.4 in.2
A2 = 0.8 (6) = 4.8 in.2 .

The centroidal coordinates of the areas are and , measured from the bottom of the cross section. The coordinate of the centroid C of the cross section is

$$\bar{y} = \frac{A_1 \overline{y_1} + A_2 \overline{y_2}}{A_1 + A_2} = \frac{6.4(4) + 4.8(8.4)}{6.4 + 4.8} = 5.886 in.$$

Compute the moment of inertia I of the cross-sectional area about the neutral axis. Using the parallel-axis theorem, where is the moment of inertia of a rectangle about its own centroidal axis Thus,

$$I = \left[\frac{0.8(8)^3}{12} + 6.4(4 - 5.886)^2\right] + \left[\frac{6(0.8)^3}{12} + 4.8(8.4 - 5.886)^2\right] = 87.49 in.^4$$

Maximum Bending stresses

The distances from the neutral axis to the top and the bottom of the cross section are $c_{top} = 8.8 - \bar{y} = 8.8 - 5886 = 2.914 in.$ and $c_{bot} = \bar{y} = 5.886 in.$, as shown in Fig.(c). Because these distances are different, we must investigate stresses at two locations: at $x = 4$ ft (where the largest positive bending moment occurs) and at $x = 10$ ft (where the largest negative bending moment occurs).

Stresses at x = 4 ft The bending moment at this section is $M = +3200$ lb · ft causing compression above the neutral axis and tension below the axis. The resulting bending stresses at the top and bottom of the cross section are

$$\sigma_{top} = -\frac{Mc_{top}}{I} = -\frac{(3200 \times 12)(2.914)}{87.49} = -1279\,psi$$

$$\sigma_{bot} = -\frac{Mc_{bot}}{I} = \frac{(3200 \times 12)(-5.886)}{87.49} = 2580\,psi$$

Stresses at x = 10 ft The bending moment at this section is $M = -4000$lb · ft, resulting in tension the neutral axis and compression below the neutral axis. The corresponding bending stresses at the extremities of the cross section are

$$\sigma_{top} = -\frac{Mc_{top}}{I} = \frac{(-4000 \times 12)(2.914)}{87.49} = 1599\,psi$$

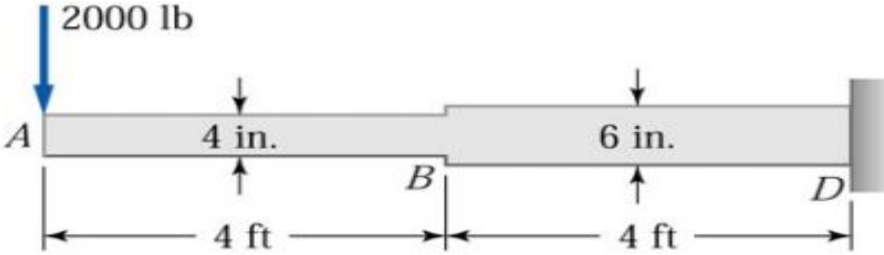
$$\sigma_{bot} = -\frac{Mc_{bot}}{I} = \frac{(-4000 \times 12) - (5.886)}{87.49} = -3230\,psi$$

Inspecting the above results, we conclude that the maximum tensile and compressive stresses in the beam are

$(\sigma_T)_{max} =$ 2580 psi (bottom of the section at $x = 4$ ft)

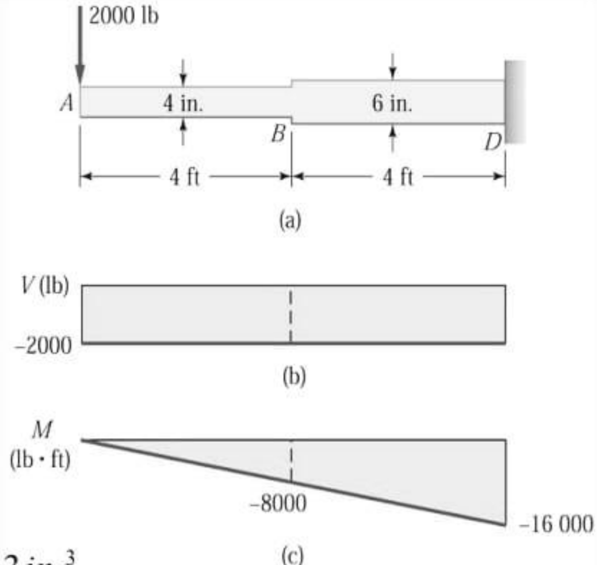
$(\sigma_c)_{max} =$ 3230 psi (bottom of the section at $x = 10$ ft)

Q.3) The cantilever beam in below Fig is composed of two segments with rectangular cross sections. The width of the each section is 2 in., but the depths are different, as shown in the figure. Determine the maximum bending stress in the beam.



Solution

Because the cross section of the beam is not constant, the maximum stress occurs either at the section just to the left of B (M_B = - 8000 lb · ft) or at the section at D (M_D = - 16000 lb · ft). the section moduli of the two segments are



$$S_{AB} = \frac{bh^2{}_{AB}}{6} = \frac{(2)(4)^2}{6} 5.333 in.^3$$

$$S_{BD} = \frac{bh^2{}_{BD}}{6} = \frac{(2)(6)^2}{6} 12.0 in.^3$$

From Eq. (5.4b) the maximum bending stresses on the two cross sections of the interest are

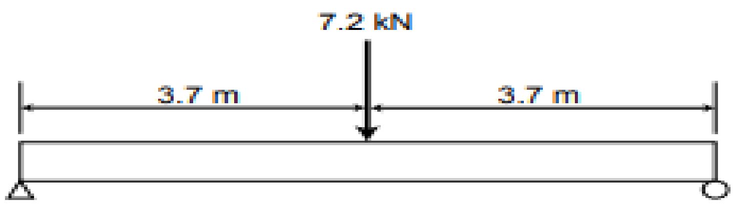
$$(\sigma_B)_{\max} = \frac{[M_B]}{S_{AB}} = \frac{8000 \times 12}{5.333} = 18000\, psi$$

$$(\sigma_D)_{\max} = \frac{[M_D]}{S_{BD}} = \frac{16000 \times 12}{12.0} = 16000\, psi$$

Comparing the above values, we find that the maximum bending stress in the beam is

$\sigma_{\max}$ = 18000 psi (on the cross section just to the left of B)

Q.4) A 89 mm×300 mm beam has a length of 7.4 m and supports a concentrated load of 7.2 kN, as illustrated below. Draw shear force and bending moment diagrams for the beam. Find the maximum maximum shear stress and the maximum bending stress.



Solution

The beam is symmetrical about its mid-point, so the reactions are equal:

RA = RB = 7.2 /2 = 3.6 kN

The load and reactions are concentrated forces so the shear forces are constant between the concentrated loads. For example, take any section through the beam at 0 < x < 3.7 m from the left end of the beam and examine the vertical forces:

$\Sigma F_y = 3.6 - V = 0$

V = 3.6 kN

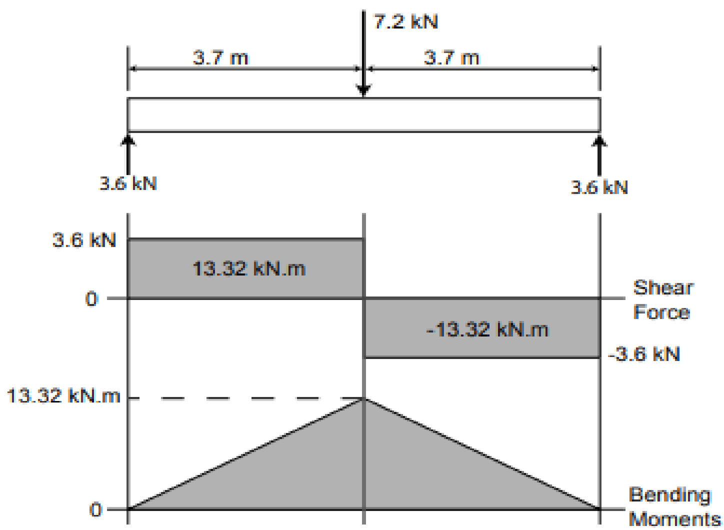
A similar calculation for any section through the beam at

3.7 < x < 7.4 m yields:

$\Sigma F_y = 3.6 - 7.2 - V = 0$

$V = -3.6$ kN

The bending moment diagrams for concentrated forces are linear; that is, they have constant slope (they are of the form y = mx + c where m is the slope). These are most easily derived from the area under the shear force diagram. The area under the shear force diagram to the left of x = 0 is 0 so the point (0,0) is on the bending moment diagram. The area under the shear force diagram immediately left of x = 3.7 m is
$3.6 \times 3.7 = 13.32$ kN · m so the point (3.7, 13.32) is on the bending moment diagram. The straight line between these points represents the bending moments for the left half of the beam. A similar procedure provides the line for the right hand side.



From the shear force diagram, the maximum shear force is 3.6 kN. The shear force is the same all the way along the beam except at points 0 m, 3.7 m and 7.4 m from the left hand end of the beam (the shear force is undened at these points), although the sign of the shear force changes from positive to negative at the middle of the beam. Maximum shear force of a rectangular section is given by:

$\tau = 3V / 2A$
$= 3 \times 3.6 \times 10^3$ N $/ 2 \times 89$ mm $\times 300$ mm
$= 0.202$ MPa

Maximum bending force is 13.32 kN. Maximum bending stresses occur at the top and the bottom of the beam, where c = 150 mm, and is given by:

$\sigma = M \times C / I$

= 13.32 × 106 N · mm × 150 mm / 89 x (300) x 0.25 mm4
= 9.98 MPa

Q.5) A rectangular beam 200mm deep and 300mm wide is simply supported over the span of 8m. What uniformly distributed load per metre the beam may carry, if the bending stress is not exceed 120N/mm2.

Solution:

Step 1: Data:
Length of beam = 8m or 8000mm
Section dimensions = 300mm X 200mm
maximum bending stress = σ = 120N/mm^2.
condition: uniformly distributed load for simply supported beam

Step 2:
Calculation of bending moment for the above condition
M = wL^2/8
= w (8)^2/8
= 8wX10^6

Step 3:
Calculation of moment of inertia
I = bd^3/12
= (300) (200^3) /12
= 2X10^8 mm^4

Step 4:
Calculation of Udl
M /I= σ / y
Substitute for above (where y = depth /2= 200/2 =100mm)
8wX10^6 /2X10^8= 120 / 100
w =3X10^4 N/m or 30 N/mm

Q.6) Calculate the maximum stress induced in a cast iron pipe of external diameter 40mm, of internal diameter 20mm and length 4m when the pipe is supported at its ends and carries a point load of 80N at its centre.

Solution:

Step 1: Data:
Length of beam = 4m or 4000mm
Internal diameter = 20mm
External diameter = 40mm
condition: point load for simply supported beam

Step 2:
Calculation of maximum bending moment
M= W L /4
M = 80 X 4000 /4
M = 80 KN-m

Step 3: Calculation of moment of inertia
$I = \pi (D^4 - d^4)/64$
$I = \pi (40^4 - 20^4)/64$
I = 117809.7mm4

Step 4: Calculation of bending stress
M /I= σ / y
Substitute for above (where y = depth /2= 40/2 =20mm)
80X1000/117809.7 = σ / 20
σ = 13.58 N/mm2

Winter Semester, 2021
B.Tech. (Civil Engineering), Semester-IV
CE-202:Mechanics of Materials
Assignment No: 5

Course Coordinator: Dr. Visalakshi Talakokula **Date of submission: 28 May 2021**

Note: Pl. read the instruction below carefully

To change the loads/length/distances take any values suitable

Total students are divided in to 7 groups

Details of group:

Group 1: Roll no 19XJ1A0101 to 19XJ1A0106 (change the cross section dimension of the beams except question no 1)

Group 2: Roll no 19XJ1A0107 to 19XJ1A0112 (change the magnitude of load and shear force)

Group 3: Roll no 19XJ1A013 to 19XJ1A0119 (Change the length of beam1,2) In question no 4 and 5 change the cross section dimension.

Group 4: Roll no 19XJ1A0120 to 19XJ1A0125 (change the magnitude of shear force except question no 1)

Group 5: Roll no 19XJ1A0126 to 19XJ1A0131 (Use the same problem given below and analyse)

Group 6: Roll no 19XJ1A032 to 19XJ1A0137 (Change both c/s dimension of beam and magnitude of shear force except question no 1)

Group 7: Roll no 19XJ1A0138 to 19XJ1A0144 (change the span of beam 1,2) In question 4 and 5 change the thickness of flange only.

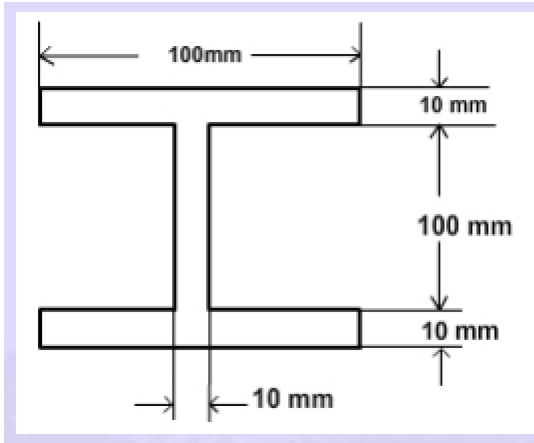
Q.1. A rectangular beam of 100 mm wide and 250mm deep is subjected to maximum Of shear force 50 KN, Determine the following

a) Average shear stress

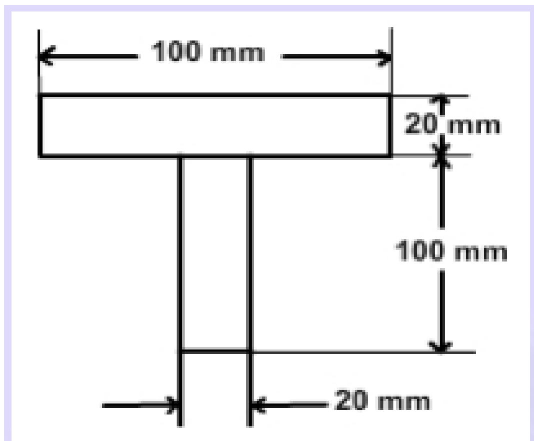
b) Maximum shear stress

c) Shear stress at the of 25mm above the NA.

Q.2. The cross section of an I beam is shown below. Find the max. shear stress in the flange if it transmits a vertical shear of 2KN.



Q.3. A vertical shear force of 1KN acts on the cross section shown below. Find the shear at the interface (per unit length)



Q.4. A hollow mild steel tube 6m long 4cm internal diameter and 6m thick is used as strut with both ends hinged? Find the crippling load and the safe load taking FOS=3? E=2x10^5N/mm^2

Q.5. A solid round bar of 3m long ang 5cm in diameter is used as strut with both edges hinged? Determine the crippling load? Take E= 2x10^5 N/mm^2 ? Determine the crippling load under the following condition

a) one end is fixed other is hinged

b) Both ends are fixed

c) one end is fixed other is free

Q.6. A steel bar of rectangular cross section 30 x 50 mm pinned at each end is 2 m long. Determine the buckling load when it is subjected to axial compression and also calculate axial: stress using Euler's expression. Determine the minimum length for which Euler's equation may be valid. Take proportionality limit as 250 MPa and E = 200 GPa (2 x 10^5)

Q.7. A hollow shaft of diameter ratio 3/8 is to transmit 375 kW power at 100 r.p.m. The maximum torque being 20% greater than the mean. The shear stress is not to exceed 60 N/mm2 and twist in a length of 4 m not to exceed 2°. Calculate its external and internal diameters which would satisfy both the above conditions. Assume modulus of rigidity, C = 0.85 x 10^5 N/mm2

Q.8. A solid cylindrical shaft is to transmit 300 kW power at 100 r.p.m.

(a) If the shear stress is not to exceed 80 N/mm2 , find its diameter.

(b) What percent saving in weight would be obtained if this shaft is replaced by a hollow one whose internal diameter equals to 0.6 of the external diameter, the length, the material and maximum shear stress **being same as above**

Q.9. Find the diameter of the shaft required to transmit 60 kW at 150 rpm if the maximum torque exceeds 25% of the mean torque for a maximum permissible shear stress of 60 MN/mm2 . Find also the angle of twist for a length of 4 m. Take G = 80 GPa.

Q.10. A solid shaft has to transmit 120 kW of power at 160 rpm. If the shear stress is not to exceed 60 MPa and the twist in a length of 3 m must not exceed 1°, find the suitable diameter of the shaft. Take G = 80 GPa.

Winter Semester, 2021
B.Tech. (Civil Engineering), Semester-IV
CE-202:Mechanics of Materials
Solution-Assignment No: 5

Q.1. A rectangular beam of 100 mm wide and 250mm deep is subjected to maximum Of shear force 50 KN, Determine the following

i) Average shear stress
ii) Maximum shear stress
iii) Shear stress at the of 25mm above the NA.

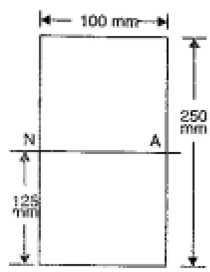
Solution

Sol. Given :

Width, $b = 100$ mm

Depth, $d = 250$ mm

Maximum shear force, $F = 50$ kN $= 50{,}000$ N.



(*i*) Average shear stress is given by,

$$\tau_{avg} = \frac{F}{\text{Area}} = \frac{50{,}000}{b \times d}$$

$$= \frac{50{,}000}{100 \times 250} = \mathbf{2\ N/mm^2}. \quad \textbf{Ans.}$$

(*ii*) Maximum shear stress is given by equation

$$\therefore \quad \tau_{max} = 1.5 \times \tau_{avg}$$

$$= 1.5 \times 2 = \mathbf{3\ N/mm^2}. \quad \textbf{Ans.}$$

(*iii*) The shear stress at a distance *y* from N.A. is given by equatio[n]

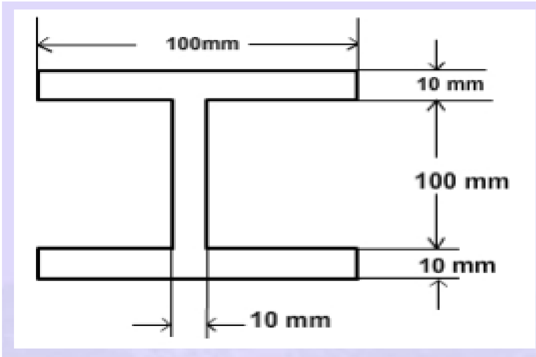
$$\therefore \quad \tau = \frac{F}{2I}\left(\frac{d^2}{4} - y^2\right)$$

$$= \frac{50000}{2I}\left(\frac{250^2}{4} - 25^2\right) \qquad (\because \ y = 25 \text{ mm})$$

$$= \frac{50000}{2 \times \frac{bd^3}{12}}\left(\frac{62500}{4} - 625\right) = \frac{50000 \times 12}{2 \times 100 \times 250^3} \times 15000 \text{ N/mm}^2$$

$$= \mathbf{2.88\ N/mm^2}. \quad \textbf{Ans.}$$

Q.2. The cross section of an I beam is shown below. Find the max. shear stress in the flange if it transmits a vertical shear of 2KN.



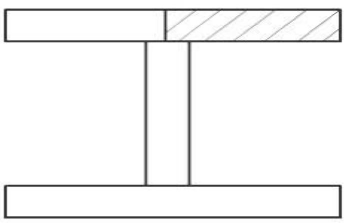
Solution

Formula used: $\tau = \dfrac{VQ}{It}$

$V = 2KN$

$$I = \frac{10\times100^3}{12} + \left(\frac{100\times10^3}{12} + 100\times10\times55^2\right)\times2 = 6.9\times10^6 \ \text{mm}^4$$

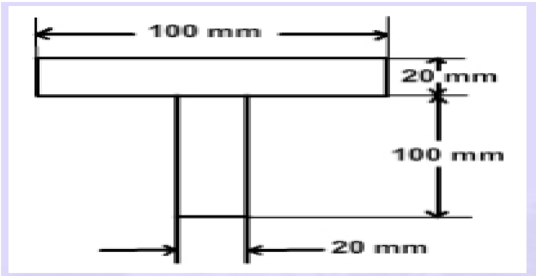
Q is maximum at the midpoint as shown below



Q = 50 × 10 × 55

$$\tau_{max} = \frac{2\times10^3\times50\times10\times55\times\left(10^{-3}\right)^3}{\left(6.9\times10^6\right)\left(10^{-3}\right)^4\times10\times10^{-3}} = 0.79 \ \text{MPa}$$

Q.3. A vertical shear force of 1KN acts on the cross section shown below. Find the shear at the interface (per unit length)

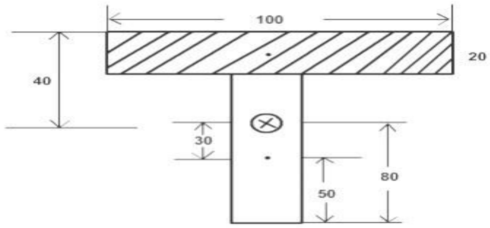


Solution

Solution:

Formula used: q = VQ/I

We first find the distance of the neutral axis from the top fiber.



All dimensions in mm

$$y_{NA} = \frac{20\times100\times10+20\times100\times70}{20\times100+20\times100} = 40\text{mm}$$

$Q = \int y dA$ of shaded area about neutral axis.

$Q = 20 \times 100 \times 30 = 6 \times 10^4$

V = 1KN

$$I = \frac{20\times100^3}{12} + 20\times100\times30^2 + \frac{100\times20^3}{12} + 100\times20\times30^2$$

$$=5.33\times10^6$$

$$q = \frac{VQ}{I} = \frac{10^3\times6\times10^4\times\phi(10^{-3})^3}{5.33\times10^6\times\left(10^{-3}\right)^4} = 1.125\times10^4\,\frac{N}{m}$$

$$= 11.25\,\frac{KN}{m}$$

Q.4. A hollow mild steel tube 6m long 4cm internal diameter and 6m thick is used as strut with both ends hinged? Find the crippling load and the safe load taking FOS=3? E=2x10^5N/mm^2

Solution

Length of tube,	$l = 6$ m = 600 cm
Internal dia.,	$d = 4$ cm
Thickness,	$t = 5$ mm = 0.5 cm
∴ External dia.,	$D = d + 2t = 4 + 2 \times 0.5 = 4 + 1 = 5$ cm
Young's modulus,	$E = 2 \times 10^5$ N/mm^2
Factor of safety	= 3.0

Moment of inertia of section, $I = \frac{\pi}{64}(D^4 - d^4) = \frac{\pi}{64}[5^4 - 4^4]$ cm^4

$$= \frac{\pi}{64}(625 - 256) = 18.11 \text{ cm}^4 = 18.11 \times 10^4 \text{ mm}^4$$

Since both ends of the strut are hinged,

∴ Effective length, $L_e = l = 600$ cm = 6000 mm

Let P = Crippling load

$$P = \frac{\pi^2 EI}{L_e^2}$$

$$= \frac{\pi^2 \times 2.0 \times 10^5 \times 18.11 \times 10^4}{6000^2} = \textbf{9929.9 say 9930 N.} \quad \textbf{Ans.}$$

And safe load $= \dfrac{\text{Crippling load}}{\text{Factor of safety}} = \dfrac{9930}{3.0} = \textbf{3310 N.}$ **Ans.**

Q.5. A solid round bar of 3m long ang 5cm in diameter is used as strut with both edges hinged? Determine the crippling load? Take E= 2x10^5 N/mm^2 ? Determine the crippling load under the following condition

a) one end is fixed other is hinged

b) Both ends are fixed

c) one end is fixed other is free

Solution

The data from Problem 19.1, is l = 3000 mm, diameter = 50 mm, $E = 2.0 \times 10^5$ N/mm^2 and $I = 30.68 \times 10^4$ mm^4.

Let P = Crippling load.

(i) Crippling load when one end is fixed and other is free

Using equation $P = \dfrac{\pi^2 EI}{4l^2} = \dfrac{\pi^2 \times 2 \times 10^5 \times 30.68 \times 10^4}{4 \times 3000^2} = \textbf{16822 N.}$ **Ans.**

Alternate Method

The crippling load for any type of end condition is given by equation

$$P = \frac{\pi^2 EI}{L_e^2} \quad ...(i)$$

where L_e = Effective length.

$$L_e = 2l = 2 \times 3000 = 6000 \text{ mm}$$

Substituting the value of L in equation (*i*), we get

$$P = \frac{\pi^2 \times 2 \times 10^5 \times 30.68 \times 10^4}{6000^2} = \textbf{16822 N.} \quad \textbf{Ans.}$$

(ii) Crippling load when both the ends are fixed

Using equation $P = \dfrac{4\pi^2 EI}{l^2} = \dfrac{4\pi^2 \times 2 \times 10^5 \times 30.68 \times 10^4}{3000^2}$

$= 269152 \text{ N} = \textbf{269.152 kN.}$ **Ans.**

Alternate Method

Using equation $P = \dfrac{\pi^2 EI}{L_e^2}$

where L_e = Effective length

$$= \frac{l}{2} \quad \text{(when both the ends are fixed)}$$

$$= \frac{3000}{2} \quad (\because \; l = 3000)$$

$$= 1500 \text{ mm}$$

$$\therefore \quad P = \frac{\pi^2 \times 2.0 \times 10^5 \times 30.68 \times 10^4}{1500^2} = \mathbf{269152\ N.} \quad \textbf{Ans.}$$

(iii) Crippling load when one end is fixed and the other is hinged

Using equation $= \dfrac{2\pi^2 EI}{l^2} = \dfrac{2 \times \pi^2 \times 2.0 \times 10^5 \times 30.68 \times 10^4}{3000^2} = \mathbf{134576\ N.}$ **Ans.**

Alternate Method

Using equation, $P = \dfrac{\pi^2 EI}{L_e^2}$

where L_e = Effective length.

$$= \frac{l}{\sqrt{2}} \quad \text{(when one end is fixed and the other is hinged)}$$

$$= \frac{3000}{\sqrt{2}}$$

$$\therefore \quad P = \frac{\pi^2 \times 2.0 \times 10^5 \times 30.68 \times 10^4}{\left(\frac{3000}{\sqrt{2}}\right)^2} = \mathbf{134576\ N.} \quad \textbf{Ans.}$$

Q.6. A steel bar of rectangular cross section 30 x 50 mm pinned at each end is 2 m long. Determine the buckling load when it is subjected to axial compression and also calculate axial: stress using Euler's expression. Determine the minimum length for which Euler's equation may be valid. Take proportionality limit as 250 MPa and E = 200 GPa (2 x 10^5)

Solution

Here, we can calculate I_{min} as follows :

$$I_{min} = \frac{50 \times 30^3}{12} = 112.5 \times 10^3 \ \text{mm}^4, \quad L = 2000 \text{ mm}$$

Using Eq. (15.5), we get

$$P_{cr} = \frac{\pi^2 EI}{L^2} = \frac{(\pi^2 \times 2 \times 10^5 \times 112.5 \times 10^3)}{(2000 \times 2000)}$$

$$P_{cr} = 55.51 \times 10^3 \text{ N} \quad \text{and} \quad \sigma_{cr} = \frac{P_{cr}}{A} = 37.01 \ \text{N/mm}^2$$

$$r_{min} = \sqrt{\left(\frac{I_{min}}{A}\right)} = 8.66 \text{ mm} \quad \text{and} \quad \frac{L}{r_{min}} = 230.94$$

Or, using Eq. (15.6)

$$\sigma_{cr} = \frac{\pi^2 E}{\left(\frac{L}{r}\right)^2} = 37.01 \text{ N/mm}^2$$

Since $\sigma_{cr} < \sigma_p$,

$$\frac{L}{r} > \pi\sqrt{\left(\frac{E}{\sigma_p}\right)} > 88.86$$

As $\sigma_{cr} < \sigma_p$ (i.e. $\frac{L}{r_{min}} > 88.86$) for $L = 2$ m.

Euler's expression is valid for limiting value of minimum length

$$\frac{L_{min}}{r_{min}} = 88.85$$

$L = 769.5 \approx 0.77$ m which is minimum length.

Q.7. A solid cylindrical shaft is to transmit 300 kW power at 100 r.p.m.

(a) If the shear stress is not to exceed 80 N/mm2 , find its diameter.

(b) What percent saving in weight would be obtained if this shaft is replaced by a hollow one whose internal diameter equals to 0.6 of the external diameter, the length, the material and maximum shear stress **being same as above**

Solution

Given:

Power, $P = 300 \text{ kW} = 300 \times 10^3 \text{ W}$

Speed, $N = 100\text{rpm}$

Max. Shear stress, $\sigma = 80 \text{ N/mm}^2$

(a)

Let D = Dia. of solid shaft

Power transmitted by the shaft is given by,

$$P = \frac{2\pi NT}{60}$$

$$300 \times 10^3 = \frac{2\pi \times 100 \times T}{60}$$

$$T = \frac{300 \times 10^3 \times 60}{2\pi \times 100} = 28647.8 \text{ Nm} = 28647800 \text{ Nmm}$$

$$T = \frac{\pi}{16} \times \tau \times D^3 \quad \text{or} \quad 28647800 = \frac{\pi}{16} \times 80 \times D^3$$

$$D = \left(\frac{16 \times 28647800}{\pi \times 80}\right)^{1/3} = 121.8 \text{ mm}$$

$$= \textbf{say 122.0 mm.} \quad \textbf{Ans.}$$

(b) Percent saving in weight

Let D_0 = External dia. of hollow shaft D_i. = Internal dia. of hollow shaft = $0.6 \times D_o$. (given)

The length, material and maximum shear stress in solid and hollow shafts are given the same. Hence torque transmitted by solid shaft is equal to the torque transmitted by hollow shaft.

But the torque transmitted by hollow shaft is given by equation,

$$T = \frac{\pi}{16} \times \tau \times \frac{(D_0^4 - D_i^4)}{D_0}$$

$$= \frac{\pi}{16} \times 800 \times \frac{[D_0^4 - (0.6\, D_0)^4]}{D_0}$$

$$= \pi \times 50 \times \frac{[D_0^4 - (0.6\, D_0)^4]}{D_0}$$

But torque transmitted by solid shaft = 28647800 N-mm.

Equating the two torques, we get

$$28647800 = \pi \times 50 \times \left(\frac{0.8704\, D_0^4}{D_0}\right) = \pi \times 50 \times 0.8704\, D_0^3$$

$$D_0 = \left(\frac{28647800}{\pi \times 50 \times 0.8704}\right)^{1/3} = 127.6 \text{ mm} = \text{say } 128 \text{ mm}$$

Internal dia, $D_i = 0.6 \times D_0 = 0.6 \times 128 = 76.8$ mm

Let, W_s = Weight of solid shaft,

W_h = Weight of hollow shaft.

Let, W_s = Weight density x Area of solid shaft x Length

$$= w \times \frac{\pi}{4} D^2 \times L$$

Similarly,

$$W_h = \text{Weight density} \times \text{Area of hollow shaft} \times \text{Length}$$

$$= w \times \frac{\pi}{4}[D_0^2 - D_i^2] \times L$$

Now percent saving in weight

$$= \frac{W_s - W_h}{W_s} \times 100$$

$$= \frac{w \times \frac{\pi}{4} D^2 \times L - w \times \frac{\pi}{4}[D_0^2 - D_i^2] \times L}{w \times \frac{\pi}{4} D^2 \times L} \times 100$$

$$= \frac{D^2 - (D_0^2 - D_i^2)}{D^2} \times 100 \qquad \left(\text{Cancelling } w \times \frac{\pi}{4} \times L\right)$$

$$= \frac{122^2 - (128^2 - 75.8^2)}{122^2} \times 100 = \frac{14884 - (16364 - 5898)}{14884} \times 100$$

$$= \frac{14884 - 10486}{14884} \times 100 = 29.55\%. \quad \textbf{Ans.}$$

Q.8. A hollow shaft of diameter ratio 3/8 is to transmit 375 kW power at 100 r.p.m. The maximum torque being 20% greater than the mean. The shear stress is not to exceed 60 N/mm2 and twist in a length of 4 m not to exceed 2°. Calculate its external and internal diameters which would satisfy both the above conditions. Assume modulus of rigidity, C = 0.85 x 10^5 N/mm2

Solution

Diameter ratio, $\dfrac{D_i}{D_0} = \dfrac{3}{8}$

$\therefore$ $D_i = \dfrac{3}{8} D_0$

Power, $P = 375 \text{ kW} = 375000 \text{ W}$

Speed, $N = 100$ r.p.m.

Max. torque, $T_{max} = 1.2\, T_{mean}$

Length, $L = 4 \text{ m} = 4000 \text{ mm}$

Max. twist, $\theta = 2° = 2 \times \dfrac{\pi}{180}$ radians $= 0.0349$ radians

Modulus of rigidity, $C = 0.85 \times 10^5 \text{ N/mm}^2$

Power is given by, $P = \dfrac{2\pi NT}{60}$ Here torque is T_{mean}

$$T = \frac{P \times 60}{2\pi N} = \frac{375000 \times 60}{2\pi \times 100} = 35810 \text{ Nm}$$

$$T_{mean} = 35810 \text{ Nm}$$

$$\therefore \quad T_{max} = 1.2 \times T_{mean} = 1.2 \times 35810$$

$$= 42972 \text{ Nm} = 42972 \times 1000 \text{ Nmm.}$$

i) Diameters of the shaft when shear stress is not to exceed 60 MPa,

For the hollow shaft, the torque transmitted is given by

$$T_{max} = \frac{\pi}{16} \times \tau \times \frac{(D_0^4 - D_i^4)}{D_0}$$

$$42972 \times 1000 = \frac{\pi}{16} \times 60 \times \frac{\left[D_0^4 - \left(\frac{3}{8} D_0\right)^4\right]}{D_0}$$

$$\frac{42972000 \times 16}{\pi \times 60} = \frac{D_0^4}{D_0}\left(1 - \frac{81}{4096}\right) = D_0^3 \times \frac{4015}{4096}$$

$$D_0^3 = \frac{42972000 \times 16 \times 4096}{\pi \times 60 \times 4015}$$

$$D_0 = \left(\frac{42972000 \times 16 \times 4096}{\pi \times 60 \times 4015}\right)^{1/3} = 154.97 \text{ mm say } 155 \text{ mm}$$

$$D_i = \frac{3}{8} D_0 = \frac{3}{8} \times 155 \simeq 58.1 \text{ mm}$$

(ii) Diameters of the shaft when the twist is not to exceed 2 degrees.

$$\frac{T}{J} = \frac{C \times \theta}{L}$$

$$\frac{42972000}{\frac{\pi}{32}[D_0^4 - D_i^4]} = \frac{(0.85 \times 10^5) \times 0.0349}{4000}$$

$$\frac{42972000 \times 4000 \times 32}{\pi \times 0.85 \times 10^5 \times 0.0349} = D_0^4 - D_i^4 = D_0^4 - \left(\frac{3}{8}D_0\right)^4 = D_0^4 - \frac{81}{4096}D_0^4$$

$$= D_0^4\left[1 - \frac{81}{4096}\right] = \frac{4015}{4096}D_0^4$$

$$\therefore \quad D_0^4 = \frac{42972000 \times 4000 \times 32 \times 4096}{\pi \times 0.85 \times 10^5 \times 0.0349 \times 4015}$$

$$\therefore \quad D_0 = 156.65 \text{ mm say } 157 \text{ mm}$$

$$D_i = \frac{3}{8} \times 156.65 = 58.74 \text{ mm say } 59 \text{ mm.}$$

The diameters of the shaft, which would satisfy both the conditions, are the greater of the two values.

External dia., $D_0 = 157$ **mm.**

Internal dia., $D_i = 59$ **mm.**

Q.9. Find the diameter of the shaft required to transmit 60 kW at 150 rpm if the maximum torque exceeds 25% of the mean torque for a maximum permissible shear stress of 60 MN/mm2 . Find also the angle of twist for a length of 4 m. Take G = 80 GPa.

Solution

P = 60 kW, N = 150 rpm, τ_s = 60 N/mm^2, θ = ?, G or C = 80 x 10^3 N/mm^2, d = ?

Power transmitted is given by,

$$P = \frac{2\pi NT}{60}$$

$$T = \frac{60 \times 60}{2 \times \pi \times 150} = 3.8197 \text{ kN-m} = 3.8197 \times 10^6 \text{ N-mm}$$

$$T_{max} = 1.257 = 1.25 \text{ x } 3.8197 \text{ x } 106 = 4.77465 \text{ x } 10^6 \text{ N mm.}$$

From torque equation, we have

$$\frac{T}{J} = \frac{\tau}{r} = \frac{G\theta}{L}$$

Where, $J = \frac{\pi d^4}{32} = \frac{\pi R^3}{2}$

(i) Diameter

$$J = \frac{\pi R^4}{2} = \left[\frac{R}{\tau_s}\right] \times T = \frac{R}{60} \times 4.77465 \times 10^6$$

$$R = \left[\frac{2 \times (4.77465 \times 10^6)}{60\pi}\right]^{\frac{1}{3}} = 37 \text{ mm}$$

(ii) Angle of twist l = 4 m, θ = ?

$$\frac{T}{J} = \frac{C\theta}{l}$$

$$\frac{\pi R^4}{2} = \frac{Tl}{C\theta}$$

$$\theta = \frac{2(4.77465 \times 10^6) \times 4000}{(80 \times 10^3) \times \pi \times 37^4} = 0.0811 \text{ rad} = \frac{180}{\pi} \times 0.0811 = 4.646^\circ.$$

Q.10. A solid shaft has to transmit 120 kW of power at 160 rpm. If the shear stress is not to exceed 60 MPa and the twist in a length of 3 m must not exceed 1°, find the suitable diameter of the shaft. Take G = 80 GPa.

Solution

P = 120 kW, N = 160 rpm, τ = 60 N/mm^2, θ = 1°, G or C = 80 x 10^3 N/mm^2, d = ?

Power transmitted is given by,

Power transmitted is given by $P = \frac{2\pi NT}{60}$

$$T = \frac{120 \times 60}{2 \times \pi \times 160} = 7.162 \text{ kN-m} = 7.162 \times 10^6 \text{ N-mm}$$

From torque equation, we have

$$\left[\frac{T}{J} \text{ or } \frac{T}{I_P}\right] = \left[\frac{\tau_s}{R}\right] = \left[\frac{C\theta}{l}\right]$$

where $J = \frac{\pi R^4}{2}$

(i) From the maximum shear stress considerations

$$J = \frac{\pi R^4}{2} = \left[\frac{R}{\tau_s}\right] \times T = \frac{R}{60} \times 7.162 \times 10^6$$

$$R = \left[\frac{2 \times (7.162 \times 10^6)}{60\pi}\right]^{\frac{1}{3}} = 42.357 \text{ mm}$$

(ii) From the maximum twist considerations

$$l = 3 \text{ m}, \ \theta = 1^\circ = 1 \times \frac{\pi}{180} \text{rad}$$

$$\frac{T}{I_P} = \frac{C\theta}{l}$$

$$\frac{\pi R^4}{2} = \frac{7.162 \times 10^6 \times 3000}{(80 \times 10^3)\left(\frac{\pi}{180}\right)} = 55.946 \text{ mm}$$

$$d = 2 \text{ x } 55.946 = 111.89 \text{ mm}$$

Choose the higher diameter among the two so that it can be safe.

CFC3- End Term Exam (w/- CO mapping, if applicable) + Model Key

Winter Semester, 2021
B.Tech. (Civil Engineering), Semester-IV
CE-202:Mechanics of Materials
End term Question Paper

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
Mahindra École Centrale
End-semester Regular/Supplementary Examination
(R 18/17/16/14 REGULATION)

Program: B. Tech.   Branch: _Civil Engineering_____   Year: __II____ Semester: ___IV___
Subject: Mechanics of Materials (CE202)

Date: 11.06.2021 **Start Time: 10.00 AM**
Time Duration: 2 Hours **Max. Marks: 50**

Instructions:
1) PART A: Answer any 2 out of the 3 questions (only first two answered will be checked)
2) PART B: Answer any 3 out of the 5 questions (only first three answered will be checked)
3) All questions carry same marks

PART A

Q. A1 What do you understand by (Marks:10)

a) Member having more/less young’s modulus
b) Principal stress and principal planes
c) Pure bending and pure torsion
d) Stable and unstable equilibrium w.r.t columns
e) Transverse section of a beam which is plane before bending remains plane after bending

Q. A2 Give reasons for (Marks:10)

a) Not considering shear force while developing bending equation
b) High strength steal offers no advantage over those made with low strength that as far as elastic backing is considered
c) Column buckles about the principal axis of C/S having least moment of inertia Stable and unstable equilibrium w.r.t columns
d) Bending moment diagram varies linearly for point load and varies parabolic for uniformly distributed load
e) Euler’s formula can be used only when slenderness ratio of steel column is 89

Q. A3 Solve: (Marks:10)

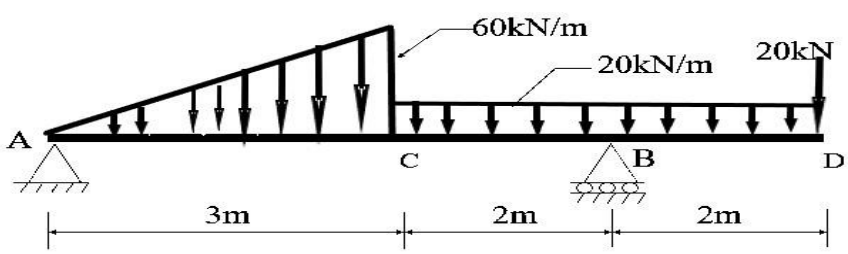
a) The normal stresses acting in three mutually perpendicular directions of a body are given as 60 N/mm^2 (tensile), 40 N/mm^2 (tensile) and 40 N/mm^2 (compressive) respectively. Determine the strain in the directions of x, y and z. Take E = 68.9 GPa and $\mu = 0.35$.

b) A steel rail 30m long is at a temperature of 24˚C. Estimate the elongation when temperature increases to 44˚C. (1) Calculate the thermal stress in the rail under the following two conditions : Take E = 200GPa, $\alpha = 18 \times 10^{-6}$ /˚C

i. No expansion gap provided
ii. If a 6mm gap is provided for expansion
iii. If the stress developed is 60MPa , what is the gap left between the rails?

PART B

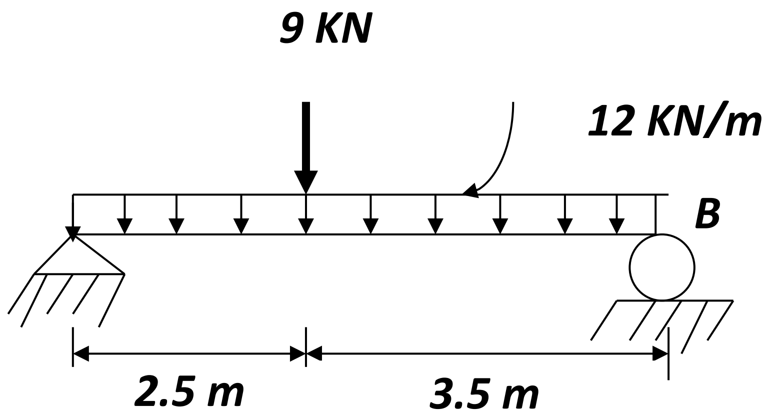
Q. B1 Draw SFD and BMD for the single side overhanging beam subjected to loading as shown below. Also calculate the point of contraflexure (Marks:10)



Q. B2 A rectangular beam of 100 mm wide and 200mm deep is subjected to 25 kN/m over its entire span, Determine the following and draw the variation of shear stress (Marks:10)

a) Average shear stress
b) Maximum shear stress
c) Shear stress distribution at 1m from the left support, by considering horizontal fibres 30mm apart from top to bottom in the cross section.

Q. B3 For the beam shown in Fig. design a rectangular section making the depth twice the width. Max permissible bending stress = 8 N/mm² .Also calculate the stress values at a depth of 50mm from the top & bottom at the section of maximum BM. (Marks:10)



Q. B4 Find the Euler's critical load for a hollow cylindrical cast iron column 150 mm external diameter, 20 mm wall thickness if it is 6 m long with hinges at both ends. Assume Young's modulus of cast iron as 80 kN/mm2 . Compare this load with given by Rankine's formula using Rankine's constant a = 1/1,600 and fc = 567 N/mm2 . (Marks:10)

Q. B5 A solid circular shaft is to transmit 300kW at 100rpm. If the shear stress is not to exceed 80 N/mm2, find the diameter of the shaft. What percentage saving in weight would be obtained if this shaft is replaced by a hallow one whose internal diameter is equal to 0.6 external diameter, the length, material and the maximum shear stress being the same. (Marks:10)

Winter Semester, 2021
B.Tech. (Civil Engineering), Semester-IV
CE-202:Mechanics of Materials
End Term Solution

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
Mahindra École Centrale
End-semester Regular/Supplementary Examination
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PART A

Q. A1 What do you understand by (Marks:10)

f) Member having more/less young's modulus
g) Principal stress and principal planes
h) Pure bending and pure torsion
i) Stable and unstable equilibrium w.r.t columns
j) Transverse section of a beam which is plane before bending remains plane after bending

Solution

a) Young's modulus represents the stiffness of member. The basic principle is that a material undergoes elastic deformation when it is compressed or extended, returning to its original shape when the load is removed. A low Young's modulus value means a solid is elastic. A high Young's modulus value means a solid is inelastic or stiff.

b) The maximum normal stress induced in a plane is called the principal stress and the plane at which the maximum stress induced referred to the principal plane where the shear stress is considered zero.

c) Pure bending refers to flexure of a beam under a constant bending moment. Therefore, pure bending occurs only in regions of a beam where the shear force is zero. ... An example of pure bending would be a beam with two couples, one on each end acting in opposite directions.

When the circular shaft is subjected to torque only without being acted upon by any bending moment or axial force, the circular shaft is said to be in the state of **pure torsion**

d) when P (axial load) is less than Pc (critical load), internal and external forces are in stable equilibrium.

If P = Pc and a small transverse force is applied, the column again will deflect, but this time, when the force is removed, the column will remain in the bent position called unstable condition.

Stable equilibrium: A stable equilibrium is one in which a body in static equilibrium on being displaced slightly, returns to its original position and continues to remain in equilibrium.

Unstable equilibrium: An unstable equilibrium is one in which a body in equilibrium on being slightly disturbed, moves away from its equilibrium position and loses its state of equilibrium.

e) It implies that there is no wrapping of the layers of the beam and strain is linear directly proportional to distance from the neutral axis.

Q. A2 Give reasons for (Marks:10)

f) Not considering shear force while developing bending equation
g) High strength steel offers no advantage over those made with low strength that as far as elastic backing is considered
h) Column buckles about the principal axis of C/S having least moment of inertia
i) Bending moment diagram varies linearly for point load and varies parabolic for uniformly distributed load
j) Euler's formula can be used only when slenderness ratio of steel column is 89

Solution

a) Bending equation is developed for pure bending zones where shear force is equal to zero, this can be justified because bending moment will be maximum at points where SF is zero.

b) The critical load is independent of the strength of the material; rather it only depends on the column's dimensions (I and L) and the material's stiffness or modulus of elasticity E. For this reason, as far as elastic buckling is concerned, columns made, for example, of highstrength steel offer no advantage over those made of lower-strength steel, since the modulus of elasticity for both is approximately the same.

c) Because M.I is directly proportional to critical load, lesser the M.I more prone to buckling

d) For point load the BM equation varies with the length of the beam to the power of 1, hence it is linear. While it varies to the power of 2 for udl hence it is parabolic

e) Column stress willexceed the yeid point before buckling, hence eulers load eq is not valid

Q. A3 Solve: (Marks:10)

c) The normal stresses acting in three mutually perpendicular directions of a body are given as 60 N/mm^2 (tensile), 40 N/mm^2 (tensile) and 40 N/mm^2 (compressive) respectively. Determine the strain in the directions of x, y and z. Take E = 68.9 GPa and $\mu = 0.35$.

d) A steel rail 30m long is at a temperature of 24˚C. Estimate the elongation when temperature increases to 44˚C. (1) Calculate the thermal stress in the rail under the following two conditions : Take E = 200GPa, $\alpha = 18 \times 10^{-6}$ /˚C

iv. No expansion gap provided
v. If a 6mm gap is provided for expansion
vi. If the stress developed is 60MPa , what is the gap left between the rails?

Solution

Free expansion

αTL = 18 × 10-6 ×(44-24) × 30 × 103 = **10.8mm**

i) No expansion joints provided:-

Temperature stress = αTE = 18 × 10-6 × 20× 200 × 103 = **72N/mm2**

ii) 6mm gap is provided for expansion Temperature stress = [(αTL – δ) / L] E

= [(10.8 – 6)/(30 × 103)] ×200 × 103

= 32N/mm2

iii) When stress = 60MPa Temperature stress

= [(αTL – δ) / L] E

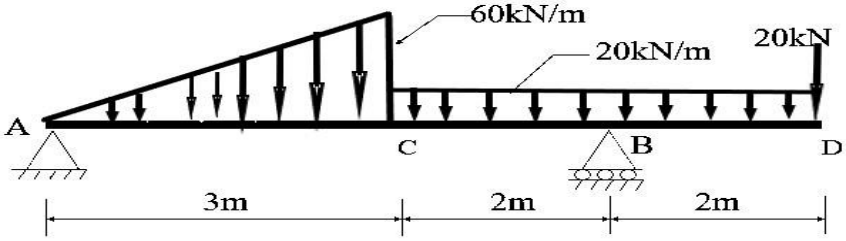
= [(10.8 – δ) / (30 × 103)] × 200 × 103

δ = **1.8mm**

PART B

Q. B1 Draw SFD and BMD for the single side overhanging beam subjected to loading as shown below. Also calculate the point of contraflexure

(Marks:10)



Solution

Step 1 Calculation of Reactions:

$\Sigma MA = 0$

- $R_B \times 5 + \frac{1}{2} \times 3 \times 60 \times (2/3) \times 3 + 20 \times 4 \times 5 + 20 \times 7 = 0 \rightarrow R_B = 144kN$

$\Sigma Fy = 0$

$R_A + 144 - \frac{1}{2} \times 3 \times 60 - 20 \times 4 - 20 = 0 \quad \rightarrow \quad R_A = 46kN$

Step 2 Shear Force Calculations:

$V_{0-0} = 0$; $V_{1-1} = +46$ kN

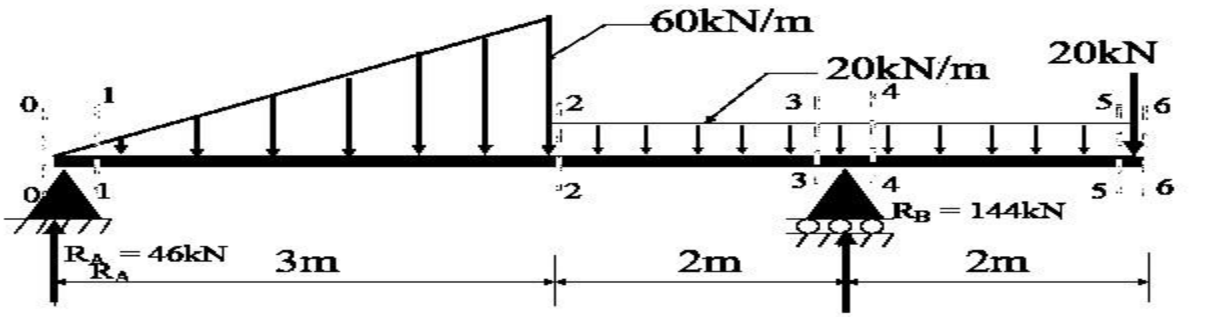
$V_{2-2} = +46 - \frac{1}{2} \times 3 \times 60 = -44$ kN

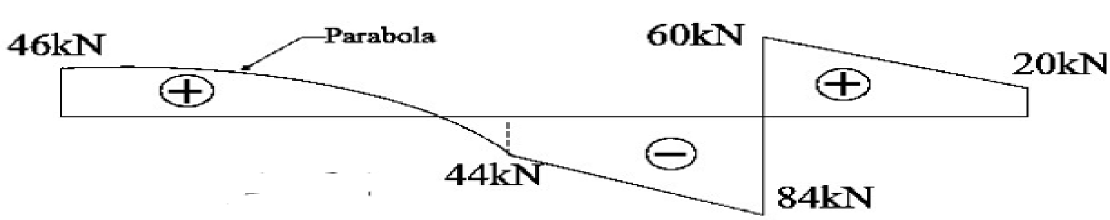
$V_{3-3} = -44 - 20 \times 2 = -84$ kN

$V_{4-4} = -84 + 144 = +60$kN

$V_{5-5} = +60 - 20 \times 2 = +20$ kN

$V_{6-6} = 20 - 20 = 0$ (Check)



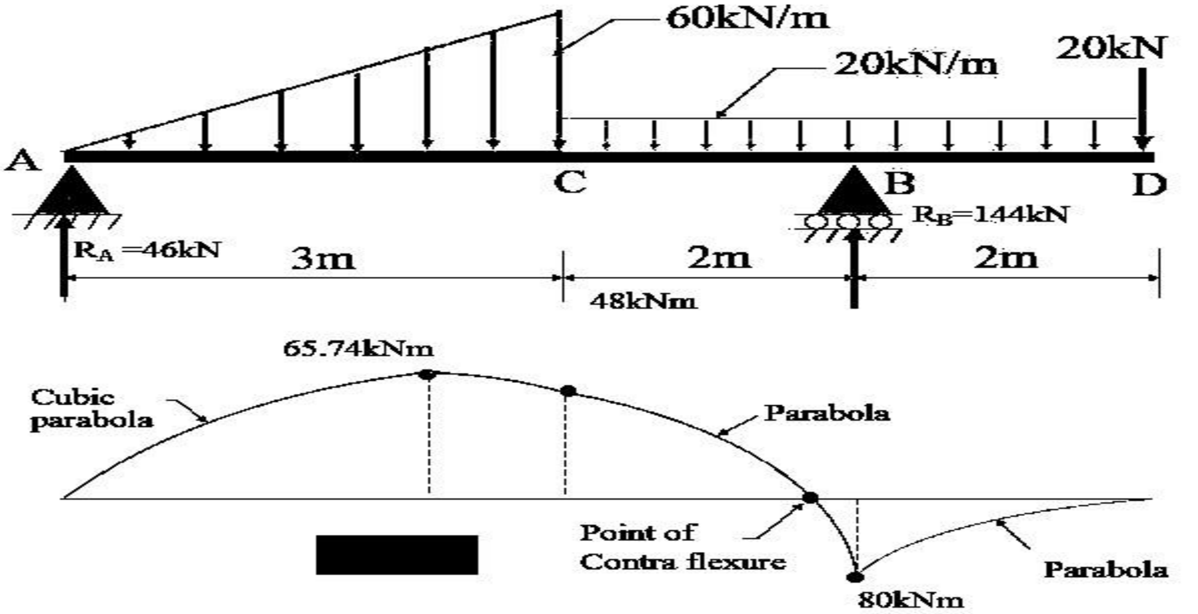


Step 3 Calculation of bending moments

$M_A = M_D = 0$

$M_C = 46 \times 3 - ½ \times 3 \times 60 \times (1/3 \times 3) = 48$ kNm[Considering LHS of section]

$M_B = -20 \times 2 - 20 \times 2 \times 1 = -80$ kNm [Considering RHS of section]



__**Absolute Maximum Bending Moment**__,

$M_{max} = 46 \times 2.145 - ½ \times 2.145 \times (2.145 \times 60/3) \times (1/3 \times 2.145)$

$= 65.74$ kNm

__**Calculations of Absolute Maximum Bending Moment**__:

Max. bending moment will occur at the section where the shear force is zero. The SFD shows that the section having zero shear force is available in the portion AC. Let that section be X-X, considered at a distance 'x' from support A as shown above. The shear force expression at that section should be equated to zero. i.e.,

$V_{x\text{-}x} = 46 - ½ .x. (60/3)x = 0 \Rightarrow x = 2.145$ m

BM at X- X ,

$M\ max = 46 \times 2.145 - ½ \times 2.145 \times (2.145 \times 60/3) \times (1/3 \times 2.145)$

=65.74kn-m

Q. B2 A rectangular beam of 100 mm wide and 200mm deep is subjected to 25 kN/m over its entire span, Determine the following and draw the variation of shear stress

(Marks:10)

a) Average shear stress

b) Maximum shear stress

c) Shear stress distribution at 1m from the left support, by considering horizontal fibres 30mm apart from top to bottom in the cross section.

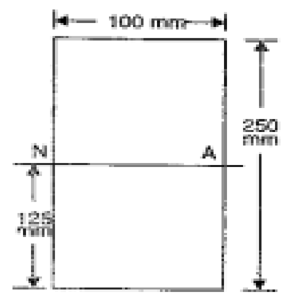
Solution SPAN OF BEAM IS NOT MENTIONED IN THE QUESTION

Sol. Given :

Width, $b = 100$ mm

Depth, $d = 250$ mm

Maximum shear force, $F = 50$ kN $= 50{,}000$ N.



(*i*) Average shear stress is given by,

$$\tau_{avg} = \frac{F}{\text{Area}} = \frac{50{,}000}{b \times d}$$

$$= \frac{50{,}000}{100 \times 250} = 2 \text{ N/mm}^2. \quad \textbf{Ans.}$$

(*ii*) Maximum shear stress is given by equation

$$\therefore \quad \tau_{max} = 1.5 \times \tau_{avg}$$

$$= 1.5 \times 2 = 3 \text{ N/mm}^2. \quad \textbf{Ans.}$$

(*iii*) The shear stress at a distance y from N.A. is given by equatio

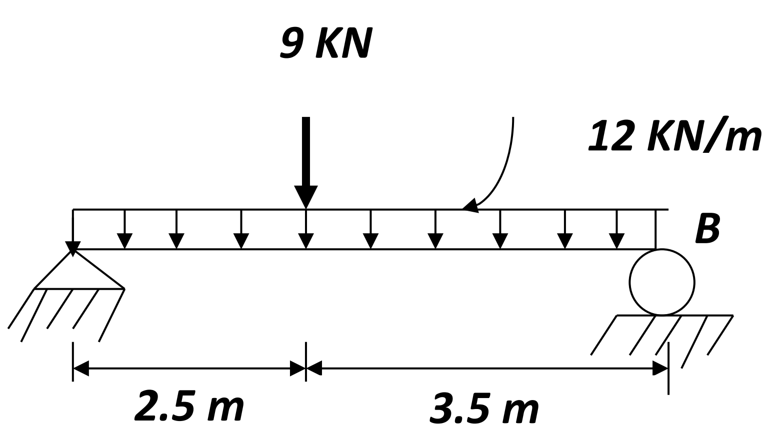
$$\therefore \quad \tau = \frac{F}{2I}\left(\frac{d^2}{4} - y^2\right)$$

$$= \frac{50000}{2I}\left(\frac{250^2}{4} - 25^2\right) \quad (\because \; y = 25 \text{ mm})$$

$$= \frac{50000}{2 \times \frac{bd^3}{12}}\left(\frac{62500}{4} - 625\right) = \frac{50000 \times 12}{2 \times 100 \times 250^3} \times 15000 \text{ N/mm}^2$$

$$= 2.88 \text{ N/mm}^2. \quad \textbf{Ans.}$$

Q. B3 For the beam shown in Fig. design a rectangular section making the depth twice the width. Max permissible bending stress = 8 N/mm² .Also calculate the stress values at a depth of 50mm from the top & bottom at the section of maximum BM. (Marks:10)



Solution

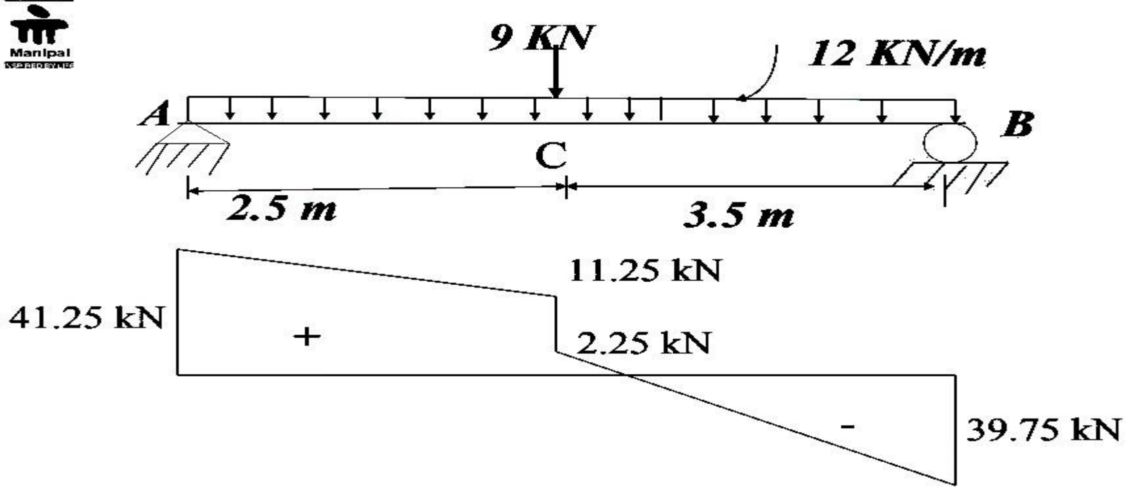
Step 1

$\Sigma M_A=0$ $(12\times6\times3)+(9\times2.5)-V_B\times6=0$

$V_B = 238.5/6 = 39.75$ kN

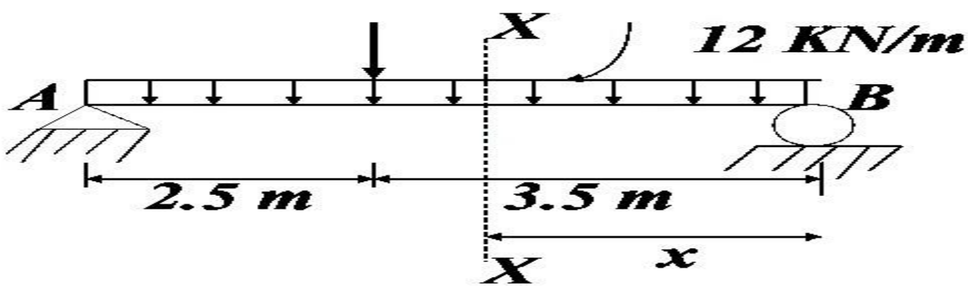
$\Sigma F_y=0$ $V_A+V_B=(12\times6)+9$

$\therefore V_A = 41.25$ kN



Step 2

Max. bending moment will occur at the section where the shear force is zero. The SFD shows that the section having zero shear force is available in the portion BC. Let that section be X-X, considered at a distance x from support B as shown below. The shear force at that section can be calculated as



$-V_B+12x=0$

i.e. $-39.75+12x=0$

$x = 39.75/12 = 3.312$ m. BM is max @ 3.312m from B.

BM@xx $= 39.75\times3.31 - 12\times3.31\times(3.31)/2$

$= 65.84$ kN-m $= 65.84\times10^6$ N mm

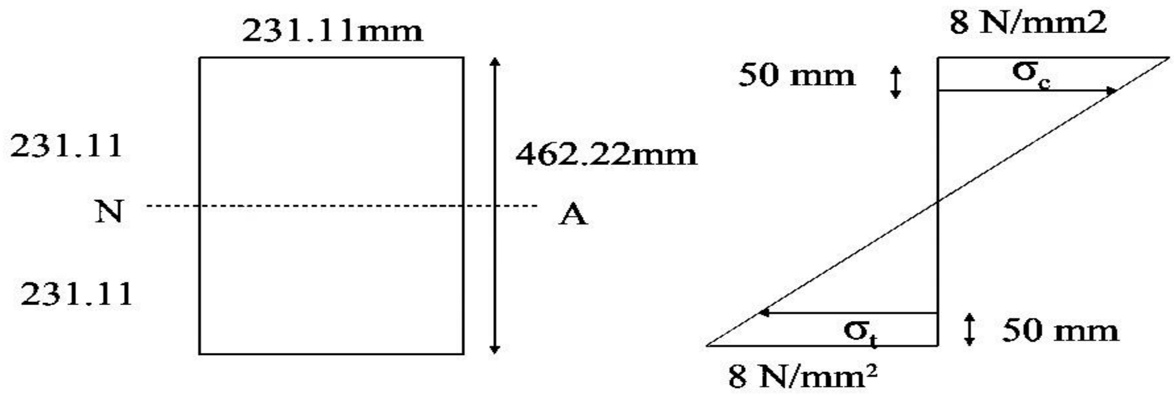
Step 3

Now $M/I_{NA} = \sigma_b/y$

$65.84\times10^6/(b\times(2b)^3/12)$

= 8/b b³= 1.5×8.23×106

∴ b= 231.11 mm , d= 2b= 462.22 mm



From similar triangles, 8/ 231.11

= σc /(231.11-50) = σt / (231.11-50)

σc = 6.27 N/ mm2 (compressive) & σt = 6.27 N/ mm2 (tensile)

Q. B4 Find the Euler's critical load for a hollow cylindrical cast iron column 150 mm external diameter, 20 mm wall thickness if it is 6 m long with hinges at both ends. Assume Young's modulus of cast iron as 80 kN/mm2 . Compare this load with given by Rankine's formula using Rankine's constant a = 1/1,600 and fc = 567 N/mm2 .

(Marks:10)

Solution

Given Data: External diameter = 150 mm, thickness = 20 mm, length = 6 m, E = 80 kN/mm^2, a = 1/1,600 and f_c = 567 N/mm^2.

$$A_0 = 8167.41 \text{ mm}^2 , I = 17.66 \text{ X } 10^6 \text{ mm}^4$$

From Euler's Condition $l_e = l$ $\quad P_E = \frac{\pi^2 EI}{l_e^2} = \frac{\pi^2 \times 80 \times 10^3 \times 17.66 \times 10^6}{6000^2} = 387.33kN$

From Rankine Formulae $\quad P_R = \frac{f_c A}{1 + a\left(\frac{l_e}{r_{min}}\right)^2} = \frac{567 \times 8167.41}{1 + \frac{1}{1600}\left(\frac{6000}{46.5}\right)^2} = 406.01kN$

Q. B5 A solid circular shaft is to transmit 300kW at 100rpm. If the shear stress is not to exceed 80 N/mm2, find the diameter of the shaft. What percentage saving in weight would be obtained if this shaft is replaced by a hallow one whose internal diameter is equal to 0.6 external diameter, the length, material and the maximum shear stress being the same. (Marks:10)

Solution

Given:

Power, $P = 300\text{ kW} = 300 \times 10^3\text{ W}$

Speed, $N = 100\text{rpm}$

Max. Shear stress, $\sigma = 80\text{ N/mm}^2$

(a)

Let D = Dia. of solid shaft

Power transmitted by the shaft is given by,

$$P = \frac{2\pi NT}{60}$$

$$300 \times 10^3 = \frac{2\pi \times 100 \times T}{60}$$

$$T = \frac{300 \times 10^3 \times 60}{2\pi \times 100} = 28647.8\text{ Nm} = 28647800\text{ Nmm}$$

$$T = \frac{\pi}{16} \times \tau \times D^3 \quad \text{or} \quad 28647800 = \frac{\pi}{16} \times 80 \times D^3$$

$$D = \left(\frac{16 \times 28647800}{\pi \times 80}\right)^{1/3} = 121.8\text{ mm}$$

$$= \textbf{say 122.0 mm.} \quad \textbf{Ans.}$$

(b) Percent saving in weight

Let D_0 = External dia. of hollow shaft D_i. = Internal dia. of hollow shaft = 0.6 x D_o. (given)

The length, material and maximum shear stress in solid and hollow shafts are given the same. Hence torque transmitted by solid shaft is equal to the torque transmitted by hollow shaft.

But the torque transmitted by hollow shaft is given by equation,

$$T = \frac{\pi}{16} \times \tau \times \frac{(D_0^4 - D_i^4)}{D_0}$$

$$= \frac{\pi}{16} \times 800 \times \frac{[D_0^4 - (0.6\,D_0)^4]}{D_0}$$

$$= \pi \times 50 \times \frac{[D_0^4 - (0.6\,D_0)^4]}{D_0}$$

But torque transmitted by solid shaft = 28647800 N-mm.

Equating the two torques, we get

$$28647800 = \pi \times 50 \times \left(\frac{0.8704\, D_0^{\,4}}{D_0}\right) = \pi \times 50 \times 0.8704\, D_0^{\,3}$$

$$D_0 = \left(\frac{28647800}{\pi \times 50 \times 0.8704}\right)^{1/3} = 127.6 \text{ mm} = \text{say } 128 \text{ mm}$$

Internal dia, $D_i = 0.6 \times D_0 = 0.6 \times 128 = 76.8$ mm

Let, W_s = Weight of solid shaft,

W_h = Weight of hollow shaft.

Let, W_s = Weight density x Area of solid shaft x Length

$$= w \times \frac{\pi}{4} D^2 \times L$$

Similarly,

$$W_h = \text{Weight density} \times \text{Area of hollow shaft} \times \text{Length}$$

$$= w \times \frac{\pi}{4} [D_0^{\,2} - D_i^{\,2}] \times L$$

Now percent saving in weight

$$= \frac{W_s - W_h}{W_s} \times 100$$

$$= \frac{w \times \frac{\pi}{4} D^2 \times L - w \times \frac{\pi}{4} [D_0^{\,2} - D_i^{\,2}] \times L}{w \times \frac{\pi}{4} D^2 \times L} \times 100$$

$$= \frac{D^2 - (D_0^{\,2} - D_i^{\,2})}{D^2} \times 100 \qquad \left(\text{Cancelling } w \times \frac{\pi}{4} \times L\right)$$

$$= \frac{122^2 - (128^2 - 75.8^2)}{122^2} \times 100 = \frac{14884 - (16364 - 5898)}{14884} \times 100$$

$$= \frac{14884 - 10486}{14884} \times 100 = \mathbf{29.55\%}. \quad \textbf{Ans.}$$

CFE1- Instructor feedback by students

Mahindra University | ÉCOLE CENTRALE SCHOOL OF ENGINEERING

Winter Semester, 2021
B.Tech. (Civil Engineering), Semester-IV
CE-202:Mechanics of Materials

Course Coordinator: Dr. Visalakshi Talakokula

Student Feedback for Teacher and Course [Theory]

Note: Your considered feedback on the course will be of great value to the concerned instructor and to the department in enhancing the quality of learning. Thank you for your quality time.

Student Feedback for course instructor

PLEASE TICK (**√**) THE APPROPRIATE BOXES

5 – EXCELLENT	4 – GOOD	3 – FAIR	2 – POOR	1 – NOT APPLICABLE

Faculty name: Dr. Visalakshi Talakokula Course title : Mechanics of Materials Course code : CE202		1	2	3	4	5
1	What is your perception of the **subject knowledge** of teacher?					√
2	How do you rate the **communication skills** of the teacher?					√
3	Does the teacher use the **right mix** of technology to make the class interesting and effective?					√
4	Did your teacher provide **relevant** practical / industrial **examples**?					√
5	Did your teacher **encourage** you to ask **questions** in the class?					√
7	How was your experience attending online classes for this course				√	
8	Did the teacher give individual / group **assignments** properly evaluate and return them promptly?					√
9	Was the teacher **punctual** in starting / ending the class and did not cancel classes?					√
10	Did the teacher **complete the syllabus** and take classes according to the lecture plan given to you?				√	

a. What should the teacher **continue** doing?

b. What should the teacher **stop** doing?

c. What should the teacher **start** doing?

d. Do you feel that I should not miss the class of this teacher

Yes,Since this was the hardest subject from this semester

e. Any other feedback / suggestions:

Winter Semester, 2021
B.Tech. (Civil Engineering), Semester-IV
CE-202:Mechanics of Materials

Course Coordinator: Dr. Visalakshi Talakokula

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Student Feedback for course instructor

PLEASE TICK (**√**) THE APPROPRIATE BOXES

5 – EXCELLENT	**4 – GOOD**	**3 – FAIR**	**2 – POOR**	**1 – NOT APPLICABLE**

Faculty name: Dr. Visalakshi Talakokula Course title : Mechanics of Materials Course code : CE202		**1**	**2**	**3**	**4**	**5**
1	What is your perception of the **subject knowledge** of teacher?				√	
2	How do you rate the **communication skills** of the teacher?				√	
3	Does the teacher use the **right mix** of technology to make the class interesting and effective?				√	
4	Did your teacher provide **relevant** practical / industrial **examples**?			√		
5	Did your teacher **encourage** you to ask **questions** in the class?					√
7	How was your experience attending online classes for this course		√			
8	Did the teacher give individual / group **assignments** properly evaluate and return them promptly?				√	
9	Was the teacher **punctual** in starting / ending the class and did not cancel classes?					√
10	Did the teacher **complete the syllabus** and take classes according to the lecture plan given to you?			√		

a. What should the teacher **continue** doing?

Should continue the same way teaching style

b. What should the teacher **stop** doing?

Giving us lots of work

c. What should the teacher **start** doing?

Real life examples by showing some videos like bending of beam in real life,but offline classes are pretty good.

d. Do you feel that I should not miss the class of this teacher
   Yes,for sure

e. Any other feedback / suggestions:

No suggestions, thankyou

CFE1- Course feedback by students

Mahindra™ University
Global Thinkers. Engaged Leaders.
ÉCOLE CENTRALE SCHOOL OF ENGINEERING

Winter Semester, 2021
B.Tech. (Civil Engineering), Semester-IV
CE-202:Mechanics of Materials

Course Coordinator: Dr. Visalakshi Talakokula

Note: Your considered feedback on the course will be of great value to the concerned instructor and to the department in enhancing the quality of learning. Thank you for your quality time.

Questions are to be answered by the students on a scale of 1 to 5 – most negative to most positive response i.e 1 relates to most negative and 5 relates to most positive.

Questionnaire	Rating (1-5)- Please tick √				
	1	2	3	4	5
overall view					
Rate the Course in General				*	
Rate the Course Content				*	
Rate the Instructor with reference to this course					*
Course Management					
Course Organization				*	
Internal Tests – Coverage of COs			*		
Internal Tests – Time Allowed			*		
Quality of Quizzes				*	
Usefulness of the assignments in promoting learning				*	
Work load					*
Learning Environment					
Positive interaction between students and Instructor existed.				*	
Students were always allowed to interrupt the Instructor to clear doubts				*	
Classroom discussions were encouraged and well moderated.					*
Required learning resources were easily available.			*		
Course Outcomes					
Course Outcomes were discussed				*	
upfront. Course Outcomes were clear.				*	
How confident are you regarding the competencies expected from you?				*	
Instructional activities helped in the attainment of the COs.				*	
Time devoted to each CO was quite				*	
adequate. Pace of coverage was				*	

comfortable throughout. Assessments were relevant to the stated COs.				*	
Instructor Characteristics					
Instructor had mastery over the content.				*	
All the students were treated impartially.					*
The instructor had excellent communication skills.					*
The instructor encouraged the students to raise questions in the classroom.					*
Technical doubts were clarified well.					*
The general attitude of the Instructor was quite supportive.				*	

Winter Semester, 2021
B.Tech. (Civil Engineering), Semester-IV
CE-202:Mechanics of Materials

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Questionnaire	Rating (1-5)- Please tick √				
	1	2	3	4	5
overall view					
Rate the Course in General				*	
Rate the Course Content				*	
Rate the Instructor with reference to this course					*
Course Management					
Course Organization				*	
Internal Tests – Coverage of COs			*		
Internal Tests – Time Allowed			*		
Quality of Quizzes				*	
Usefulness of the assignments in promoting learning				*	
Work load					*
Learning Environment					
Positive interaction between students and Instructor existed.				*	
Students were always allowed to interrupt the Instructor to clear doubts				*	
Classroom discussions were encouraged and well moderated.					*
Required learning resources were easily available.			*		
Course Outcomes					
Course Outcomes were discussed upfront.				*	
Course Outcomes were clear.				*	
				*	

How confident are you regarding the competencies expected from you?				*	
Instructional activities helped in the attainment of the COs.				*	
Time devoted to each CO was quite adequate.				*	
Pace of coverage was comfortable throughout. Assessments were relevant to the stated COs.				*	
Instructor Characteristics					
Instructor had mastery over the content.				*	
All the students were treated impartially.					*
The instructor had excellent communication skills.					*
The instructor encouraged the students to raise questions in the classroom.					*
Technical doubts were clarified well.					*
The general attitude of the Instructor was quite supportive.				*	

CFE1- Course Outcomes-Co's feedback by students

Winter Semester, 2021
B.Tech. (Civil Engineering), Semester-IV
CE-202:Mechanics of Materials

Course Coordinator: Dr. Visalakshi Talakokula

Course Outcomes:

CO1. Understand and apply the principles of equilibrium and determine internal loadings in statically determinate structures, subjected to an external load viz. axial, transverse load, torsional and bending moment.

CO2. Evaluate normal and shear stress on plane and inclined sections and be able to determine the state of stress, principal stresses and maximum in-plane shear stresses.

CO3. Determine the internal forces developed in the beam due to transverse loading and able to draw the variation of these under different loading and support conditions.

CO4. Analyse the torsional stresses in shafts and calculate the power transmitted

CO5. Apply the concepts of stability and analyse buckling in columns

Questionnaire:

1. After studying this course, you are able to understand different types of loading on structures and the effect of these loadings??

○ ○ ○ ○ ○
Strongly Disagree Neutral Agree Strongly
Disagree agree

2. You are able to find the principal stresses and its direction for any loading condition

○ ○ ○ ○ ○
Strongly Disagree Neutral Agree Strongly
Disagree agree

3. You are able to find the maximum and minimum bending and shear stresses acting on beams and draw its variation for different loads and supports??

○ ○ ○ ○ ○
Strongly Disagree Neutral Agree Strongly
Disagree agree

4. Analyse the shafts for torsional stresses and find the power transmitted??

○ ○ ○ ○ ○
Strongly Disagree Neutral Agree Strongly
Disagree agree

4. Analyse the column based on its failure criteria??

○ ○ ○ ○ ○
Strongly Disagree Neutral Agree Strongly Disagree agree

Winter Semester, 2021
B.Tech. (Civil Engineering), Semester-IV
CE-202:Mechanics of Materials
Result analysis

CE202-Mechanics of Materials Marks & Grades
Internal evaluation components: 80 marks (Assignments:20, Quizzes:20, Question & Answer session during class:20, Group project:10)
End term examination: 30 marks
Total: 100 marks

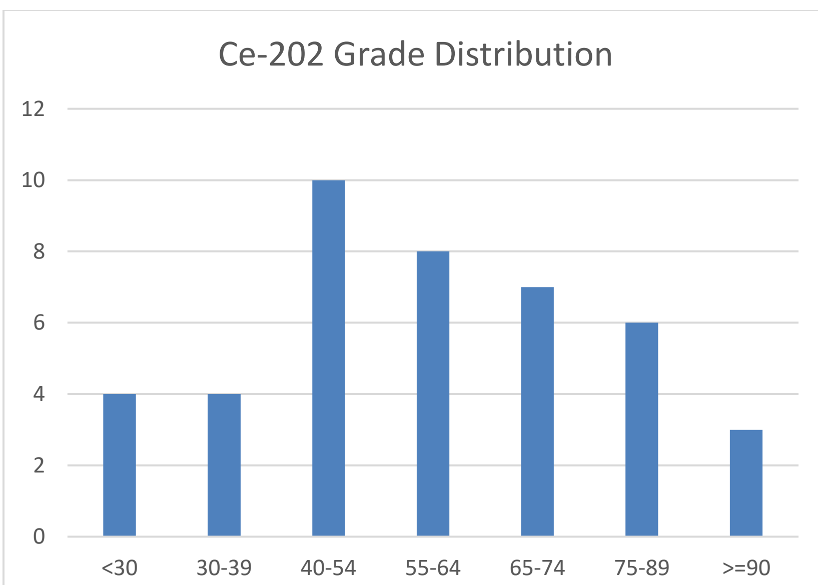
S. No	Roll No	Name	Assignments (20 Marks)	Quiz (20 Marks)	Q&A (20 Marks)	Project (10 Marks)	Total Internal (70 Marks)	End term (30 Marks)	Total 100 Marks	Grade
1	19XJ1A0101	A DURGA GAYATRI VINUTHNA	20	12	20	8	60	15	75	B+
2	19XJ1A0102	A PRITIKA REDDY	19	15	20	9	63	27	90	A
3	19XJ1A0104	ANVITHA YADAMA	6	6	8	8	28	15	43	C
4	19XJ1A0105	AITIPAMULA BHAVANI	18	10	16	8	52	23	75	B+
5	19XJ1A0106	AMAY SHUKLA	17	10	12	7	46	17	63	C+
6	19XJ1A0107	BONDADA CH ABHISHEK KUMAR	19	13	20	9	61	29	90	A
7	19XJ1A0108	V.S.Ch.Dheeraj Kumar Bondada	17	11	20	9	57	18	75	B+
8	19XJ1A0109	CAROL RACHEL KAKILETI	14	10	8	8	40	18	58	C+
9	19XJ1A0110	DEVANSH BANSAL	15	10	8	7	40	15	55	C+
10	19XJ1A0111	DUGGIRALA SAI VAISHNAV	16	11	20	7	54	21	75	B+
11	19XJ1A0112	GATIKA ABHISTA SAI RISHI KUMAR	9	12	4	7	32	13	45	C
12	19XJ1A0113	INDRANEEL REDDY BILLA	6	7	6	7	26	12	38	D
13	19XJ1A0114	SHANTAN REDDY JANNUPREDDY	9	8	4	7	28	11	39	D

14	19XJ1A0115	KADIRI BHUVANESH	8	5	0	0	13	14	27	F
15	19XJ1A0116	KALAMSETTY VISWATEJA	5	2	4	0	11	12	23	F
16	19XJ1A0117	KANIGIRI CHANDRAKANTH REDDY	16	11	16	8	51	14	65	B
17	19XJ1A0118	BHUVAN ALLADI	9	10	6	0	25	13	38	D
18	19XJ1A0119	MANVITHA THEEGALA	19	12	16	8	55	18	73	B
19	19XJ1A0120	MOHAMMED KHURRAM HASSAN GHORI	2	4	0	0	6	15	21	F
20	19XJ1A0121	MOHAMMED MUJTABA MOID	16	12	12	8	48	15	63	C+
21	19XJ1A0122	NAVARI SIDDARTH REDDY	20	15	18	9	62	28	90	A
22	19XJ1A0123	NEERUDI YESHWANTH	8	9	8	9	34	15	49	C
23	19XJ1A0124	PENUMATSA GOWTHAM VARMA	10	7	6	0	23	14	37	D
24	19XJ1A0125	SAKETHRAM REDDYGARI	10	13	8	0	31	15	46	C
25	19XJ1A0126	SAKSHAM RAJPUT	20	9	12	8	49	21	70	B
26	19XJ1A0127	SHERI SAKETH REDDY	12	10	6	0	28	13	41	C
27	19XJ1A0128	SIRI REDDY PANNALA	16	13	12	8	49	18	67	B
28	19XJ1A0129	SREE VANSH BUDDINENI	14	12	8	8	42	15	57	C+
29	19XJ1A0131	VANGA AMULYA REDDY	14	9	16	8	47	20	67	B
30	19XJ1A0132	VENKAT RISHI BADIGA	9	9	8	7	33	16	49	C
31	19XJ1A0133	VUNGARALA YASHWANTH RAO SUBASH	17	11	8	8	44	15	59	C+
32	19XJ1A0134	Y RIDHIMA REDDY	12	5	4	9	30	15	45	C
33	19XJ1A0135	AMITH CHANDRA KODALI	10	6	4	9	29	18	47	C
34	19XJ1A0136	DEVIREDDY SOWMYA	15	9	4	8	36	16	52	C
35	19XJ1A0137	GOPU VENKATA SIVA SAI SAMEER	14	10	4	7	35	17	52	C
36	19XJ1A0138	SLOKA GAMPA	18	5	4	8	35	23	58	C+
37	19XJ1A0139	SYNTHIA MAIYUKHI KOTAMRAJU	18	12	16	8	54	17	71	B

38	19XJ1A0140	NAINENI RAGHU CHANDER	7	11	12	8	38	18	56	C+
39	19XJ1A0141	P VISHWAAJITH	18	11	20	8	57	23	80	B+
40	19XJ1A0142	Sumedh	20	14	16	8	58	16	74	B
41	19XJ1A0143	Sourab Vokkalkar	2	0	0	0	2	14	16	F
42	19XJ1A0144	Semanth Reddy	19	11	20	9	59	24	83	B+

Grading Scheme

Marks	Grade	No. of Students
<30	F	4
30-39	D	4
40-54	C	10
55-64	C+	8
65-74	B	7
75-89	B+	6
>=90	A	3
	Total	42



CFD1- COs, Evaluation criteria, CO – PO and CO – PSO mapping (articulation

CE-202:Mechanics of Materials
Co-PO mapping

CO – PO AND CO – PSO MAPPING

Course Outcomes:

CO1. Understand and apply the principles of equilibrium and determine internal loadings in statically determinate structures, subjected to an external load viz. axial, transverse load, torsional and bending moment.

CO2. Evaluate normal and shear stress on plane and inclined sections and be able to determine the state of stress, principal stresses and maximum in-plane shear stresses.

CO3. Determine the internal forces developed in the beam due to transverse loading and able to draw the variation of these under different loading and support conditions.

CO4. Analyze the torsional stresses in shafts and calculate the power transmitted

CO5. Apply the concepts of stability and analyze buckling in columns

Articulation matrices

Program Outcomes (POs)

Broad themes as defined by NBA for engineering graduates

PO1. Engineering Knowledge

PO2. Problem analysis

PO3. Design / Development of solutions

PO4. Conduct investigations of complex problems

PO5. Modern tool usage

PO6. The engineer and society

PO7. Environment and sustainability.

PO8. Ethics

PO9. Individual and team work.

PO10. Communication

PO11. Project management and finance

PO12. Life-long learning

CO - PO mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CE202.1	3	3	2	1	1					1		
CE202.2	3	3	2	1	1					1		
CE202.3	3	3	2	1	1					1		
CE202.4	3	3	2	1	1					1		
CE202.5	3	3	2	1	1					1		
Course Targets	3	3	3	3	3					**3**		

Program Specific Outcomes (PSOs)

PSO1: Apply the knowledge of mathematics and physical sciences in practice to solve challenging problems in civil engineering

PSO2: Illustrate functional knowledge on professional ethics, public policies, safety, and quality control.

PSO3: Ability to work with teams of multidisciplinary nature for creating modern avenues

PSO4: Able to be an active and effective part of a research organization or industry to provide sustainable solutions.

CO - PSO mapping

	PSO1	PSO2	PSO3	PSO 4
CE202.1	2			
CE202.2	2			
CE202.3	2			
CE202.4	3			
CE202.5	3			
Course Targets	**2**			

Extent of correlation: 1- Slight, 2 - Moderate, 3 - Strong.

CFD2- Methodology used to measure CO attainment

CE-202: Mechanics of Materials
Methodology for CO Attainment

Procedure for calculation of CO, PO and PSO attainments

The CO attainments for the course are calculated using attainment levels by both direct and indirect assessments. The direct assessment is given a weight of 80% and the indirect assessment is given a weight of 20% in order to calculate the final attainment values.

The direct attainment for the course is calculated using all the assessments employed over the course of the semester (exams, assignments, quizzes, projects etc.). The questions in each of the assessment methods are mapped to relevant COs and the BT level is identified. The marks secured by the students, according to each question are used to obtain the marks obtained for each CO. Using this, the maximum marks and the marks obtained by each student, for each CO are obtained, for each of the assessments carried out. In each assessment, students are deemed to have attained a CO on securing more than 50% of the marks (threshold marks attainment for CO) for that CO. If more than 60% of the students attain a CO, the attainment level is assigned a value 3. If the fraction of students who crossed the threshold marks attainment for the CO is between 40% and 60%, the attainment level is 2 and is 1 if the fraction of student who crossed the threshold marks attainment for the CO is less than 40%. This gives us the attainment levels for each CO for each of the assessments in the semester.

COF_ASSM1_j: Fraction (percentage) attainment for CO # j in Assessment 1.

= 100 x No. of students with more than 50% marks for CO # j in Assessment 1/ No. of students

COA_ASSM1_j: Attainment for level CO # j in Assessment 1.

= 1 if $COF\_ASSM1_j < 40$, 2 if $COF\_ASSM1_j \geq 40$ and $COF\_ASSM1_j < 60$, 3 if $COF\_ASSM1_j \geq 60$

The attainment of each CO over the course of the semester using direct assessment methods is calculated as the weighted average over all the assessments. The weights assigned to each assessment for calculating the final score and grade are used to calculate the final attainment.

COF_DA_j: Fraction (percentage) attainment for CO # j using all direct assessments.

$$= \frac{W_{ASSM1} \times COF_{ASSM1\,j} + W_{ASSM2} \times COF_{ASSM2\,j} + \cdots + W_{ASSMn} \times COF_{ASSMn\,j}}{W_{ASSM1} + W_{ASSM2} + \cdots + W_{ASSMn}}$$

COA_DA_j: Fraction (percentage) attainment for CO # j using all direct assessments.

$$= \frac{W_{ASSM1} \times COA_{ASSM1\,j} + W_{ASSM2} \times COA_{ASSM2\,j} + \cdots + W_{ASSMn} \times COA_{ASSMn\,j}}{W_{ASSM1} + W_{ASSM2} + \cdots + W_{ASSMn}}$$

where *ASSM1, ASSM1,… ASSMn* are n different assessments carried out over the course of the semester (mid-terms, end sem exam, quizzes, homeworks, assignments, projects etc.) and *W* denotes the weight of each assessment.

The calculation of attainment levels for the indirect assessment is based on student responses to a survey designed for the course. In the survey, students answer questions that qualitatively assess the attainment of COs from the students' perspective. Students respond to each question on a 5 point Likert scale with responses ranging from strongly disagreeing to attainment of a course outcome to strongly agreeing to attainment of a course outcome. This response is numerically assigned a score of 1 to 5, correspondingly. The average response to all the questions pertaining to a given CO is calculated and to scaled to 100 (multiplied by 20). This is treated as the attainment percentage (fraction) and the attainment level is calculated as before (1, if attainment fraction is < 40%, 2 if it is > 40% and < 60%, 3 if > 60%).

COF_IA_j: Fraction (percentage) attainment for CO # j (Indirect Assessment)

= 20 x Average response determined using the 5 point Likert scale.

COA_IA_j: Attainment for level CO # j (Indirect Assessment)

= 1 if $COF\_IA_j < 40$, 2 if $COF\_IA_j \geq 40$ and $COF\_IA_j < 60$, 3 if $COF\_IA_j \geq 60$

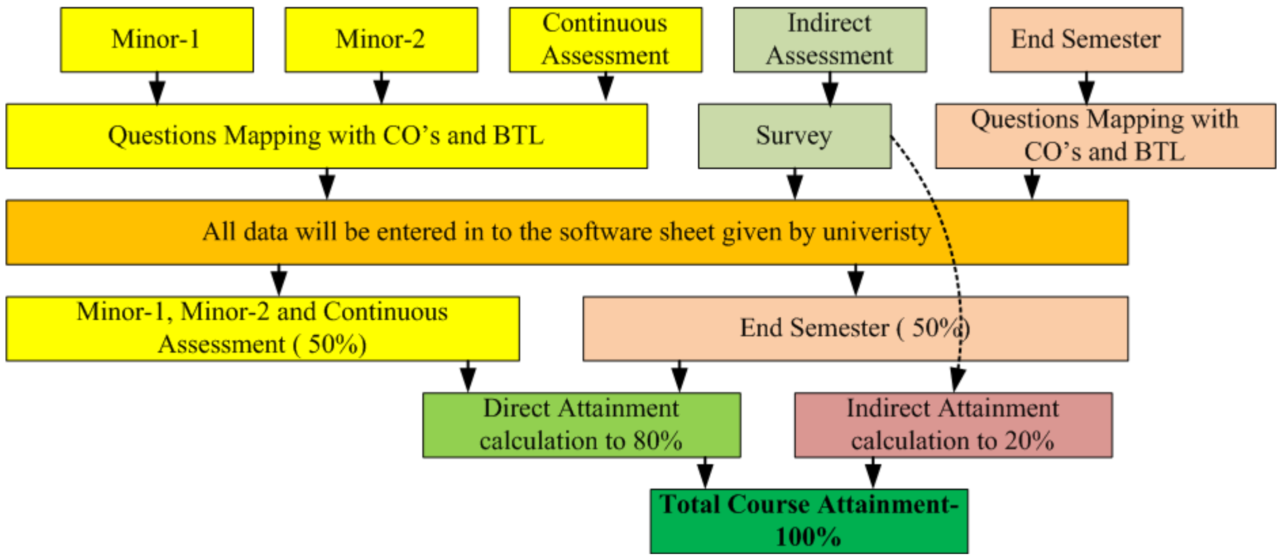
The Final attainment calculations for the course are made by giving the direct assessment a weight of 80% and the indirect assessment is given a weight of 20%.

COF_FA_j: Final fractional (percentage) attainment for CO # j

$= 0.8 \times COF\_DA_j + 0.2 \times COF\_IA_j$

COA_FA_j: Final attainment for level CO # j

$= 0.8 \times COA\_DA_j + 0.2 \times COA\_IA_j$



Schematic for CO attainment calculations

Procedure for calculation of PO and PSO attainments

The evaluation of the attainments of POs and PSOs for each course begins with the appropriate description of the articulation matrices using relevant weights that map the level of correlation of each CO with each PO and PSO.

	PO1	**..**	**..**	**PO # i**	**..**	**..**
CO # 1	..	..	..	$WPO_i\_CO_1$	..	..
..	..	..	..	..	..	..
CO # j	..	..	..	$WPO_i\_CO_j$	..	..
..	..	..	..	..	..	..
Course	$\boldsymbol{WPO_1}$	**..**	**..**	$\boldsymbol{WPO_i}$	**..**	**..**

Here, each $WPO_i\_CO_j$ can be assigned a value of 1 for slight correlation, 2 for moderate correlation and 3 for a strong correlation between CO # j and PO # i, or may even be left uncorrelated. Thus the average 'weight' for each PO, averaged over all populated CO correlations reflects the target attainment level for said PO, i.e.,

$$\boldsymbol{WPO_i} = \text{average}\left(WPO_i\_CO_1, \dots, WPO_i\_CO_j, ..\right)$$

The actual attainment for each PO is obtained from the final attainments of each CO and the correlation levels of each of the COs with the relevant PO.

	FA	PO1	..	..	PO # i	..	..
CO # 1	COA_FA_1	..	..	..	$WPO_{i\_}CO_1$	..	..
..	..	..	..	..	..	..	..
CO # j	COA_FA_j	..	..	..	$WPO_{i\_}CO_j$	..	..
..	..	..	..	..	..	..	..
Course		$\boldsymbol{APO_1}$	..	..	$\boldsymbol{APO_i}$	..	..

Here, the actual attainment level of PO # i is given by

$$\boldsymbol{APO_i} = \frac{\sum_{\boldsymbol{j}} COA\_FA_j \times WPO_{i\_}CO_j}{\sum_{\boldsymbol{j}} WPO_{i\_}CO_j}$$

A similar calculation procedure is followed for the PSO attainment calculations.

CFD3- CO Attainment Sheet (In detail with formulae and headings)

CE-202: Mechanics of Materials
Complete Analysis of Course Attainment and PO Attainment

Assignment- CO-PO mapping (20% Weightage)

S. No	Roll no	Name	Assignment no1	Assignment no2	Assignment no3	Assignment no4	Assignment no5	TOTAL ASSIGNMENT MARKS (20)
		CO attainment	CO1	CO2	CO3	CO4	CO5	
		Total Marks	10	10	10	10	10	
1	19XJ1A0101	A DURGA GAYATRI VINUTHNA	10	10	10	9	10	20
2	19XJ1A0102	A PRITIKA REDDY	10	5	8	10	10	19
3	19XJ1A0104	ANVITHA YADAMA	NA	NA	8	NA	7	6
4	19XJ1A0105	AITIPAMULA BHAVANI	6	10	8	10	10	18
5	19XJ1A0106	AMAY SHUKLA	8	6	10	10	8	17
6	19XJ1A0107	BONDADA CH ABHISHEK KUMAR	10	10	8	10	9	19
7	19XJ1A0108	V.S.Ch.Dheeraj Kumar Bondada	8	8	8	8	10	17
8	19XJ1A0109	CAROL RACHEL KAKILETI	8	6	5	8	7	14
9	19XJ1A0110	DEVANSH BANSAL	8	6	7	2	8	15
10	19XJ1A0111	DUGGIRALA SAI VAISHNAV	8	NA	9	7	10	16
11	19XJ1A0112	GATIKA ABHISTA SAI RISHI KUMAR	8	NA	5	4	4	9
12	19XJ1A0113	INDRANEEL REDDY BILLA	NA	NA	5	NA	8	6
13	19XJ1A0114	SHANTAN REDDY JANNUPREDDY	NA	3	8	6	5	9
14	19XJ1A0115	KADIRI BHUVANESH	NA	NA	8	8	9	8

15	19XJ1A0116	KALAMSETTY VISWATEJA	NA	NA	NA	8	6	5
16	19XJ1A0117	KANIGIRI CHANDRAKANTH REDDY	8	8	NA	9	10	16
17	19XJ1A0118	BHUVAN ALLADI	6	NA	8	NA	7	9
18	19XJ1A0119	MANVITHA THEEGALA	10	10	8	9	10	19
19	19XJ1A0120	MOHAMMED KHURRAM HASSAN GHORI	NA	NA	NA	5	NA	2
20	19XJ1A0121	MOHAMMED MUJTABA MOID	8	6	6	10	10	16
21	19XJ1A0122	NAVARI SIDDARTH REDDY	10	10	10	10	10	20
22	19XJ1A0123	NEERUDI YESHWANTH	6	NA	NA	6	8	8
23	19XJ1A0124	PENUMATSA GOWTHAM VARMA	3	NA	5	6	9	10
24	19XJ1A0125	SAKETHRAM REDDYGARI	4	NA	6	6	9	10
25	19XJ1A0126	SAKSHAM RAJPUT	10	8	10	10	10	20
26	19XJ1A0127	SHERI SAKETH REDDY	6	NA	NA	NA	NA	12
27	19XJ1A0128	SIRI REDDY PANNALA	10	NA	10	10	9	16
28	19XJ1A0129	SREE VANSH BUDDINENI	4	NA	10	10	10	14
29	19XJ1A0131	VANGA AMULYA REDDY	10	8	8	9	NA	14
30	19XJ1A0132	VENKAT RISHI BADIGA	6	NA	NA	0	6	9
31	19XJ1A0133	VUNGARALA YASHWANTH RAO SUBASH	10	6	10	7	9	17
32	19XJ1A0134	Y RIDHIMA REDDY	NA	NA	7	5	6	12
33	19XJ1A0135	AMITH CHANDRA KODALI	8	6	4	NA	7	10
34	19XJ1A0136	DEVIREDDY SOWMYA	8	8	7	5	8	15
35	19XJ1A0137	GOPU VENKATA SIVA SAI SAMEER	6	7	5	7	9	14
36	19XJ1A0138	SLOKA GAMPA	8	6	10	10	10	18

37	19XJ1A0139	SYNTHIA MAIYUKHI KOTAMRAJU	8	8	10	8	10	18
38	19XJ1A0140	NAINENI RAGHU CHANDER	NA	NA	7	5	5	7
39	19XJ1A0141	P VISHWAAJITH	8	8	10	10	9	18
40	19XJ1A0142	Sumedh	10	8	10	10	10	20
41	19XJ1A0143	Sourab Vokkalkar	4	NA	NA	NA	NA	2
42	19XJ1A0144	Semanth Reddy	8	8	10	10	10	19
		No of Students attempted this CO	34	24	35	36	38	42
		Number of students who attained more than 50% of marks in this CO	30	23	34	33	37	
		Percentage of students who attained more than 50% of marks in this CO	88.2353	95.833	97.143	91.67	97.368	
		COs	CO1	CO2	CO3	CO4	CO5	
		CO1 Attainment	88.2353					
		CO2 Attainment	95.8333					
		CO3 Attainmnet	97.1429					
		CO4 Attainmnet	91.6667					
		CO5 Attainmnet	97.3684					

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Quiz-CO-PO mapping (20% Weightage)

Roll no	Name	QUIZ 1	QUIZ 2	QUIZ 3	Quiz 4	Quiz 5	Quiz 6	TOTAL QUIZ MARKS(20)
	CO attainment	CO1	CO1	CO2	CO3	CO4	CO5	
	Total Marks	10	10	10	10	10	10	
19XJ1A0101	A DURGA GAYATRI VINUTHNA	2	7	8	4	2	4	12
19XJ1A0102	A PRITIKA REDDY	6	5	10	NA	6	6	15
19XJ1A0104	ANVITHA YADAMA	0	5	NA	4	2	2	6
19XJ1A0105	AITIPAMULA BHAVANI	4	7	8	4	2	0	10
19XJ1A0106	AMAY SHUKLA	NA	7	8	6	2	0	10
19XJ1A0107	BONDADA CH ABHISHEK KUMAR	6	6	8	6	6	2	13
19XJ1A0108	V.S.Ch.Dheeraj Kumar Bondada	4	3	8	6	6	2	11
19XJ1A0109	CAROL RACHEL KAKILETI	4	8	8	4	0	0	10
19XJ1A0110	DEVANSH BANSAL	4	8	NA	6	4	2	10
19XJ1A0111	DUGGIRALA SAI VAISHNAV	4	6	6	6	2	4	11
19XJ1A0112	GATIKA ABHISTA SAI RISHI KUMAR	4	10	6	6	2	4	12
19XJ1A0113	INDRANEEL REDDY BILLA	NA	6	2	4	0	4	7
19XJ1A0114	SHANTAN REDDY JANNUPREDDY	NA	5	10	4	0	0	8
19XJ1A0115	KADIRI BHUVANESH	4	NA	NA	6	0	2	5
19XJ1A0116	KALAMSETTY VISWATEJA	4	NA	NA	0	NA	0	2
19XJ1A0117	KANIGIRI CHANDRAKANTH REDDY	4	8	8	6	0	0	11
19XJ1A0118	BHUVAN ALLADI	NA	7	8	4	4	0	10
19XJ1A0119	MANVITHA THEEGALA	6	6	8	6	4	2	12
19XJ1A0120	MOHAMMED KHURRAM HASSAN GHORI	NA	1	8	NA	NA	NA	4
19XJ1A0121	MOHAMMED MUJTABA MOID	2	5	8	4	4	6	12
19XJ1A0122	NAVARI SIDDARTH REDDY	NA	7	10	6	6	6	15

19XJ1A0123	NEERUDI YESHWANTH	4	5	6	4	2	2	9
19XJ1A0124	PENUMATSA GOWTHAM VARMA	4	5	4	2	2	0	7
19XJ1A0125	SAKETHRAM REDDYGARI	2	9	8	6	6	0	13
19XJ1A0126	SAKSHAM RAJPUT	NA	6	6	6	0	4	9
19XJ1A0127	SHERI SAKETH REDDY	6	6	6	4	0	2	10
19XJ1A0128	SIRI REDDY PANNALA	4	10	10	4	2	4	13
19XJ1A0129	SREE VANSH BUDDINENI	4	NA	8	6	6	4	12
19XJ1A0131	VANGA AMULYA REDDY	4	5	8	2	2	2	9
19XJ1A0132	VENKAT RISHI BADIGA	NA	4	8	6	2	2	9
19XJ1A0133	VUNGARALA YASHWANTH RAO SUBASH	6	NA	8	6	4	2	11
19XJ1A0134	Y RIDHIMA REDDY	4	NA	8	NA	NA	NA	5
19XJ1A0135	AMITH CHANDRA KODALI	0	5	6	0	0	2	6
19XJ1A0136	DEVIREDDY SOWMYA	4	4	6	4	4	4	9
19XJ1A0137	GOPU VENKATA SIVA SAI SAMEER	6	7	8	2	0	0	10
19XJ1A0138	SLOKA GAMPA	2	NA	NA	4	4	2	5
19XJ1A0139	SYNTHIA MAIYUKHI KOTAMRAJU	4	8	10	6	0	2	12
19XJ1A0140	NAINENI RAGHU CHANDER	8	6	4	4	4	2	11
19XJ1A0141	P VISHWAAJITH	4	6	8	4	4	4	11
19XJ1A0142	Sumedh	4	10	10	6	4	4	14
19XJ1A0143	Sourab Vokkalkar	NA	NA	NA	NA	NA	NA	0
19XJ1A0144	Semanth Reddy	6	7	6	6	2	2	11
	No of Students attempted this CO	33	35	36	38	38	39	
	Number of students who attained more than 50% of marks in this CO	8	31	33	18	6	3	
	Percentage of students who attained more than 50% of marks in this CO	24.242424	88.571429	91.666667	47.36842	15.78947	7.692308	

COs	CO1	CO1	CO2	CO3	CO4	CO5	
CO1 Attainment	56.406926						
CO2 Attainment	91.666667						
CO3 Attainmnet	47.368421						
CO4 Attainmnet	15.789474						
CO5 Attainmnet	7.6923077						

Project- CO-PO mapping (10% Weightage)

Roll no	Name	Project (10 Marks)
	CO attainment	CO1& CO2
	Total Marks	10
19XJ1A0101	A DURGA GAYATRI VINUTHNA	8
19XJ1A0102	A PRITIKA REDDY	9
19XJ1A0104	ANVITHA YADAMA	8
19XJ1A0105	AITIPAMULA BHAVANI	8
19XJ1A0106	AMAY SHUKLA	7
19XJ1A0107	BONDADA CH ABHISHEK KUMAR	9
19XJ1A0108	V.S.Ch.Dheeraj Kumar Bondada	9
19XJ1A0109	CAROL RACHEL KAKILETI	8
19XJ1A0110	DEVANSH BANSAL	7
19XJ1A0111	DUGGIRALA SAI VAISHNAV	7
19XJ1A0112	GATIKA ABHISTA SAI RISHI KUMAR	7
19XJ1A0113	INDRANEEL REDDY BILLA	7
19XJ1A0114	SHANTAN REDDY JANNUPREDDY	7
19XJ1A0115	KADIRI BHUVANESH	0
19XJ1A0116	KALAMSETTY VISWATEJA	0
19XJ1A0117	KANIGIRI CHANDRAKANTH REDDY	8
19XJ1A0118	BHUVAN ALLADI	0
19XJ1A0119	MANVITHA THEEGALA	8
19XJ1A0120	MOHAMMED KHURRAM HASSAN GHORI	0
19XJ1A0121	MOHAMMED MUJTABA MOID	8
19XJ1A0122	NAVARI SIDDARTH REDDY	9
19XJ1A0123	NEERUDI YESHWANTH	9
19XJ1A0124	PENUMATSA GOWTHAM VARMA	0
19XJ1A0125	SAKETHRAM REDDYGARI	0
19XJ1A0126	SAKSHAM RAJPUT	8
19XJ1A0127	SHERI SAKETH REDDY	0
19XJ1A0128	SIRI REDDY PANNALA	8
19XJ1A0129	SREE VANSH BUDDINENI	8
19XJ1A0131	VANGA AMULYA REDDY	8
19XJ1A0132	VENKAT RISHI BADIGA	7
19XJ1A0133	VUNGARALA YASHWANTH RAO SUBASH	8
19XJ1A0134	Y RIDHIMA REDDY	9
19XJ1A0135	AMITH CHANDRA KODALI	9
19XJ1A0136	DEVIREDDY SOWMYA	8

19XJ1A0137	GOPU VENKATA SIVA SAI SAMEER	7
19XJ1A0138	SLOKA GAMPA	8
19XJ1A0139	SYNTHIA MAIYUKHI KOTAMRAJU	8
19XJ1A0140	NAINENI RAGHU CHANDER	8
19XJ1A0141	P VISHWAAJITH	8
19XJ1A0142	Sumedh	8
19XJ1A0143	Sourab Vokkalkar	0
19XJ1A0144	Semanth Reddy	9
	No of Students attempted this CO	42
	Number of students who attained more than 50% of marks in this CO	34
	Percentage of students who attained more than 50% of marks in this CO	80.95238095
	COs	CO1& CO2
	CO1 Attainment	40.47619048
	CO2 Attainment	40.47619048

Class interaction-CO-PO mapping (20% Weightage)

Roll no	Name	Q&A (20 Marks)
	CO attainment	CO4 & CO5
	Total Marks	10
19XJ1A0101	A DURGA GAYATRI VINUTHNA	20
19XJ1A0102	A PRITIKA REDDY	20
19XJ1A0104	ANVITHA YADAMA	8
19XJ1A0105	AITIPAMULA BHAVANI	16
19XJ1A0106	AMAY SHUKLA	12
19XJ1A0107	BONDADA CH ABHISHEK KUMAR	20
19XJ1A0108	V.S.Ch.Dheeraj Kumar Bondada	20
19XJ1A0109	CAROL RACHEL KAKILETI	8
19XJ1A0110	DEVANSH BANSAL	8
19XJ1A0111	DUGGIRALA SAI VAISHNAV	20
19XJ1A0112	GATIKA ABHISTA SAI RISHI KUMAR	4
19XJ1A0113	INDRANEEL REDDY BILLA	6
19XJ1A0114	SHANTAN REDDY JANNUPREDDY	4
19XJ1A0115	KADIRI BHUVANESH	0
19XJ1A0116	KALAMSETTY VISWATEJA	4
19XJ1A0117	KANIGIRI CHANDRAKANTH REDDY	16
19XJ1A0118	BHUVAN ALLADI	6
19XJ1A0119	MANVITHA THEEGALA	16
19XJ1A0120	MOHAMMED KHURRAM HASSAN GHORI	0
19XJ1A0121	MOHAMMED MUJTABA MOID	12
19XJ1A0122	NAVARI SIDDARTH REDDY	18
19XJ1A0123	NEERUDI YESHWANTH	8
19XJ1A0124	PENUMATSA GOWTHAM VARMA	6
19XJ1A0125	SAKETHRAM REDDYGARI	8
19XJ1A0126	SAKSHAM RAJPUT	12
19XJ1A0127	SHERI SAKETH REDDY	6
19XJ1A0128	SIRI REDDY PANNALA	12
19XJ1A0129	SREE VANSH BUDDINENI	8
19XJ1A0131	VANGA AMULYA REDDY	16
19XJ1A0132	VENKAT RISHI BADIGA	8
19XJ1A0133	VUNGARALA YASHWANTH RAO SUBASH	8
19XJ1A0134	Y RIDHIMA REDDY	4
19XJ1A0135	AMITH CHANDRA KODALI	4

19XJ1A0136	DEVIREDDY SOWMYA	4
19XJ1A0137	GOPU VENKATA SIVA SAI SAMEER	4
19XJ1A0138	SLOKA GAMPA	4
19XJ1A0139	SYNTHIA MAIYUKHI KOTAMRAJU	16
19XJ1A0140	NAINENI RAGHU CHANDER	12
19XJ1A0141	P VISHWAAJITH	20
19XJ1A0142	Sumedh	16
19XJ1A0143	Sourab Vokkalkar	0
19XJ1A0144	Semanth Reddy	20
	No of Students attempted this CO	42
	Number of students who attained more than 50% of marks in this CO	31
	Percentage of students who attained more than 50% of marks in this CO	73.80952
	COs	CO4 & CO5
	CO1 Attainment	36.90476
	CO2 Attainment	36.90476

End Semester CO-PO mapping (30% Weightage)

Question	Q1(A1)	Q2(A2)	Q3(A3)	Q4(B1)	Q5(B2)	Q6(B3)	Q7(B4)	Q8(B5)	Total Marks
Marks	10	10	10	10	10	10	10	10	
COs	CO1	CO2	CO2	CO3	CO3	CO3	CO5	CO4	
19XJ1A0101	1		4.5	5		4		5	19.5
19XJ1A0102	10		8	9		7		8	42
19XJ1A0104	7			5		6		7	25
19XJ1A0105	7		6.5	6		7		5	31.5
19XJ1A0106	6		2.5	5		5		6	24.5
19XJ1A0107	7		8.5	8		8		7	38.5
19XJ1A0108	8		2.5	6		6		5	27.5
19XJ1A0109	6		4	6		5		5	26
19XJ1A0110	7		1.5	5		5		5	23.5
19XJ1A0111	7		4	8		6		6	31
19XJ1A0112	6		1.5	2		5		5	19.5
19XJ1A0113	3		2.5	2		5		5	17.5
19XJ1A0114	6		1.5	2		3		3	15.5
19XJ1A0115	5		1.5	2			8	4	20.5
19XJ1A0116	6		1.5	3		3		5	18.5
19XJ1A0117	7		1.5	2		4		5	19.5
19XJ1A0118	6		1.5	3		4		5	19.5
19XJ1A0119	7		2.5	7		5		5	26.5
19XJ1A0120	8		2.5	3		4		4	21.5
19XJ1A0121	6		2.5	3		5		6	22.5
19XJ1A0122	9		8	8		5		8	38
19XJ1A0123	6		2.5	4		5		5	22.5
19XJ1A0124	5		2.5	4		3		5	19.5
19XJ1A0125	7		2.5	3		2		5	19.5
19XJ1A0126	8		3.5	8		5		6	30.5
19XJ1A0127	4		3	3		4		4	18
19XJ1A0128	7		4	6		5		3	25
19XJ1A0129	7		2.5	3		4		5	21.5
19XJ1A0131	8		2.5	7		6		6	29.5
19XJ1A0132	7		2.5	5		4		5	23.5
19XJ1A0133	5		2.5	7			2	5	21.5
19XJ1A0134	8		2	4		4		4	22
19XJ1A0135	7		2.5	7		5		5	26.5

19XJ1A0136	7		2.5	5		4		5	23.5
19XJ1A0137	7		2.5	4		6		5	24.5
19XJ1A0138	8		2.5	8			10	6	34.5
19XJ1A0139	9		5			5		4	23
19XJ1A0140	7		2.5	6		6		5	26.5
19XJ1A0141	6		6	9		7		4	32
19XJ1A0142	8			6		7		7	28
19XJ1A0143	8		1.5	3		4		5	21.5
19XJ1A0144	8		7	8			6	8	37
No of Students attempted this CO	42	0	40	41	0	38	4	42	
Number of students who attained more than 50% of marks in this CO	39	0	7	24	0	24	3	34	
Percentage of students who attained more than 50% of marks in this CO	92.85714286	0	17.5	58.53658537	0	63.15789474	75	80.95238095	
COs	CO1	CO2	CO2	CO3	CO3	CO3	CO5	CO4	

CO1 Attainment	92.85714286
CO2 Attainment	17.5
CO3 Attainmnet	60.84724005
CO4 Attainmnet	80.95238095
CO5 Attainmnet	75

Average of each CO

Indirect Analysis

Question	Q1	Q2	Q3	Q4	Q5
COs	5	5	5	5	5
student1	4	4	5	4	4
student2	5	3	5	5	5
student3	4	4	4	3	3
student4	2	5	5	4	4
student5	3	4	4	4	4
student6	5	5	5	3	3
student7	4	3	4	4	4
student8	3	2	3	5	5
student9	2	5	4	3	3
student10	3	4	5	3	3
student11	4	4	3	4	4
student12	5	4	5	5	5
student13	3	3	5	3	3
student14	4	2	4	4	4
student15	5	5	5	4	4
student16	2	4	4	3	3
student17	2	5	5	4	4
student18	5	4	4	4	4
student19	3	4	2	3	3
student20	2	5	5	4	4
student21	3	4	4	4	4
student22	5	5	5	3	3

Average of overall	3.545455	4	4.318182	3.772727	3.772727
Percentage of students who attained this CO	70.90909	80	86.36364	75.45455	75.45455

Assignment Carries 20% weight (weighted average)						
		CO1	CO2	CO3	CO4	CO5
Number of students who attained more than 50% of marks of each CO		30	23	34	33	37
Percentage of students who attained more than 50% of marks of each CO		88.23529412	95.83333333	97.14285714	91.66666667	97.36842105

Quiz (weighted average) Carries 20% weightage							
		CO1	CO1	CO2	CO3	CO4	CO5
Number of students who attained more than 50% of marks of each CO		8	31	33	18	6	3
Percentage of students who attained more than 50% of marks of each CO		24.24242424	88.57142857	91.66666667	47.36842105	15.78947368	7.692307692

Project carries 10 % weightage(weighted average)			
		CO1	CO2
Number of students who attained more than 50% of marks of each CO		34	34
Percentage of students who attained more than 50% of marks of each CO		80.95238095	80.95238095

Class Interaction carries 20% (weighted average)			
		CO4	CO5
Number of students who attained more than 50% of marks of each CO		31	31
Percentage of students who attained more than 50% of marks of each CO		73.80952381	73.80952381

Criterion Followed	
Class Stre	42
No of CO	5
Threshold	50
Target	55
Level 1	<39
Level 2	40 to 55
Level 3	>55

Internal assessment (weighted average) 70%		End term (weighted average) 30%		Indirect Analysis		Overall Assessment (80% Direct+20%		Attainment level
CO1	48.30506748	CO1	27.85714	CO1	70.90909	CO1	75.11159	3
CO2	45.5952381	CO2	5.25	CO2	80	CO2	56.67619	3
CO3	28.90225564	CO3	36.50834	CO3	86.36364	CO3	69.60121	3
CO4	36.25313283	CO4	24.28571	CO4	75.45455	CO4	63.52199	3
CO5	35.77405051	CO5	22.5	CO5	75.45455	CO5	61.71015	3

CFD4- Analysis of CO’s attained and Action plan for remedial

CE-202:Mechanics of Materials
Action Plan

Remedies

Final Assessment				
	Attainment %	**Attainment Level**	**Target %**	**Attainment**
CE202.1	**75.1**	**3.0**	55.0	**Yes**
CE202.2	**56.6**	**3.0**	55.0	**Yes**
CE202.3	**69.6**	**3.0**	55.0	**Yes**
CE202.4	**63.5**	**3.0**	55.0	**Yes**
CE202.5	**61.7**	**3.0**	55.0	**Yes**

Based on the final attainment calculations, all course objectives were attained. However, as the course is a foundation for the other structural analysis and design courses the attainment level and its target can be increased with more practical knowledge.