

# **MAR ATHANASIOUS COLLEGE OF ENGINEERING**

**(Government Aided & Autonomous)**

Kothamangalam 686 666

Affiliated to APJ Abdul Kalam Technological University

Thiruvananthapuram



**Master of Technology (M. Tech.)**

**Computer Aided Structural Engineering**

**Curriculum - 2024**

## **COLLEGE VISION AND MISSION**

### **VISION**

Excellence in education through resource integration.

### **MISSION**

The institution is committed to transform itself into a centre of excellence in Technical Education upholding the motto "Knowledge is Power."

This is to be achieved by imparting quality education to mould technically competent professionals with moral integrity, ethical values and social commitment, and by promoting innovative activities in the thrust areas emerging from time to time.

# **MAR ATHANASIOUS COLLEGE OF ENGINEERING**

**(GOVT. AIDED & AUTONOMOUS)**

**M.TECH CURRICULUM AND SCHEME-2024**

**Department of Civil Engineering**

**Computer Aided Structural Engineering**

## **PROGRAM OUTCOMES – PO**

Outcomes are the attributes that are to be demonstrated by a graduate after completing the programme.

**PO1:** An ability to independently carry out research/investigation and development work in engineering and allied streams

**PO2:** An ability to communicate effectively, write and present technical reports on complex engineering activities by interacting with the engineering fraternity and with society at large.

**PO3:** An ability to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor programme.

**PO4:** An ability to apply stream knowledge to design or develop solutions for real world problems by following the standards

**PO5:** An ability to identify, select and apply appropriate techniques, resources and state-of-the-art tool to model, analyse and solve practical engineering problems.

**PO6:** An ability to engage in life-long learning for the design and development of the stream related problems taking into consideration sustainability, societal, ethical and environmental aspects. Also to develop cognitive skills for project management and finance which focus on Industry and Entrepreneurship.

The departments conducting the M.Tech programme shall define their own PSOs, if required, and evaluation shall also to be done for the same.

**SEMESTER I**

| Slot  | Course Code     | Courses                                     | Marks |     | L-T-P-S | Hours | Credit |
|-------|-----------------|---|-------|-----|---------|-------|--------|
|       |                 |   | CIE   | ESE |         |       |        |
| A     | M24CE1T101      | Numerical methods in Structural Engineering | 40    | 60  | 4-0-0-4 | 4     | 4      |
| B     | M24CE1T102      | Theory of Elasticity & Plasticity           | 40    | 60  | 4-0-0-4 | 4     | 4      |
| C     | M24CE2T103      | Advanced Analysis of Structures             | 40    | 60  | 4-0-0-4 | 4     | 4      |
| D     | M24CE2E104<br>A | Programme Elective 1                        | 40    | 60  | 3-0-0-3 | 3     | 3      |
| E     | M24CE2E105<br>A | Programme Elective 2                        | 40    | 60  | 3-0-0-3 | 3     | 3      |
| J     | M24CE1R106      | Research Methodology & IPR                  | 40    | 60  | 2-0-0-2 | 2     | 2      |
| G     | M24CE1L107      | Advanced Structural Engineering Lab         | 60    | 40  | 0-0-3-3 | 3     | 2      |
| Total |                 |   | 300   | 400 |         | 23    | 22     |

Teaching Assistance: 7 hours

Self-study- 23 Hrs

**PROGRAMME ELECTIVE-1**

| Slot | COURSE CODE | COURSE NAME                          | L-T-P-S | HOURS | Credit |
|------|-------------|--------------------------------------|---------|-------|--------|
| D    | M24CE1E104A | Prestressed Concrete                 | 3-0-0-3 | 3     | 3      |
|      | M24CE2E104B | Analysis and Design of Substructures | 3-0-0-3 | 3     | 3      |
|      | M24CE2E104C | Fracture Mechanics                   | 3-0-0-3 | 3     | 3      |
|      | M24CE2E104D | Advanced Concrete Technology         | 3-0-0-3 | 3     | 3      |

### PROGRAMME ELECTIVE-2

| Slot | COURSE CODE | COURSE NAME                            | L-T-P-S | HOURS | Credit |
|------|-------------|--|---------|-------|--------|
| E    | M24CE1E105A | Structural Dynamics                    | 3-0-0-3 | 3     | 3      |
|      | M24CE2E105B | Mechanics of Composite Structures      | 3-0-0-3 | 3     | 3      |
|      | M24CE1E105C | Advanced Design of Steel Structures    | 3-0-0-3 | 3     | 3      |
|      | M24CE2E105D | Characterization of Building Materials | 3-0-0-3 | 3     | 3      |

### SEMESTER II

| Slot  | Course Code | Courses  | Marks |     | L-T-P-S | Hours | Credit |
|-------|-------------|--|-------|-----|---------|-------|--------|
|       |             |  | CIE   | ESE |         |       |        |
| A     | M24CE1T201  | Advanced Design of Concrete Structures                 | 40    | 60  | 4-0-0-4 | 4     | 4      |
| B     | M24CE2T202  | Analysis and Design of Earthquake Resistant Structures | 40    | 60  | 4-0-0-4 | 4     | 4      |
| C     | M24CE2E203A | Programme Elective 3                                   | 40    | 60  | 3-0-0-3 | 3     | 3      |
| D     | M24CE2E204A | Programme Elective 4                                   | 40    | 60  | 3-0-0-3 | 3     | 3      |
| E     | M24CE1S205  | Building Information Modelling                         | 40    | 60  | 3-0-0-3 | 3     | 3      |
| G     | M24CE1P206  | Mini project   | 100   | -   | 0-0-3-3 | 3     | 2      |
| P     | M24CE1L207  | Structural Design Studio Lab                           | 60    | 40  | 0-0-3-3 | 3     | 2      |
| TOTAL |             |  | 320   | 380 |         | 23    | 21     |

Teaching Assistance: 7 hours

Self-study- 23 Hrs

### PROGRAM ELECTIVE 3

| Slot | COURSE CODE | COURSE NAME                                    | L-T-P   | HOURS | Credit |
|------|-------------|--|---------|-------|--------|
| C    | M24CE1E203A | Design of Bridges                              | 3-0-0-3 | 3     | 3      |
|      | M24CE2E203B | Experimental Methods in Structural Engineering | 3-0-0-3 | 3     | 3      |
|      | M24CE1E203C | Structural Health Monitoring                   | 3-0-0-3 | 3     | 3      |
|      | M24CE2E203D | Design of Tall Buildings                       | 3-0-0-3 | 3     | 3      |

### PROGRAM ELECTIVE 4

| Slot | COURSE CODE | COURSE NAME  | L-T-P-S | HOURS | Credit |
|------|-------------|--|---------|-------|--------|
| D    | M24CE1E204A | Finite Element Method                                | 3-0-0-3 | 3     | 3      |
|      | M24CE2E204B | Theory of Plates and Shells                          | 3-0-0-3 | 3     | 3      |
|      | M24CE1E204C | Forensic Engineering in Civil Engineering Structures | 3-0-0-3 | 3     | 3      |
|      | M24CE2E204D | Prefabrication and modular construction              | 3-0-0-3 | 3     | 3      |

### SEMESTER III

| TRACK 1 |             |                         |                              |     |         |       |        |
|---------|-------------|-------------------------|------------------------------|-----|---------|-------|--------|
| Slot    | Course Code | Courses                 | Marks                        |     | L-T-P   | Hours | Credit |
|         |             |                         | CIE                          | ESE |         |       |        |
| A       | M24CE2M301  | *MOOC                   | To be completed successfully |     | --      | --    | 2      |
| B       | M24CE2E302A | Programme Elective 5    | 40                           | 60  | 3-0-0-3 | 3     | 3      |
| K       | M24CE2I303  | **Internship            | 50                           | 50  | --      | --    | 3      |
| P       | M24CE2P304  | Dissertation Phase 1    | 100                          | --  | 0-0-16  | 16    | 11     |
| TOTAL   |             |                         | 190                          | 110 |         | 19    | 19     |
| TRACK 2 |             |                         |                              |     |         |       |        |
| A       | M24CE2M305  | * MOOC 1                | To be completed successfully |     | --      | --    | 2      |
| B       | M24CE2M306  | * MOOC 2                | To be completed successfully |     | -       | -     | 2      |
| K       | M24CE2I307  | ## Internship           | 50                           | 50  | --      | -     | 4      |
| P       | M24CE2P308  | ###Dissertation Phase 1 | 100                          | --  | -       | -     | 11     |
| TOTAL   |             |                         | 150                          | 50  |         |       | 19     |

Teaching Assistance: 7 hours

\*MOOC Course of minimum 8 weeks duration to be successfully completed before the end of fourth semester (starting from semester 1).

\*\*Internship- mandatory internship of 6 to 8 weeks

## Internship - mandatory internship of more than 16 weeks

###Dissertation Phase 1 – Should be done in Industry

## PROGRAM ELECTIVE 5

| Slot | Sl.No. | COURSE CODE | COURSE NAME                                       | L-T-P-S | HOURS | Credit |
|------|--------|-------------|---|---------|-------|--------|
| D    | 1      | M24CE1E302A | Maintenance and Rehabilitation of Structures      | 3-0-0-3 | 3     | 3      |
|      | 2      | M24CE1E302B | Structural Stability                              | 3-0-0-3 | 3     | 3      |
|      | 3      | M24CE1E302C | Artificial Intelligence in Structural Engineering | 3-0-0-3 | 3     | 3      |
|      | 4      | M24CE2E302D | Soil Structure Interaction                        | 3-0-0-3 | 3     | 3      |

### TRACK 1 / TRACK 2

In second year, the students can choose either of the two tracks: TRACK 1 or TRACK 2. Track 1 is conventional M Tech programme in which the dissertation Phase 1 is conducted in college. Track 2 is M Tech programme designed for students who undergone long term internship (not less than 16 weeks) in industry. An aspirant in track 2 needs to do the dissertation in the industry. The candidates should also be good with performing in-depth research and colluding the conclusions of research led by them. Such students are expected to have the following skills: Technical Skills, Research Skills, Communication Skills, Critical Thinking Skills, and Problem-Solving Skills.

The eligibility for Track 2:

- > Shall have qualified in the GATE or have a SGPA above 8.0 during the first semester, and
- > Qualify an interview during the end of second semester by an expert committee constituted by the College.

### SEMESTER IV

| TRACK 1 |             |                       |       |     |           |       |        |
|---------|-------------|-----------------------|-------|-----|-----------|-------|--------|
| Slot    | Course Code | Courses               | Marks |     | L-T-P-S   | Hours | Credit |
|         |             |                       | CIE   | ESE |           |       |        |
| P       | M24CE2P401  | Dissertation Phase II | 100   | 100 | 0-0-27-24 | 27    | 18     |
|         | TOTAL       |                       | 100   | 100 |           | 27    | 18     |

| TRACK 2                             |            |                         |     |     |  |  |    |
|-------------------------------------|------------|-------------------------|-----|-----|--|--|----|
| P                                   | M24CE2P402 | ##Dissertation Phase II | 100 | 100 |  |  | 18 |
|                                     | TOTAL      |                         | 100 | 100 |  |  | 18 |
| Total credits in all four semesters |            |                         |     |     |  |  | 80 |

##Dissertation Phase II- Should be done in Industry

## COURSE NUMBERING SCHEME

The course number consists of digits/alphabets. The pattern to be followed is

**For General Courses – MYYBBXCSNN**

**For Elective Courses- MYYBBXCSNNA**

- M: MASTERS
- YY: Last two digits of year of regulation
- BB: DEPARTMENT

| Sl. No. | Department                    | Course Prefix |
|---------|-------------------------------|---------------|
| 01      | Civil Engg                    | CE            |
| 02      | Computer Science              | CS            |
| 03      | Electrical & Electronics      | EE            |
| 04      | Electronics & Communication   | EC            |
| 05      | Mechanical Engg               | ME            |
| 06      | Any                           | GE            |
| 07      | External (Industry/NPTEL etc) | EX            |

- X: Specialization number
- C: Course Type
  - T - Core Course
  - E - Elective Course
  - R - Research Methodology & IPR
  - L - Laboratory Course

- S - Industry Integrated Course
- I - Internship
- M - MOOC
- P - Project/Dissertation

- S: Semester of Study
  1. Semesters 1
  2. Semester 2
  3. Semester 3
  4. Semester 4
- NN: Course sequence number
- A: Elective sequence number - A/B/C/D/E

It is illustrated below: Examples:

M24CE1T202 is a second core course of first specialization offered by the Civil Department in semester 2

M24EC1R106 is Research Methodology & IPR offered in semester 1

M24EC1E104A is the first subject of Elective 1 of first specialization offered by the EC Department in semester 1

## EVALUATION PATTERN

### (i) CORE COURSES

Evaluation shall only be based on application, analysis or design based questions (for both internal and end semester examinations).

|  |          |                 |
|--|----------|-----------------|
| <b>Continuous Internal Evaluation</b>  | <b>:</b> | <b>40 marks</b> |
| Micro project/Course based project     | :        | 10 marks        |
| Course based task/Seminar/Quiz         | :        | 10 marks        |
| Test paper 1 (Module 1 and Module 2)   | :        | 10 marks        |
| Test paper 2 (Module 3 and Module 4)   | :        | 10 marks        |
| The project shall be done individually |          |                 |
| <b>End Semester Examination</b>        | <b>:</b> | <b>60marks</b>  |

The end semester examination will be conducted by the college. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis,

synthesis, evaluation and understanding of the students), with 1 question from each module, having 4 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 8 marks. Total duration of the examination will be 3 Hrs.

## **(ii) ELECTIVE COURSES**

Evaluation shall only be based on application, analysis or design based questions (for both internal and end semester examinations).

|  |   |                 |
|--|---|-----------------|
| <b>Continuous Internal Evaluation</b>  | : | <b>40 marks</b> |
| Seminar*   | : | 10 marks        |
| Course based task/Micro Project//Data collection and interpretation/Case study | : | 10 marks        |
| Test paper 1 (Module 1 and Module 2)   | : | 10 marks        |
| Test paper 2 (Module 3 and Module 4)   | : | 10 marks        |

\*Seminar should be conducted in addition to the theory hours. Topics for the seminar should be from recent technologies in the respective course.

**End Semester Examination** : **60 marks**

The end semester examination will be conducted by the College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 4 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 8 marks. Total duration of the examination will be 3 Hrs.

### **(iii) RESEARCH METHODOLOGY & IPR**

**Continuous Internal Evaluation** : **40 marks**

Preparing a review article based on peer reviewed

Original publications in the relevant discipline

(minimum 10 publications shall be referred) : 10 marks

Course based task/Seminar/Quiz : 10 marks

Test paper 1 (Module 1 and Module 2) : 10 marks

Test paper 2 (Module 3 and Module 4) : 10 marks

**End Semester Examination** : **60 marks**

The end semester examination should be conducted by the college. The time duration will be for 3 Hrs and will contain 7 questions, with minimum one question from each module of which student should answer any five. Each question can carry 12 marks.

### **(iv) INTERNSHIP**

Internships are educational and career development opportunities, providing practical experience in a field or discipline. They are structured, short-term, supervised placements often focused around particular tasks or projects with defined timescales. An internship may be compensated or non-compensated by the organization providing the internship. The internship has to be meaningful and mutually beneficial to the intern and the organization. It is important that the objectives and the activities of the internship program are clearly defined and understood. The internship offers the students an opportunity to gain hands-on industrial or organizational exposure; to integrate the knowledge and skills acquired through the coursework; interact with professionals and other interns; and to improve their presentation, writing, and communication skills. Internship often acts as a gateway for final placement for many students.

A student shall opt for carrying out the Internship at an Industry/Research Organization or at another institute of higher learning and repute (Academia). The organization for Internship shall be selected/decided by the students on their own with prior approval from the faculty advisor/respective PG Programme Coordinator/Guide/Supervisor. Every student shall be assigned an internship Supervisor/Guide at the beginning of the Internship. The training shall be related to their specialization after the second semester

for a minimum duration of six to eight weeks. On completion of the course, the student is expected to be able to develop skills in facing and solving the problems experiencing in the related field.

### **Objectives**

- Exposure to the industrial environment, which cannot be simulated in the classroom and hence creating competent professionals for the industry.
- Provide possible opportunities to learn understand and sharpen the real time technical / managerial skills required at the job.
- Exposure to the current technological developments relevant to the subject area of training.
- Create conducive conditions with quest for knowledge and its applicability on the job.
- Understand the social, environmental, economic and administrative considerations that influence the working environment.
- Expose students to the engineer's responsibilities and ethics.

### **Benefits of Internship**

#### **Benefits to Students**

- An opportunity to get hired by the Industry/ organization.
- Practical experience in an organizational setting & Industry environment.
- Excellent opportunity to see how the theoretical aspects learned in classes are integrated into the practical world. On-floor experience provides much more professional experience which is often worth more than classroom teaching.
- Helps them decide if the industry and the profession is the best career option to pursue.
- Opportunity to learn new skills and supplement knowledge.
- Opportunity to practice communication and teamwork skills.
- Opportunity to learn strategies like time management, multi-tasking etc in an industrial setup.
- Makes a valuable addition to their resume.
- Enhances their candidacy for higher education/placement.
- Creating network and social circle and developing relationships with industry people.
- Provides opportunity to evaluate the organization before committing to a full time position.

### **Benefits to the Institute**

- Build industry academia relations.
- Makes the placement process easier.
- Improve institutional credibility & branding.
- Helps in retention of the students.
- Curriculum revision can be made based on feedback from Industry/ students.
- Improvement in teaching learning process.

### **Benefits to the Industry**

- Availability of ready to contribute candidates for employment.
- Year round source of highly motivated pre-professionals.
- Students bring new perspectives to problem solving.
- Visibility of the organization is increased on campus.
- Quality candidate's availability for temporary or seasonal positions and projects.
- Freedom for industrial staff to pursue more creative projects.
- Availability of flexible, cost-effective workforce not requiring a long-term employer commitment.
- Proven, cost-effective way to recruit and evaluate potential employees.
- Enhancement of employer's image in the community by contributing to the educational enterprise.

### **Types of Internships**

- Industry Internship with/without Stipend
- Govt / PSU Internship (BARC/Railway/ISRO etc)
- Internship with prominent education/research Institutes
- Internship with Incubation centres /Start-ups

### **Guidelines**

- All the students need to go for internship for minimum duration of 6 to 8 weeks.
- Students can take mini projects, assignments, case studies by discussing it with concerned authority from industry and can work on it during internship.
- All students should compulsorily follow the rules and regulations as laid by industry.
- Every student should take prior permissions from concerned industrial authority if they want to use any drawings, photographs or any other document from industry.
- Student should follow all ethical practices and SOP of industry.

- Students have to take necessary health and safety precautions as laid by the industry.
- Student should contact his /her Guide/Supervisor from college on weekly basis to communicate the progress.
- Each student has to maintain a diary/log book
- After completion of internship, students are required to submit
  - Report of work done
  - Internship certificate copy
  - Feedback from employer / internship mentor
  - Stipend proof (in case of paid internship).

**Total Marks 100:** The marks awarded for the Internship will be on the basis of (i) Evaluation done by the Industry (ii) Students diary (iii) Internship Report and (iv) Comprehensive Viva Voce.

|                                       |          |                 |
|---------------------------------------|----------|-----------------|
| <b>Continuous Internal Evaluation</b> | <b>:</b> | <b>50 marks</b> |
| Student's diary                       | -        | 25 Marks        |
| Evaluation done by the Industry       | -        | 25 Marks        |

**Student's Diary/ Daily Log:** The main purpose of writing daily diary is to cultivate the habit of documenting and to encourage the students to search for details. It develops the students' thought process and reasoning abilities. The students should record in the daily training diary the day to day account of the observations, impressions, information gathered and suggestions given, if any. It should contain the sketches & drawings related to the observations made by the students. The daily training diary should be signed after every day by the supervisor/ in charge of the section where the student has been working. The diary should also be shown to the Faculty Mentor visiting the industry. Student's diary will be evaluated on the basis of the following criteria:

- Regularity in maintenance of the diary
- Adequacy & quality of information recorded
- Drawings, design, sketches and data recorded
- Thought process and recording techniques used
- Organization of the information.

**The format of student's diary**

Name of the Organization/Section :  
 Name and Address of the Section Head :  
 Name and Address of the Supervisor :  
 Name and address of the student :  
 Internship Duration : From ..... To .....  
 Brief description about the nature of internship:

|     |  |
|-----|--|
| Day | Brief write up about the Activities carried out: Such as design, sketches, result observed, issues identified, data recorded, etc. |
| 1   |  |
| 2   |  |
| 3   |  |

*Signature of Industry Supervisor*                      *Signature of Section Head/HR Manager Office Seal*

**Attendance Sheet**

Name of the Organization/Section :  
 Name and Address of the Section Head :  
 Name and Address of the Supervisor :  
 Name and address of the student :  
 Internship Duration : From ..... To .....

|              |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |     |  |
|--------------|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|-----|--|
| Month & Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | ... |  |
|              |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |     |  |
| Month & Year |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |     |  |
|              |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |     |  |
| Month & Year |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |     |  |
|              |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |     |  |

*Signature of Industry Supervisor*                      *Signature of Section Head/HR Manager Office Seal*

**Note:**

- Student's Diary shall be submitted by the students along with attendance record and an evaluation sheet duly signed and stamped by the industry to the Institute immediately after the completion of the training.
- Attendance Sheet should remain affixed in daily training diary. Do not remove or tear it off.
- Student shall sign in the attendance column. Do not mark 'P'.
- Holidays should be marked in red ink in the attendance column. Absent should be marked as 'A' in red ink.

**Evaluation done by the Industry (Marks 25)****Format for Supervisor Evaluation of Intern**

Student Name : \_\_\_\_\_ Date: \_\_\_\_\_

Supervisor Name : \_\_\_\_\_ Designation: \_\_\_\_\_

Company/Organization : \_\_\_\_\_

Internship Address: \_\_\_\_\_

Dates of Internship: From \_\_\_\_\_ To \_\_\_\_\_

*Please evaluate intern by indicating the frequency with which you observed the following parameters:*

| <b>Parameters Marks</b>                  | <b>Needs improvement<br/>(0 – 0.25 mark)</b> | <b>Satisfactory<br/>(0.25 – 0.50 mark)</b> | <b>Good<br/>(0.75 mark)</b> | <b>Excellent<br/>(1 mark)</b> |
|--|--|--|-----------------------------|-------------------------------|
| Behavior                                 |  |  |                             |                               |
| Performs in a dependable Manner          |  |  |                             |                               |
| Cooperates with coworkers and supervisor |  |  |                             |                               |
| Shows interest in work                   |  |  |                             |                               |
| Learns quickly                           |  |  |                             |                               |
| Shows initiative                         |  |  |                             |                               |
| Produces high quality work               |  |  |                             |                               |
| Accepts responsibility                   |  |  |                             |                               |
| Accepts criticism                        |  |  |                             |                               |
| Demonstrates organizational skills       |  |  |                             |                               |
| Uses technical knowledge and expertise   |  |  |                             |                               |

|                                     |  |  |  |  |
|-------------------------------------|--|--|--|--|
| Shows good judgment                 |  |  |  |  |
| Demonstrates creativity/originality |  |  |  |  |
| Analyzes problems effectively       |  |  |  |  |
| Is self-reliant                     |  |  |  |  |
| Communicates well                   |  |  |  |  |
| Writes effectively                  |  |  |  |  |
| Has a professional attitude         |  |  |  |  |
| Gives a professional appearance     |  |  |  |  |
| Is punctual                         |  |  |  |  |
| Uses time effectively               |  |  |  |  |

Overall performance of student

Intern (Tick one) : Needs improvement (0 - 0.50 mark) /  
Satisfactory (0.50 – 1.0 mark) / Good  
(1.5 mark) / Excellent (2.0 mark)

Additional comments, if any (2 marks) :

*Signature of Industry Supervisor*

*Signature of Section Head/HR Manager Office Seal*

**End Semester Evaluation (External Evaluation) : 50 Marks**  
Internship Report - 25 Marks  
Viva Voce - 25 Marks

**Internship Report:** After completion of the internship, the student should prepare a comprehensive report to indicate what he has observed and learnt in the training period and should be submitted to the faculty mentor. The student may contact Industrial Supervisor/ Faculty Mentor for assigning special topics and problems and should prepare the final report on the assigned topics. Daily diary will also help to a great extent in writing the industrial report since much of the information has already been incorporated by the student into the daily diary. The training report should be signed by the Internship Supervisor, Programme Coordinator and Faculty Mentor.

The Internship report (25 Marks) will be evaluated on the basis of following criteria:

- Originality
- Adequacy and purposeful write-up
- Organization, format, drawings, sketches, style, language etc.
- Variety and relevance of learning experience
- Practical applications, relationships with basic theory and concepts taught in the course

Viva Voce (25 Marks) will be done by a committee comprising Faculty Mentor, PG Programme Coordinator and an external expert (from Industry or research/academic Institute). This committee will be evaluating the internship report also.

#### **(v) LABORATORY COURSES**

Lab work and Viva-voce : 60 marks

Final evaluation Test and Viva voce : 40 marks

The laboratory courses will be having only Continuous Internal Evaluation and carries 100 marks. Final evaluation shall be done by two examiners; one examiner will be a senior faculty from the same department.

#### **(vi) INDUSTRY INTEGRATED COURSE**

Engineering students frequently aspire to work in areas and domains that are key topics in the industry. There are concerns by recruiters that skill sets of engineering students did not match with the Industry requirements, especially in the field of latest topics. In response to their desires, the College has incorporated Industry integrated course in the curriculum.

The evaluation pattern for Industry based courses is as follows:

**Continuous Internal Evaluation : 40 marks**

Seminar : 10 marks

Course based task/Seminar/Data collection  
and interpretation/Case study : 10 marks

|                                      |   |                 |
|--------------------------------------|---|-----------------|
| Test paper 1 (Module 1 and Module 2) | : | 10 marks        |
| Test paper 2 (Module 3 and Module 4) | : | 10 marks        |
| <b>End Semester Examination</b>      | : | <b>60 marks</b> |

The examination will be conducted by the College with the question paper provided by the Industry. The examination will be for 3 Hrs and will contain 7 questions, with minimum one question from each module of which student should answer any five. Each question can carry 12 marks. The valuation of the answer scripts shall be done by the expert in the Industry handling the course.

#### **(vii) MOOC COURSES**

The MOOC course shall be considered only if it is conducted by the agencies namely AICTE/NPTEL/SWAYAM or NITTTR. The MOOC course should have a minimum duration of 8 weeks and the content of the syllabus shall be enough for at least 40 hours of teaching. The course should have a proctored/offline end semester examination. The students can do the MOOC course according to their convenience, but shall complete it before the end of fourth semester. The list of MOOC courses will be provided by the concerned BoS if at least 70% of the course content match with the area/stream of study. The course shall not be considered if its content has more than 50% of overlap with a core/elective course in the concerned discipline.

MOOC Course to be successfully completed before the end of fourth semester (starting from semester 1) A credit of 2 will be awarded to all students whoever successfully completes the MOOC course as per the evaluation pattern of the respective agency conducting the MOOC course.

#### **(viii) MINIPROJECT**

**Total marks: 100, only CIE**

Mini project can help to strengthen the understanding of student's fundamentals through application of theoretical concepts and to boost their skills and widen the horizon of their thinking. The ultimate aim of an engineering student is to resolve a problem by applying theoretical knowledge. Doing more projects increases problem-solving skills. The introduction of mini projects ensures preparedness of students to undertake dissertation. Students should identify a topic of interest in consultation with

Faculty mentor. Demonstrate the novelty of the project through the results and outputs. The progress of the mini project is evaluated based on three reviews, two interim reviews and a final review. A report is required at the end of the semester.

Interim evaluation: 40 (20 marks for each review), final evaluation by a Committee (will be evaluating the level of completion and demonstration of functionality/specifications, clarity of presentation, oral examination, work knowledge and involvement): 35, Report (the committee will be evaluating for the technical content, adequacy of references, templates followed and permitted plagiarism level is not more than 25%): 15, Supervisor/Guide: 10

#### **(ix) DISSERTATION**

**Dissertation:** All Students should carry out the dissertation in the college or can work either in any CSIR/Industrial R&D organization/any other reputed Institute which have facilities for dissertation work in the area proposed.

**Dissertation outside the Institute:** For doing dissertation outside the Institution, the following conditions are to be met:

- They have completed successfully the course work prescribed in the approved curriculum up to the second semester.
- They should choose Track 2 in semester 3 and 4
- The student has to get prior approval from the DLAC and CLAC.
- Facilities required for doing the dissertation shall be available in the Organization/Industry (A certificate stating the facilities available in the proposed organization and the time period for which the facilities shall be made available to the student, issued by a competent authority from the Organization/Industry shall be submitted by the student along with the application).
- They should have an external as well as an internal supervisor. The internal supervisor should belong to the parent institution and the external supervisor should be Scientists or Engineers from the Institution/Industry/ R&D organization with which the student is associated for doing the dissertation work. The external supervisor shall be with a minimum post graduate degree in the related area.

- The student has to furnish his /her monthly progress as well as attendance report signed by the external guide and submit the same to the concerned Internal guide.
- The external guide is to be preferably present during all the stages of evaluation of the dissertation.

Note1- Students availing this facility should continue as regular students of the College itself.

Note 2-The course work in the 3rd semester is to be completed as per the curriculum requirements (i) MOOC can be completed as per the norms mentioned earlier

**Internship leading to Dissertation:** The M. Tech students who after completion 16 weeks internship at some reputed organization are allowed to continue their work as dissertation for the third and fourth semester after getting approval from the DLAC. Such students shall make a brief presentation regarding the work they propose to carry out before the DLAC for a detailed scrutiny and to resolve its suitability for accepting it as an M.Tech dissertation. These students will be continuing as regular students of the Institute in third semester for carrying out all academic requirements as per the curriculum/regulation. However, they will be permitted to complete their dissertation in the Industry/Organization (where they have successfully completed their internship) during fourth semester.

**Dissertation as part of Employment:** Students may be permitted to discontinue the programme and take up a job provided they have completed all the courses till second semester (FE status students are not permitted) prescribed in the approved curriculum. The dissertation work can be done during a later period either in the organization where they work if it has R & D facility, or in the Institute. Such students should submit application with details (copy of employment offer, plan of completion of their project etc.) to the Dean (PG) through HoD. The application shall be vetted by CLAC before granting the approval. When the students are planning to do the dissertation work in the organization with R & D facility where they are employed, they shall submit a separate application having following details:

- Name of R&D Organization/Industry
- Name and designation of an external supervisor from the proposed Organization/Industry (Scientists or Engineers with a minimum post graduate degree in the related area) and his/her profile with consent
- Name and designation of a faculty member of the Institute as internal supervisor with his/her consent
- Letter from the competent authority from the Organization/Industry granting permission to do the dissertation
- Details of the proposed work
- Work plan of completion of project

DLAC will scrutinize the proposal and forward to CLAC for approval.

When students are doing dissertation work along with the in job in the organization (with R & D facility) where they are employed, the dissertation work shall be completed in four semesters normally (two semesters of dissertation work along with the job may be considered as equivalent to one semester of dissertation work at the Institute). Extensions may be granted based on requests from the student and recommendation of the supervisors such that he/she will complete the M. Tech programme within four years from the date of admission as per the regulation. Method of evaluation and grading of the dissertation will be the same as in the case of regular students. The course work in the 3rd semester for such students are to be completed as per the curriculum requirements MOOC courses can be completed as per the norms mentioned earlier. However, for self-learning students, all evaluations shall be carried out in their parent Institution as in the case of regular students.

### **Mark Distribution:**

**Phase 1: Total marks: 100, only CIE**

**Phase 2: Total marks: 200, CIE = 100 and ESE = 100 marks**

- Maximum grade (S grade) for the dissertation phase II will be awarded preferably if the student publishes the dissertation work in a peer reviewed journal.
- Final Evaluation (ESE) should be done by a three-member committee comprising of the Department Project coordinator, Guide and an External expert. The external expert shall be an academician or from industry.

## **(x)TEACHING ASSISTANCESHIP (TA)**

All M.Tech students irrespective of their category of admission, shall undertake TA duties for a minimum duration as per the curriculum. Being a TA, the student will get an excellent opportunity to improve their expertise in the technical content of the course, enhance communication skills, obtain a hands-on experience in handling the experiments in the laboratory and improve peer interactions.

The possible TA responsibilities include the following: facilitate a discussion section or tutorial for a theory/ course, facilitate to assist the students for a laboratory course, serve as a mentor for students, and act as the course web-master. TAs may be required to attend the instructor's lecture regularly. A TA shall not be employed as a substitute instructor, where the effect is to relieve the instructor of his or her teaching responsibilities.

### **For the tutorial session:**

- (i) Meet the teacher and understand your responsibilities well in advance, attend the lectures of the course for which you are a tutor, work out the solutions for all the tutorial problems yourself, approach the teacher if you find any discrepancy or if you need help in solving the tutorial problems, use reference text books, be innovative and express everything in English only.
- (ii) Try to lead the students to the correct solutions by providing appropriate hints rather than solving the entire problem yourself, encourage questions from the students, lead the group to a discussion based on their questions, plan to ask them some questions be friendly and open with the students, simultaneously being firm with them.
- (iii) Keep track of the progress of each student in your group, give a periodic feedback to the student about his/her progress, issue warnings if the student is consistently underperforming, report to the faculty if you find that a particular student is consistently underperforming, pay special attention to slow-learners and be open to the feedback and comments from the students and faculty.
- (iv) After the tutorial session you may be required to grade the tutorials/assignments/tests. Make sure that you work out the solutions to the questions yourself, and compare it with the answer key, think and work out possible alternate solutions to the same question, understand the marking scheme from the teacher. Consult the teacher and

make sure that you are not partial to some student/students while grading. Follow basic ethics.

### **Handling a laboratory Session:**

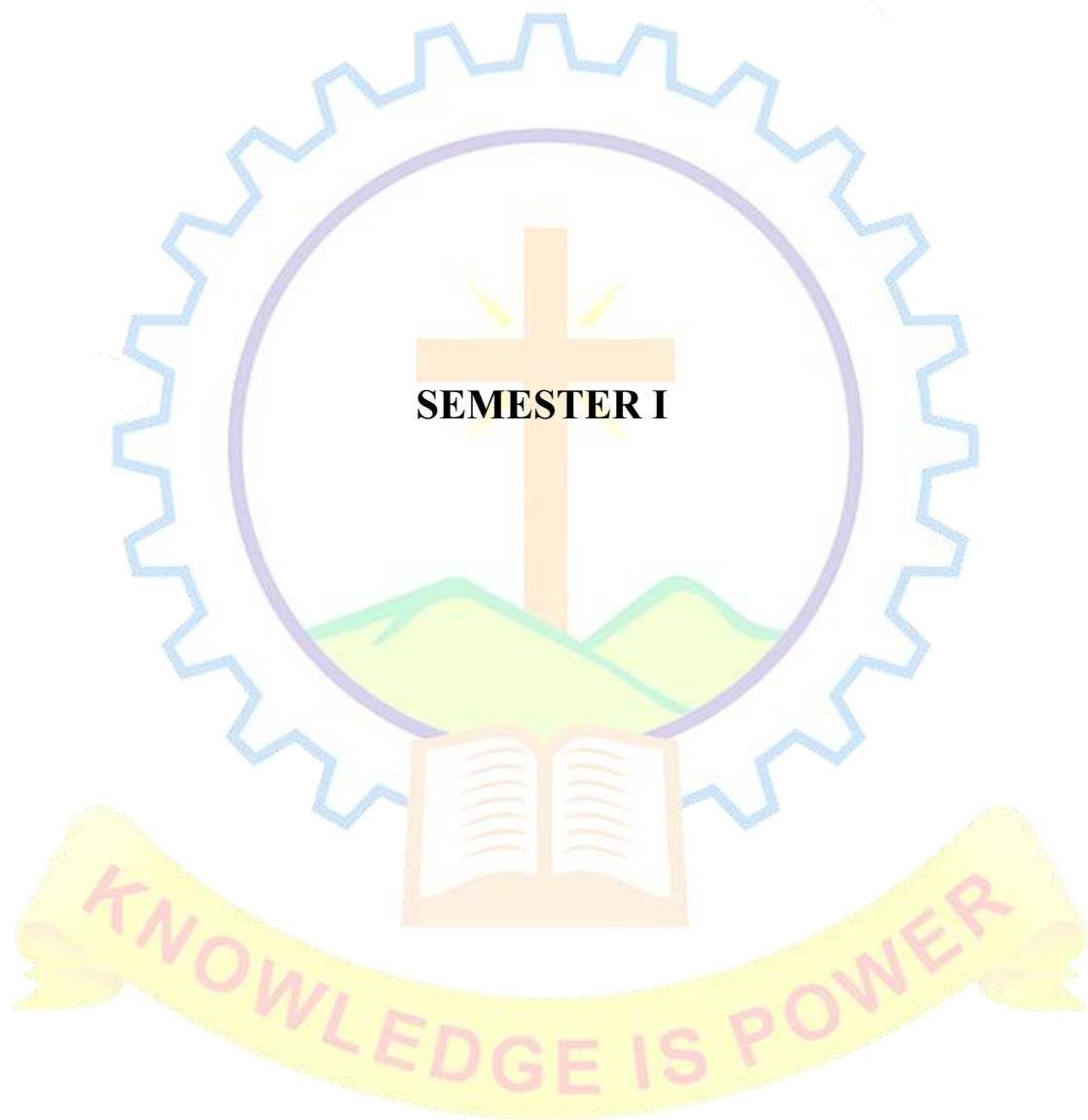
- (i) Meet the faculty – in- charge a few days in advance of the actual lab class and get the details of the experiment, get clarifications from him/her regarding all aspects of the experiment and the expectations, prepare by reading about the theoretical background of the experiment, know the physical concepts involved in the experiment, go to the laboratory and check out the condition of the equipment/instrumentation, perform the laboratory experiment at least once one or two days before the actual laboratory class, familiarize with safety/ security aspects of the experiment / equipment/laboratory, prepare an instruction sheet for the experiment in consultation with the faculty, and keep sufficient copies ready for distribution to students for their reference.
- (ii) Verify condition of the equipment/set up about 30 minutes before the students arrive in the class and be ready with the hand outs, make brief introductory remarks about the experiment, its importance, its relevance to the theory they have studied in the class, ask the students suitable questions to know their level of preparation for the experiment, discuss how to interpret results, ask them comment on the results.
- (iii) Correct/evaluate/grade the submitted reports after receiving suitable instructions from the faculty in charge, continue to interact with students if they have any clarifications regarding any aspect of the laboratory session, including of course grading, Carefully observe instrument and human safety in laboratory class, Preparing simple questions for short oral quizzing during explanation of experiments enables active participation of students, facilitate attention, provides feedback and formative evaluation.

### **POINTS TO REMEMBER**

1. Arrange an awareness programme to all M.Tech students on day 1 regarding the curriculum and the regulation.
2. The departments should prepare the list of MOOC courses suitable to their programmes and encourage the students to complete at the earliest.
3. Make a tie up with industries by the middle of semester for Industry Integrated Course. While choosing the course, it should be ensured that the programme is relevant and updated in that discipline. The Industry expert handling the course shall be a postgraduate degree holder. The evaluation procedure shall also be clearly explained to

them.

4. Each department offering M.Tech programme should be careful in selecting the mini project in semester 2.
5. The departments should invite the Industries/research organizations during first semester and inform them about the mandatory 6-8 weeks internship that the students should undergo after their second semester. The possibility of doing their dissertation at the Industry shall also be explored. They should also be made aware about the evaluation procedure of the Internships. They may also be informed that it is possible to continue internship provided if it leads to their dissertation. Proposals may be collected from them for allotting to students according to their fields of interest.
6. Make sure that all internal evaluations and the end semester examinations to be conducted by the college are carried out as per the evaluation procedure listed in the curriculum. Any dilution from the prescribed procedure shall be viewed seriously.
7. Teaching assistance shall be assigned to all students as per the curriculum. However, a TA shall not be employed as a substitute instructor, where the effect is to relieve the instructor of his or her teaching responsibilities.
8. The possible TA responsibilities include the following: facilitate a discussion section or tutorial for a theory/ course, facilitate to assist the students for a laboratory course, serve as a mentor for students, and act as the course web-master.



| CODE       | COURSE NAME                                 | CATEGORY | L | T | P | S | CREDIT |
|------------|---|----------|---|---|---|---|--------|
| M24CE1T101 | NUMERICAL METHODS IN STRUCTURAL ENGINEERING | CORE     | 4 | 0 | 0 | 4 | 4      |

Preamble: The course provides a comprehensive understanding of diverse numerical techniques applicable in civil engineering across different domains. Special focus is given to optimization problems, explaining its significance, versatility and fundamental concepts relevant to civil engineering scenarios.

**Prerequisite** : Calculus and Linear Algebra

**Course Outcomes** : After the completion of the course the student will be able to

|      |   |
|------|---|
| CO 1 | Solve both linear and non-linear systems of equations simultaneously. <b>(Cognitive knowledge level: Apply)</b>   |
| CO 2 | Apply solution technique in structural engineering problems. <b>(Cognitive knowledge level: Analyse)</b>  |
| CO 3 | Evaluate numerical solutions for ordinary differential equations and their application in structural engineering. <b>(Cognitive knowledge level: Analyse)</b> |
| CO 4 | Comprehend various optimization algorithms and tools to tackle problem-solving tasks. <b>(Cognitive knowledge level: Evaluate)</b>                            |
| CO 5 | Develop problem formulations and apply appropriate techniques to solve them. <b>(Cognitive knowledge level: Evaluate)</b>                                     |

#### Mapping of course outcomes with program outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
|------|------|------|------|------|------|------|
| CO 1 | 1    | 1    | 1    | 2    | 2    | 2    |
| CO 2 | 1    | 1    | 1    | 2    | 2    | 2    |
| CO 3 | 1    | 1    | 1    | 2    | 2    | 2    |
| CO 4 | 1    | 1    | 2    | 2    | 2    | 2    |
| CO 5 | 1    | 1    | 2    | 2    | 2    | 2    |

**Assessment Pattern**

| Course Name      | NUMERICAL METHODS IN STRUCTURAL ENGINEERING |                  |                                    |
|------------------|---|------------------|------------------------------------|
| Bloom's Category | Continuous Assessment Tests                 |                  | End Semester Examination (% Marks) |
|                  | Test 1 (% Marks)                            | Test 2 (% Marks) |                                    |
| Remember         |   |                  |                                    |
| Understand       | 10  | 10               | 10                                 |
| Apply            | 50  | 50               | 50                                 |
| Analyse          | 30  | 30               | 30                                 |
| Evaluate         | 10  | 10               | 10                                 |
| Create           |   |                  |                                    |

**Mark distribution**

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 100         | 40        | 60        | 3 Hours      |

|   |   |          |
|---|---|----------|
| <b>Continuous Internal Evaluation Pattern</b> | : |          |
| Micro project/Course based project            | : | 10 marks |
| Course based task/Seminar/Quiz                | : | 10 marks |
| Test paper 1 (Module 1 and Module 2)          | : | 10 marks |
| Test paper 2 (Module 3 and Module 4)          | : | 10 marks |

**End Semester Examination Pattern:** The end semester examination will be conducted by the college. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 4 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 8 marks. Total duration of the examination will be 3 Hrs.

## SYLLABUS

### MODULE 1 (11 hours)

Solution of Linear and Non-linear equations: - Linear system of equations, Gaussian Elimination, Numerical examples. Nonlinear system of equations: Newton-Raphson's method for single and multiples variables, limitations. Modified Newton-Raphson's methods, Numerical examples.

Solution Techniques for Eigenvalue Problems: - Eigenvalue problems in structural engineering, Solution by characteristics polynomial, Numerical examples.

### MODULE 2 (11 hours)

Numerical Integration:- Newmark's Method: Equivalent Loads, Newmark's Procedure, Application of Newmark's method for the slope and deflection of beams (Simply supported, Cantilever and Overhanging) having uniform and varying flexural rigidity with different loading cases (Concentrated, Uniformly distributed and uniformly varying). Slope and deflection of propped cantilevers and fixed beams having uniform flexural rigidity with uniformly distributed loads.

### MODULE 3 (11 hours)

Finite Difference Technique for Ordinary Differential Equations and its Applications in Structural Engineering: - Forward, Backward and central difference. Initial and boundary value problems.

Application of finite difference method for statically determinate beam problems: Calculation of bending moment and deflection of beams (simply supported and cantilever) having uniform and varying flexural rigidity subjected to loads (concentrated and uniformly distributed).

Application of finite difference method for statically indeterminate beam problems: Calculation of bending moment and deflection of beams (propped cantilevers and fixed) having uniform and varying flexural rigidity subjected to loads (concentrated and uniformly distributed).

### MODULE 4 (6 hours)

Introduction to optimization-Definitions, classification. Single variable optimization algorithms – optimality criteria, bracketing methods, region elimination methods, gradient based methods. Root finding using optimization techniques. Unconstrained optimization algorithm - Multivariable optimization algorithms – optimality criteria, direct search methods, gradient search methods.

### MODULE 5 (6 hours)

Constrained optimization algorithms - Multivariable Optimization-Lagrange Multipliers - Kuhn-Tucker Conditions- Introduction to Genetic algorithms. Application of GAs in structural optimization- Particle Swarm Optimization -Problems

**References**

1. Gupta,S.K. “Numerical Methods for Engineers”. Wiley Eastern, New Delhi, 1995.
2. Singiresu S. Rao, “Engineering Optimization: Theory and Practice”, Willey, 5th edition. 2019.
3. K. K. Jain, S. R. K Iyengar and R. K. Jain, “Numerical Methods - Problem and Solutions”, Wiley India Pvt. Ltd, 2001.
4. Rajasekaran S., “Numerical Methods in Science and Engineering, A practical approach”, A H Wheeler & Co., first edition, 2003.
5. Krishna Raju N. and Muthu K.U, “Numerical Methods for Engineering Problems”, Macmillan India Limited, first edition, 1990.
6. J. H. Mathews and K.D. Fink, “Numerical Methods using MATLAB”, Pearson Education,2004.
7. Kalyanmay Deb, “Optimization of Engineering Design: Algorithms and Examples”, PHI Learning, second edition, 2012.

**COURSE CONTENTS AND LECTURE SCHEDULE**

| No              | Topic   | No. of Lecture/<br>Tutorial hours |
|-----------------|---|-----------------------------------|
| <b>Module 1</b> |   | <b>11</b>                         |
| 1.1             | Solution of Linear and Non-linear equations:- Linear system of equations  | 1                                 |
| 1.2             | Gaussian Elimination, Numerical examples.   | 2                                 |
| 1.3             | Nonlinear system of equations: Newton-Raphson’s method for single and multiples variables, Limitations.   | 2                                 |
| 1.4             | Modified Newton-Raphson's methods, Numerical examples.  | 3                                 |
| 1.5             | Solution Techniques for Eigenvalue Problems:- Eigenvalue problems in structural engineering, Solution by characteristics polynomial, Numerical examples.                              | 3                                 |
| <b>Module 2</b> |   | <b>11</b>                         |
| 2.1             | Newmark’s Method: Equivalent Loads, Newmark’s Procedure   | 1                                 |
| 2.2             | Slope and deflection of simply supported beams having uniform and varying flexural rigidity with different loading cases (Concentrated, Uniformly distributed and uniformly varying). | 2                                 |
| 2.3             | Slope and deflection of cantilever beams having uniform and varying flexural rigidity with different loading cases (Concentrated, uniformly distributed and uniformly varying).       | 2                                 |
| 2.4             | Slope and deflection of Overhanging beams having uniform and  | 2                                 |

M Tech in Computer Aided Structural Engineering

|     |   |           |
|-----|---|-----------|
|     | varying flexural rigidity with different loading cases (Concentrated, Uniformly distributed and uniformly varying).   |           |
| 2.5 | Slope and deflection of propped cantilevers having uniform flexural rigidity with uniformly distributed loads.  | 2         |
| 2.6 | Slope and deflection of fixed beams having uniform flexural rigidity with uniformly distributed loads.  | 2         |
|     | <b>Module 3</b>   | <b>11</b> |
| 3.1 | Finite Difference Technique Forward, Backward and central difference  | 2         |
| 3.2 | Initial and boundary value problems   | 1         |
| 3.3 | Application of finite difference method for statically determinate beam problems: Calculation of bending moment and deflection of beams (simply supported and cantilever) having uniform and varying flexural rigidity subjected to loads (concentrated, uniformly distributed).    | 4         |
| 3.4 | Application of finite difference method for statically indeterminate beam problems: Calculation of bending moment and deflection of beams (propped cantilevers and fixed) having uniform and varying flexural rigidity subjected to loads (concentrated and uniformly distributed). | 4         |
|     | <b>Module 4</b>   | <b>6</b>  |
| 4.1 | Introduction to optimization-Definitions, classification.   | 1         |
| 4.2 | Single variable optimization algorithms- optimality criteria  | 1         |
| 4.3 | Bracketing methods, region elimination methods, gradient-based methods  | 1         |
| 4.4 | Root finding using optimization techniques  | 1         |
| 4.5 | Multivariable optimization algorithms – optimality criteria   | 1         |
| 4.6 | Direct search methods, gradient search methods  | 1         |
|     | <b>Module 5</b>   | <b>6</b>  |
| 5.1 | Constrained optimization algorithms Multivariable Optimization  | 1         |
| 5.2 | Lagrange Multipliers - Kuhn-Tucker Conditions   | 2         |
| 5.3 | Introduction to Genetic Algorithms- Application of GAs in Structural Optimization   | 1         |
| 5.4 | Particle Swarm Optimization   | 2         |

**Model Question Paper**

**QP CODE:**

Pages: 2

Reg. No.: \_\_\_\_\_

Name: \_\_\_\_\_

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM  
FIRST SEMESTER M.TECH DEGREE EXAMINATION, DECEMBER 2024**

**Course Code: M24CE1T101**

**Course Name: NUMERICAL METHODS IN STRUCTURAL ENGINEERING**

Max. Marks:60

Duration: 3 hours

**PART A**

**Answer all questions. Each question carries 4 marks.**

1. Determine the roots of the following pairs of simultaneous non-linear equations by modified N-R method

$$x^2 - 2y^2 + 4.82 = 0$$

$$2x + 4y^2 - 16.74 = 0$$

Starting value may be assumed as  $x_0 = 1.30$  and  $y_0 = 1.70$

2. A cantilever of length L and uniform flexural rigidity EI supports a uniformly distributed load of intensity w kN/m over its entire span length. Evaluate the maximum slope and deflection at the free end using Newmark's method.
3. The boundary value problem governing the deflection of a beam of length 3m is given by

$$\frac{d^4 y}{dx^4} + 2y = \frac{1}{9}x^2 + \frac{2}{3}x + 4, y(0) = y'(0) = y(3) = y''(3) = 0$$

Determine the deflection at pivotal points  $x=1$  and  $x=2$ .

4. Find the points on the circle  $x^2 + y^2 = 100$  which are closest to and farthest from the point (1,2). Use the Lagrange Multiplier method
5. What is the significance of Particle Swarm Optimization in structural engineering

**PART B**

*Answer any five questions. Each question carries 8 marks.*

6. Solve the system of equations Gaussian Elimination

$$5x_1 + x_2 + x_3 = 10$$

$$x_1 + 5x_2 + 2x_3 = -20$$

$$x_1 + 2x_2 + 3x_3 = -40$$

7. A simply supported beam of length  $L$ , supports a uniformly distributed load of intensity  $w$  kN/m. Calculate the maximum moment and deflection in the beam. Assume  $EI$  as constant. Use a third order differential equation. Divide the beam into four equal parts with nodal points 0, 1, 2, 3, 4.
8. A propped cantilever  $AB$  fixed at  $A$  and propped at  $B$  is of length  $L$  and has constant flexural rigidity  $EI$ . The cantilever supports a udl of  $w$  kN/m over the whole length as shown in Fig. 1. Using 4 subintervals, estimate the deflection at pivotal points using 4<sup>th</sup> order differential equations.

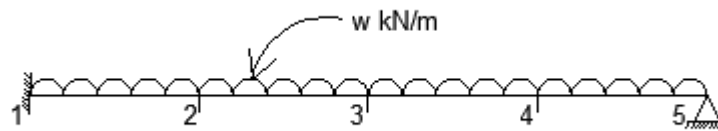


Fig.1

9. A simply supported beam of length " $L$ " span supports a uniformly distributed  $w$  kN/m over the mid  $1/3^{\text{rd}}$  span. Estimate the maximum deflection in the beam. Apply the finite difference method.
10. A propped cantilever  $AB$  fixed at  $A$  and propped at  $B$  is of length  $L$  and has a constant flexural rigidity. The cantilever supports a concentrated load of  $W$  kN at the centre of the left quarter span. Assuming four intervals, estimate the deflection under load.
11. A fully enclosed rectangular box is to be constructed from a sheet metal with a total area of  $10 \text{ m}^2$ . The goal is to maximize the volume of the box. The dimensions of the box are represented by length  $l$ , breadth  $b$ , and height  $h$  (all in meters).
- Convert this into a two variable unconstrained optimization problem in  $l$  and  $b$ .
  - Choose a suitable optimization technique to determine the optimal dimensions of the box. Take initial assumption as  $l=b=0.5\text{m}$
12. Enumerate the principle and operation of genetic algorithms? How it can be used for solving structural engineering problems.

| CODE       | COURSE NAME                         | CATEGORY | L | T | P | S | CREDIT |
|------------|-------------------------------------|----------|---|---|---|---|--------|
| M24CE1T102 | THEORY OF ELASTICITY AND PLASTICITY | CORE     | 4 | 0 | 0 | 4 | 4      |

**Preamble:** The course offers a strong foundation for analyzing and optimizing the behaviour of materials under various mechanical and environmental situations by combining theoretical precision with real-world application.

**Prerequisite** : Mechanics of Solids

**Course Outcomes** : After the completion of the course the student will be able to

|     |  |
|-----|--|
| CO1 | Interpret the relationships between forces, stress, strain, and deformations and their applications in structural elements. <b>(Cognitive knowledge level: Understand)</b>       |
| CO2 | Apply concepts of elasticity in plane stress and plane strain conditions to solve problems in engineering contexts <b>(Cognitive knowledge level: Apply)</b>                     |
| CO3 | Acquire a comprehensive understanding of axisymmetric problems, enabling them to analyze and evaluate complex engineering problems. <b>(Cognitive knowledge level: Evaluate)</b> |
| CO4 | Apply the concepts of torsion in different structural configurations. <b>(Cognitive knowledge level: Apply)</b>  |
| CO5 | Apply theoretical concepts to solve practical engineering problems related to material behaviour and failure prediction. <b>(Cognitive knowledge level: Apply)</b>               |

#### Mapping of course outcomes with program outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
|------|------|------|------|------|------|------|
| CO 1 | 1    | 1    | 1    | 1    | 2    | 2    |
| CO 2 | 1    | 1    | 2    | 2    | 1    | 2    |
| CO 3 | 1    | 1    | 2    | 1    | 1    | 2    |
| CO 4 | 1    | 1    | 2    | 2    | 2    | 2    |
| CO 5 | 1    | 1    | 2    | 2    | 2    | 2    |

**Assessment Pattern**

| Course Name      | Theory of Elasticity & Plasticity |                  |                                    |
|------------------|-----------------------------------|------------------|------------------------------------|
| Bloom's Category | Continuous Assessment Tests       |                  | End Semester Examination (% Marks) |
|                  | Test 1 (% Marks)                  | Test 2 (% Marks) |                                    |
| Remember         |                                   |                  |                                    |
| Understand       | 10                                | 10               | 10                                 |
| Apply            | 50                                | 50               | 50                                 |
| Analyse          | 30                                | 30               | 30                                 |
| Evaluate         | 10                                | 10               | 10                                 |
| Create           |                                   |                  |                                    |

**Mark distribution**

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 100         | 40        | 60        | 3Hours       |

|   |   |          |
|---|---|----------|
| <b>Continuous Internal Evaluation Pattern</b> | : |          |
| Microproject/Course based project             | : | 10 marks |
| Course based task/Seminar/Quiz                | : | 10 marks |
| Test paper 1 (Module 1 and Module 2)          | : | 10 marks |
| Test paper 2 (Module 3 and Module 4)          | : | 10 marks |

**End Semester Examination Pattern:** The end semester examination will be conducted by the college. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 4 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 8 marks. Total duration of the examination will be 3 Hrs.

## SYLLABUS

### MODULE 1 (8 hours)

**Elasticity:** Forces acting on a body – stress, strain and deformations- relationships between stress and strain in Three Dimensions- Equilibrium equations- Strain displacement relationships – Compatibility equations- Decomposition of deformation into symmetric and anti-symmetric parts- State of stress on an oblique plane – stress transformation – principal stresses and principal planes-Generalized Hooke's Law

### MODULE 2 (10 hours)

**Problems of Elasticity:** Plane stress and plane strain Problems. Analysis–transformation equations– stress–strain relations– equilibrium equations in Cartesian and polar co-ordinates Airy's stress function– Biharmonic Equilibrium–St Venant's principle–2D problems in Cartesian coordinate– cantilever with concentrated load at free end– Simply supported with UDL–Cantilever with moment at free end.

### MODULE 3 (9 hours)

**Axisymmetric problems:** Introduction - Definition and significance of axisymmetric problems. Overview of polar coordinates:  $r$ (radial),  $\theta$  (angular), and  $z$  (axial) components. Basic concepts of stress and strain in polar coordinates. General equations in polar co-ordinates–Stress distribution symmetric about an axis– Stress analysis of thick-walled and thin-walled cylinders.-Lame's equations and their applications-Cylinders subjected to internal pressure: applications in pressure vessels.

### MODULE 4 (9 hours)

**Torsion:** Introduction – St.Venant's approach- boundary conditions – Expression for torque- torsion of circular cross section- torsion of elliptical cross section- torsion of rectangular cross section. Membrane analogy – sand heap analogy - torsion of narrow rectangular strip- torsion of multi connected thin-walled sections.

### MODULE 5 (9 hours)

**Plasticity:** Introduction – idealized stress-strain behaviour – Elastic- perfectly plastic material-perfectly plastic material – linearly strain hardening material –strain hardening- nominal and true stress strain- Yielding criteria independent of hydrostatic pressure – Tresca's Failure Criteria – von Mises Hencky Failure Criteria.

**References**

1. Timoshenko S P and Goodier J. N, “Theory of Elasticity”, Tata Mcgraw Hill International Student Edition, third edition, 1970.
2. Johnson W and Mellor P. B, “Plasticity for mechanical engineers”, Van Company Ltd., first edition, 1973.
3. H. Jane Helena, “Theory of Elasticity and Plasticity”, Prentice Hal, first edition, 1980.
4. Sadhu Singh, “Theory of elasticity”, Khanna Publishers, Delhi, first edition 1970.
5. Srinath L. S, “Advanced mechanics of solids”, Tata McGraw– Hill Publishing Company Ltd., New Delhi, first edition 1973.
6. Sokolnikoff, “Mathematical Theory of Elasticity”,Mcgraw-hill Book Company New York and London, second edition 1956.
7. W.B. Lee,” Plasticity”Division of Applied Mathematics, Brown University, first edition, 1966.

**COURSE CONTENTS AND LECTURE SCHEDULE**

| No              | Topic  | No. of Lecture /Tutorial hours |
|-----------------|--|--------------------------------|
| <b>Module 1</b> |  | <b>8</b>                       |
| 1.1             | Forces acting on a body – stress, strain and deformations- relationships between stress and strain | 1                              |
| 1.2             | Equilibrium equations- Strain displacement relationships   | 1                              |
| 1.3             | Compatibility equations-Decomposition of deformation into symmetric and anti-symmetric parts       | 1                              |
| 1.4             | State of stress on an oblique plane  | 2                              |
| 1.5             | Stress transformation  | 1                              |
| 1.6             | Principal stresses and principal planes  | 1                              |
| 1.7             | Generalized Hooke’s Law  | 1                              |
| <b>Module 2</b> |  | <b>10</b>                      |
| 2.1             | Plane stress and plain strain problems   | 1                              |
| 2.2             | Analysis–transformation equations–stress–strain relations  | 1                              |
| 2.3             | Equilibrium equations in Cartesian and polar co-ordinates Airy’s stress function                   | 2                              |
| 2.4             | Biharmonic Equilibrium   | 1                              |
| 2.5             | St Venant’s principle  | 1                              |

M Tech in Computer Aided Structural Engineering

|                 |   |          |
|-----------------|---|----------|
| 2.6             | 2D problems in Cartesian coordinate–cantilever with concentrated load at free end | 2        |
| 2.7             | Simply supported with UDL   | 1        |
| 2.8             | Cantilever with moment at free end  | 1        |
| <b>Module 3</b> |   | <b>9</b> |
| 3.1             | Introduction-Definition and significance of axisymmetric problems                 | 1        |
| 3.2             | Overview of polar coordinates: radial,angular,axial components                    | 1        |
| 3.3             | Basic concepts of stress and strain in polar coordinates                          | 1        |
| 3.4             | Stress distribution symmetric about an axis                                       | 2        |
| 3.5             | Stress analysis of thick walled and thin walled cylinders                         | 1        |
| 3.6             | Lame’s equations and their applications   | 1        |
| 3.3             | Cylinder subjected to internal pressures  | 2        |
| <b>Module 4</b> |   | <b>9</b> |
| 4.1             | Introduction – St.Venant’s approach- boundary conditions                          | 1        |
| 4.2             | Expression for torque- torsion of circular cross section                          | 1        |
| 4.3             | Torsion of elliptical cross section   | 1        |
| 4.4             | Torsion of rectangular cross section  | 2        |
| 4.5             | Membrane analogy – sand heap analogy  | 2        |
| 4.6             | Torsion of narrow rectangular strip   | 1        |
| 4.7             | Torsion of muti connected thin-walled sections                                    | 1        |
| <b>Module 5</b> |   | <b>9</b> |
| 5.1             | Introduction – idealized stress-strain behaviour                                  | 1        |
| 5.2             | Elastic- perfectly plastic material-perfectly plastic material                    | 1        |
| 5.3             | Linearly strain hardening material –strain hardening                              | 1        |
| 5.4             | Nominal and true stress strain  | 1        |
| 5.5             | Yeilding criteria independent of hydrostatic pressure                             | 1        |
| 5.6             | Tresca’s Failure Criteria   | 2        |
| 5.7             | Von Mises Hencky Failure Criteria   | 2        |

**Model Question Paper**

**QP CODE:**

Pages:2

Reg. No.: \_\_\_\_\_

Name: \_\_\_\_\_

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM  
FIRST SEMESTER M. TECH DEGREE EXAMINATION, DECEMBER 2024**

*Course Code: M24CE1T102*

*Course Name: THEORY OF ELASTICITY AND PLASTICITY*

Max.Marks:60

Duration: 3 hours

**PARTA**

*Answer all questions. Each question carries 4 marks.*

1. Identify how compatibility equations are essential for analyzing deformations in structures.
2. Examine the difference between plane stress and plane strain problems in elasticity? Provide examples of situations where each type of problem would be applicable.
3. Develop axisymmetric problems in the context of elasticity analysis.
4. Illustrate the primary factors that influence torsional behavior in materials in the context of mechanics.
5. Examine the concept of Airy's stress function which can be used in solving two-dimensional elasticity problems.

**PART B**

*Answer any five questions. Each question carries 8 marks.*

6. a. Examine the concept of principal stresses and principal planes (2marks)  
b. Discuss the state of stress on an oblique plane. How can it be analyzed and resolved into principal stresses? (6 marks)
7. Investigate a cantilever beam with a moment applied at the free end. Apply two- dimensional elasticity analysis techniques to determine the stress distribution and deflection of the beam.
8. Consider a cylindrical pressure vessel subjected to external and internal pressures. Using axisymmetric analysis techniques, determine the stress distribution within the cylinder and discuss the implications for structural integrity.
9. Analyze the torsion of a narrow rectangular strip. What assumptions are made in the analysis,

and how do they simplify the problem?

10. a. Inspect how the behavior of elastic-perfectly plastic material differ from other idealizations. Conclude it with the help of its characteristics (3 marks)
- b. Compare and contrast Tresca's and von Mises-Hencky's failure criteria. What are the strengths and weaknesses of each criterion? (5 marks)
11. A tubular section having three cells as shown in the figure 1 is subjected to a torque of 113 kN-m. Determine the shear stresses developed in the walls of the section.

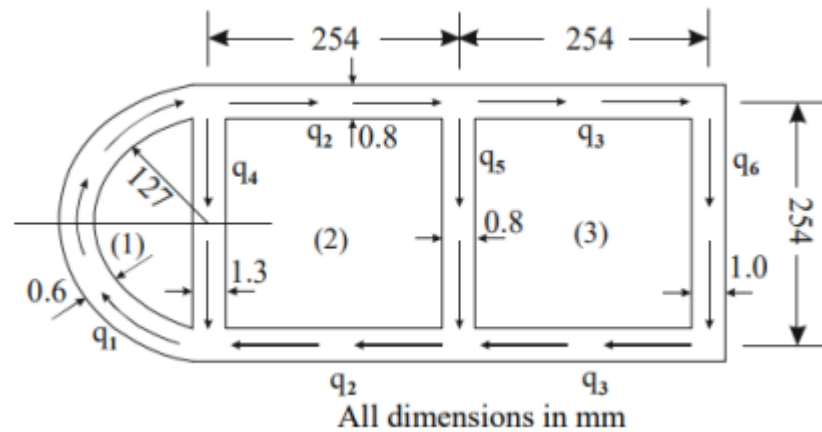


Fig:1

12. Provide examples or scenarios where the concepts of stress, strain, deformation, and their relationships are applied in real-world engineering or structural analysis problems.



| CODE       | COURSE NAME                     | CATEGORY | L | T | P | S | CREDIT |
|------------|---------------------------------|----------|---|---|---|---|--------|
| M24CE2T103 | ADVANCED ANALYSIS OF STRUCTURES | CORE     | 4 | 0 | 0 | 4 | 4      |

**Preamble:** The course explores the sophisticated methods and principles for analyzing complex structural systems. Students acquire knowledge in advanced techniques for evaluating structural components, stability, stiffness, and load-bearing capacities, equipping them with essential skills for tackling real-world engineering challenges.

**Prerequisite** : Mechanics of Solids, Structural Analysis

**Course Outcomes** : After the completion of the course the student will be able to

|     |  |
|-----|--|
| CO1 | Master the fundamentals of structural analysis and apply these concepts to classify and analyze structures. <b>(Cognitive Knowledge Level-Understand)</b>            |
| CO2 | Develop comprehensive skills in structural analysis using stiffness and direct stiffness methods. <b>(Cognitive Knowledge Level-Apply)</b>                           |
| CO3 | Analyse the rigid and pin-jointed beams, frames and trusses using the flexibility method. <b>(Cognitive Knowledge Level-Analyse)</b>                                 |
| CO4 | Analyze the effects of axial force on the flexural stiffness of braced and unbraced beam-columns under axial compression. <b>(Cognitive Knowledge Level-Analyse)</b> |
| CO5 | Evaluate the prismatic beam-columns using slope deflection method and stability functions. <b>(Cognitive Knowledge Level-Evaluate)</b>                               |

**Mapping of course outcomes with program outcomes:**

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
|------|------|------|------|------|------|------|
| CO 1 | 2    | 1    | 2    | 2    | 1    | 1    |
| CO 2 | 2    | 1    | 2    | 2    | 2    | 2    |
| CO 3 | 2    | 1    | 2    | 2    | 2    | 2    |
| CO 4 | 2    | 1    | 2    | 1    | 2    | 2    |
| CO 5 | 2    | 1    | 2    | 1    | 2    | 2    |

**Assessment Pattern:**

| Course Name      | Advanced Analysis of Structures |                  |                                   |
|------------------|---------------------------------|------------------|-----------------------------------|
| Bloom's Category | Continuous Evaluation Tests     |                  | End Semester Examination (%Marks) |
|                  | Test 1 (% Marks)                | Test 2 (% Marks) |                                   |
| Remember         | -                               | -                | -                                 |
| Understand       | 2                               | -                | 10                                |
| Apply            | 30                              | 40               | 30                                |
| Analyze          | 40                              | 40               | 40                                |
| Evaluate         | 10                              | 20               | 20                                |
| Create           | -                               | -                | -                                 |

**Mark distribution:**

| Total Marks | CIE marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 100         | 40        | 60        | 3 Hours      |

|   |   |          |
|---|---|----------|
| <b>Continuous Internal Evaluation Pattern</b> | : |          |
| Microproject/Course based project             | : | 10 marks |
| Course based task/Seminar/Quiz                | : | 10 marks |
| Test paper 1 (Module 1 and Module 2)          | : | 10 marks |
| Test paper 2 (Module 3 and Module 4)          | : | 10 marks |

**End Semester Examination Pattern:** The end semester examination will be conducted by the college. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 4 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 8 marks. Total duration of the examination will be 3 Hrs.

## SYLLABUS

### MODULE 1 (7 hours)

**Overview of fundamental principles in structural analysis:** Basic structural components, connections, and supports; Internal Hinge characteristics; Stability, stiffness, and static and kinematic indeterminacy; Types of loads; Equilibrium equations; Compatibility conditions; Force-displacement relationships; Classification of structures; Nodes and degrees of freedom; Coordinate systems; Boundary conditions; Direction cosines; Member Stiffness Matrix concept; Member Flexibility Matrix concept.

### MODULE 2 (10 hours)

#### Matrix Methods in Structural Analysis:

**Stiffness method:** Element stiffness matrix analysis of pin jointed frames (temperature effect, lack of fit), continuous beams (settlement of supports), rigid jointed frames and grids.

**Direct stiffness approach:** Structure stiffness matrix, assembly, equivalent joint load, incorporation of boundary conditions, solutions, Gauss elimination, analysis of pin jointed frames, continuous beams, and frames.

### MODULE 3 (9 hours)

**Flexibility method:** Element Flexibility matrix, truss element, beam element, force transformation matrix, analysis of pin jointed and rigid jointed structures (including support movements) analysis of plane grid.

### MODULE 4 (9 hours)

**Analysis of Elastic Instability:** Effects of axial force on flexural stiffness; Review of buckling of ideal columns, flexural behavior and stiffness measures for beam-columns - braced and unbraced, under axial compression.

### MODULE 5 (10 hours)

**Analysis of Prismatic Beam Columns and Second-Order Effects:** Slope deflection equations for prismatic beam columns using stability functions- modifications for pinned and guided-fixed-end conditions; fixed end moments in beam-columns. The stiffness matrix for prismatic beam-column element; estimation of critical elastic buckling loads; second-order analysis.

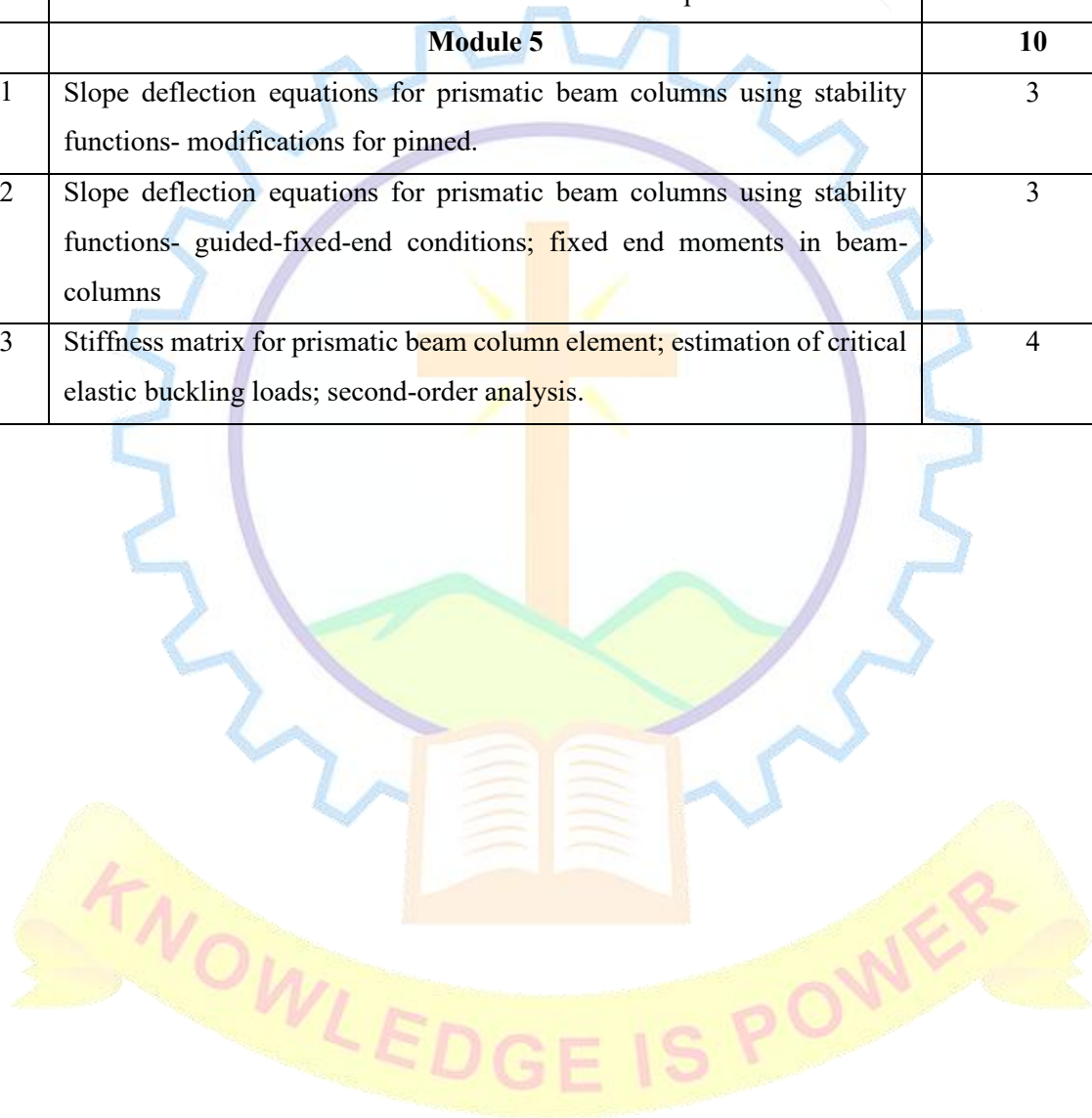
**References**

1. Devdas Menon, "Advanced Structural Analysis", Narosa Publishing House, 2009.
2. Devdas Menon, "Structural Analysis", Narosa Publishing House, 2008.
3. Basic Structural Analysis: Wilbur and Norris, first edition, 1971.
4. Basic Structural Analysis by C S Reddy, first edition, 2004.
5. Matrix Methods for structural engineering. by Gere, Weaver.
6. Structural Analysis by R.C. Hibbeler, 10th edition, 2016.
7. Advanced Structural Analysis by Praveen Nagarajan, first edition, 2010.

**COURSE CONTENTS AND LECTURE SCHEDULE**

| No  | Topic  | No. of Lecture/<br>Tutorial hours |
|-----|--|-----------------------------------|
|     | <b>Module 1</b>  | <b>7</b>                          |
| 1.1 | Basic structural components, connections, and supports; Internal Hinge characteristics; Stability, stiffness.  | 1                                 |
| 1.2 | Static and kinematic indeterminacy   | 1                                 |
| 1.3 | Types of loads; Equilibrium equations; Compatibility conditions; Force-displacement relationships;   | 1                                 |
| 1.4 | Classification of structures; Nodes and degrees of freedom; Coordinate systems; Boundary conditions; Direction cosines;  | 2                                 |
| 1.5 | Member Stiffness Matrix concept; Member Flexibility Matrix concept.  | 2                                 |
|     | <b>Module 2</b>  | <b>10</b>                         |
| 2.1 | Element stiffness matrix analysis of pin jointed frames (temperature effect, lack of fit). Element stiffness matrix analysis of continuous beams (settlement of supports)  | 3                                 |
| 2.2 | Element stiffness matrix analysis of rigid jointed frames and grids.   | 2                                 |
| 2.3 | Direct stiffness approach: Structure stiffness matrix, assembly, equivalent joint load, incorporation of boundary conditions, solutions, Gauss elimination. Direct stiffness approach: Analysis of pin jointed frames. | 3                                 |
| 2.4 | Direct stiffness approach: Analysis of continuous beams, and frames.   | 2                                 |
|     | <b>Module 3</b>  | <b>9</b>                          |
| 3.1 | Element Flexibility matrix, truss element, beam element, force transformation matrix.  | 3                                 |
| 3.2 | Analysis of pin jointed and rigid jointed structures (including support movements)   | 3                                 |
| 3.3 | Analysis of plane grid.  | 3                                 |

| <b>Module 4</b> |   | <b>9</b>  |
|-----------------|---|-----------|
| 4.1             | Analysis of Elastic Instability and Second –Order Effects: Effects of axial force on flexural stiffness.  | 3         |
| 4.2             | Review of buckling of ideal columns flexural behavior and stiffness measures for beam-columns unbraced under axial compression.                 | 3         |
| 4.3             | Review of buckling of ideal columns flexural behavior and stiffness measures for beam-columns – braced under axial compression.                 | 3         |
| <b>Module 5</b> |   | <b>10</b> |
| 5.1             | Slope deflection equations for prismatic beam columns using stability functions- modifications for pinned.                                      | 3         |
| 5.2             | Slope deflection equations for prismatic beam columns using stability functions- guided-fixed-end conditions; fixed end moments in beam-columns | 3         |
| 5.3             | Stiffness matrix for prismatic beam column element; estimation of critical elastic buckling loads; second-order analysis.                       | 4         |



**Model Question Paper**

**QP CODE :**

**Pages : 2**

**Reg No.:** .....

**Name:** .....

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM  
FIRST SEMESTER M.TECH DEGREE EXAMINATION, DECEMBER 2024**

**Course Code: M24CE2T103**

**Course Name: ADVANCED ANALYSIS OF STRUCTURES**

**Max. Marks:60**

**Duration: 3 hours**

**PART A**

**Answer all questions. Each question carries 4 marks.**

1. Compare and contrast pin-jointed frames and rigid frames, demonstrating understanding through examples.
2. Analyze the impact of lack of fit in pin-jointed truss analysis, applying knowledge of structural analysis principles to evaluate its effects on truss stability and member forces.
3. Apply the flexibility method to determine the deflection at the free end of a cantilever beam with a length of '2L' and a center point load.
4. Describe the concept of slope deflection equations for prismatic beam columns, highlighting the role of stability functions in their formulation and application.
5. Given a prismatic beam-column with length L, flexural rigidity EI, and axial load P, use the slope deflection equations to determine the moments at the ends of the beam-column for pinned and guided-fixed-end conditions.

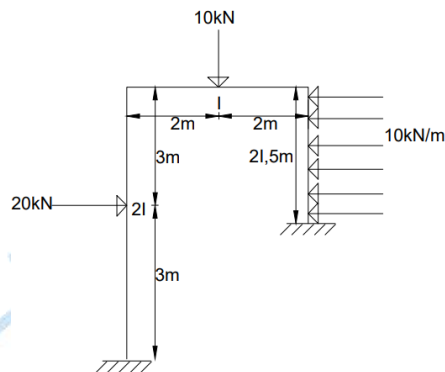
**PART B**

**Answer any five questions. Each question carries 8 marks.**

6. a. Elaborate how the member stiffness matrix concept is utilized in the analysis of complex structural systems. (4 Marks)

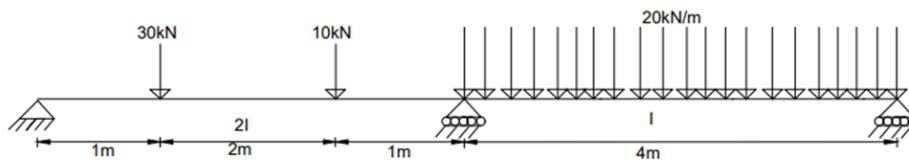
- b. Calculate the member stiffness matrix for a simple beam element, given its material properties and geometric characteristics. (4 Marks)

7. Analyze the structure using the element stiffness approach.

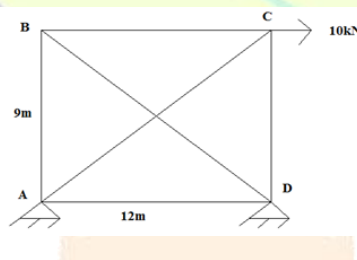


8. Illustrate the application of the flexibility matrix method in analyzing a real-world plane grid structure. What considerations need to be considered when using this method for practical structural analysis?

9. Analyze the continuous beam shown below using the direct stiffness method.



10. Analyze the truss using flexibility method.



11. a. Using the principles of second-order analysis, determine the critical buckling load for a column based on its length, material properties, and specified boundary conditions. (4 Marks)

- b. Analyze the impact of P-delta effects in second-order analysis on structural stability and design, demonstrating understanding through examples to illustrate how these effects influence the behavior of structures under various loading conditions. (4 Marks)

12. Derive the slope deflection equations for prismatic beam columns using stability functions, including modifications for pinned and guided-fixed-end conditions.

| CODE       | COURSE NAME                | CATEGORY | L | T | P | S | CREDIT |
|------------|----------------------------|----------|---|---|---|---|--------|
| M24CE1R106 | RESEARCH METHODOLOGY & IPR | THEORY   | 2 | 0 | 0 | 2 | 2      |

**Preamble:** The course covers strategies and methods essential for scientific research. Students will learn to write technical thesis, reports and research papers. Key topics include publication, patenting, and the importance of ethics in research.

**Prerequisite** : NIL

**Course Outcomes** : After the completion of the course the student will be able to

|      |  |
|------|--|
| CO 1 | Conduct extensive literature study to identify a research problem( <b>Cognitive Knowledge Level: Apply</b> )   |
| CO 2 | Design suitable methodological approach that suits the research and formulate methods for data collection ( <b>Cognitive Knowledge Level: Apply</b> )                    |
| CO 3 | Analyse data and interpret results implementing statistical methods ( <b>Cognitive Knowledge Level: Analyse</b> )  |
| CO 4 | Prepare well-structured technical presentations and technical reports ( <b>Cognitive Knowledge Level: Apply</b> )  |
| CO 5 | Adopt methodologies for ethical and effective publication of research outcomes and to acquire intellectual property rights ( <b>Cognitive Knowledge Level: Analyse</b> ) |

#### Mapping of course outcomes with program outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
|------|------|------|------|------|------|------|
| CO 1 | 1    | 1    | 1    | 2    | 1    | 1    |
| CO 2 | 1    | 2    | 2    | 1    | 1    | 1    |
| CO 3 | 2    | 2    | 2    | 1    | 1    | 1    |
| CO 4 | 2    | 2    | 2    | 1    | 1    | 1    |
| CO 5 | 2    | 2    | 2    | 2    | 2    | 1    |

**Assessment Pattern**

| Course Name      | Research Methodology & IPR  |                  |                                    |
|------------------|-----------------------------|------------------|------------------------------------|
| Bloom's Category | Continuous Evaluation Tests |                  | End Semester Examination (% Marks) |
|                  | Test 1 (% Marks)            | Test 2 (% Marks) |                                    |
| Remember         |                             |                  |                                    |
| Understand       |                             |                  |                                    |
| Apply            | 70                          | 70               | 70                                 |
| Analyse          | 30                          | 30               | 30                                 |
| Evaluate         |                             |                  |                                    |
| Create           |                             |                  |                                    |

**Mark distribution**

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 100         | 40        | 60        | 3 Hours      |

**Continuous Internal Evaluation Pattern** :

|  |   |          |
|--|---|----------|
| Preparing a review article based on peer reviewed Original publications in the relevant discipline (minimum 10 publications shall be referred) | : | 10 marks |
| Course based task/Seminar/Quiz   | : | 10 marks |
| Test paper 1 (Module 1 and Module 2)   | : | 10 marks |
| Test paper 2 (Module 3 and Module 4)   | : | 10 marks |

**End Semester Examination Pattern:** The end semester examination should be conducted by the college. The time duration will be for 3 Hrs and will contain 7 questions, with minimum one question from each module of which student should answer any five. Each question can carry 12 marks.

## SYLLABUS

### MODULE 1 (4 hours)

#### Introduction to Research & Literature Study:

Philosophy of research, Purpose of research, Research methodology, Research process-Problem identification and formulation, Frameworks in research, Literature review - Systematic Literature Review, Sources of Literature – Introduction to tools for Reference Management.

### MODULE 2 (5 hours)

#### Research Design and Data Collection:

Research Design - Types of research, Methods of data collection - Types of data- Primary & Secondary data- Scales of measurement- Instrument Design - Validity and Reliability.

### MODULE 3 (5 hours)

#### Sampling and Statistical Analysis

Sampling: Types of sampling distributions, Sampling error - Statistics in research: Descriptive statistics and inferential statistics, Hypothesis testing - multivariate analysis - Parametric and Nonparametric tests, Correlation and regression- Simple regression.

### MODULE 4 (5 hours)

#### Research Communication and Report Writing

Research Communication: Philosophy, Research Outlets - Reporting and presenting research - Written and oral communications, Scientific Writing: Paper title, abstract, graphical abstract and keywords, Introduction, Literature Review, Methods, Results, Findings, Discussion, Implication, Conclusion, Limitation, Future Studies, References, Bibliography, Annexure, Appendix, Tables and Figures, Citation, Reference styles, Introduction to tools for document preparation.

### MODULE 5 (5 hours)

#### Publication & IPR

Various forms of publication – Research paper, Conference publication, Technical note

Reviewing process – Submission, Revision, Acceptance

Research metrics - Journal level, Article level, Author level

Research Ethics: Scientific misconduct, Plagiarism, Falsification, Tools for Plagiarism check.

Intellectual property rights: Copyright - Patents - Industrial Design - Trademarks – Geographical Design,

**References**

1. Kothari, Chakravanti Rajagopalachari. Research methodology: Methods and techniques. New Age International, 2013.
2. Krishnaswamy, K. N., Appa Iyer Sivakumar, and M. Athirajan. Management research methodology: Integration of principles, methods and techniques. Pearson Education India, 2006.
3. Gupta, S.P. Statistical Methods, Sultan Chand, New Delhi, 46<sup>th</sup> Ed., 2021
4. Levin, R. I., and D. S. Rubin. "Statistics for Management Prentice-Hall." Inc., New Jersey, 1987.
5. Box, George EP, et al. Time series analysis: forecasting and control. John Wiley & Sons, 2015.
6. Jackson, Sherri L. "Research methods and statistics: A critical thinking approach." 2009.
7. Lebrun, Jean-Luc, and Justin Lebrun. Scientific writing 3.0: a reader and writer's guide. World Scientific, 2021.

**COURSE CONTENTS AND LECTURE SCHEDULE**

| No              | Topic  | No. of Lecture/<br>Tutorial hours |
|-----------------|--|-----------------------------------|
| <b>Module 1</b> |  | <b>4</b>                          |
| 1.1             | Philosophy of research, Purpose of research, Research methodology                | 1                                 |
| 1.2             | Research process, Problem identification and formulation, Frameworks in research | 1                                 |
| 1.3             | Literature review - Systematic Literature Review                                 | 1                                 |
| 1.4             | Sources of Literature - Reference Management Tools                               | 1                                 |
| <b>Module 2</b> |  | <b>5</b>                          |
| 2.1             | Research Design  | 1                                 |
| 2.2             | Types of research  | 1                                 |
| 2.3             | Methods of data collection - Types of data- Primary & Secondary data             | 1                                 |
| 2.4             | Scales of measurement  | 1                                 |
| 2.5             | Instrument Design - Validity and Reliability                                     | 1                                 |
| <b>Module 3</b> |  | <b>5</b>                          |
| 3.1             | Sampling: Types of sampling distributions, Sampling error                        | 1                                 |
| 3.2             | Statistics in research: Descriptive statistics and inferential statistics        | 1                                 |
| 3.3             | Hypothesis testing - multivariate analysis                                       | 1                                 |

M Tech in Computer Aided Structural Engineering

|                 |  |          |
|-----------------|--|----------|
| 3.4             | Parametric and Nonparametric tests, Correlation and regression-<br>Simple regression   | 2        |
| <b>Module 4</b> |  | <b>5</b> |
| 4.1             | Research Communication: Philosophy, Research Outlets -   | 1        |
| 4.2             | Reporting and presenting research - Written and oral<br>communications   | 1        |
| 4.3             | Scientific Writing: Paper title, abstract and keywords,<br>Introduction, Literature Review, Methods, Results, Findings,<br>Discussion, Implication, Conclusion, Limitation, Future Studies,<br>References, Bibliography, Annexure, Appendix, Tables and<br>Figures, Citation, Reference styles | 2        |
| 4.4             | Introduction to tools for document preparation   | 1        |
| <b>Module 5</b> |  | <b>5</b> |
| 5.1             | Relative importance of various forms of publication: Journal,<br>Conference, Technical note  | 1        |
| 5.2             | Reviewing process: Stages in the realization of a paper –<br>Submission, Revision, Acceptance  | 1        |
| 5.3             | Research metrics: Journal level, Article level and Author level  | 1        |
| 5.4             | Research Ethics: Scientific misconduct, Plagiarism, Falsification,<br>Tools for Plagiarism check.  | 1        |
| 5.5             | Intellectual property rights : Copyright - Patents - Industrial<br>Design - Trademarks - Geographical Design   | 1        |



**Model Question Paper**

**QP CODE:**

Pages: 1

Reg. No.: \_\_\_\_\_

Name: \_\_\_\_\_

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM  
FIRST SEMESTER M.TECH DEGREE EXAMINATION, DECEMBER 2024**

**Course Code: M24CE1R106**

**Course Name: RESEARCH METHODOLOGY & IPR**

Max. Marks:60

Duration: 3 hours

***Answer any five questions. Each question carries 12 marks.***

1. Analyse the different research types and identify the most appropriate type of research to address a contemporary challenge faced by either an organization or society. Provide justification for your selection.
2. How does conducting a comprehensive literature review and suitably identifying research gaps contribute to the success and relevance of the research process?
3. What guidelines apply to effectively formulate a research problem with social relevance? Discuss with an example.
4. "Students who eat breakfast will perform better on a mathematics examination than students who do not eat breakfast." Examine the type of hypothesis. Explain various types of hypotheses. What is the significance of formulating the hypothesis in research work?
5. Explain essential features of scientific report writing highlighting the importance and implication of research outcomes.
6. How can researchers assess and compare journals and authors in their respective fields by analyzing research matrices? Detail with significant examples.
7. Describe the procedure for filing for a patent. What are the benefits associated with the reception of a patent?



| CODE        | COURSE NAME          | CATEGORY | L | T | P | S | CREDIT |
|-------------|----------------------|----------|---|---|---|---|--------|
| M24CE1E104A | PRESTRESSED CONCRETE | ELECTIVE | 3 | 0 | 0 | 3 | 3      |

**Preamble:** The course equips students with the knowledge needed to design various types of prestressed concrete elements, including flexural, compression, and tension members. Composite member design broadens students' perspectives, highlighting the versatility of prestressed concrete.

**Prerequisite** : Structural Analysis, Reinforced Concrete Design

**Course Outcomes** : After the completion of the course the student will be able to

|      |  |
|------|--|
| CO 1 | Understand the basic aspects of prestressed concrete structures and compute the losses in prestressing. <b>(Cognitive knowledge level: Apply)</b>    |
| CO 2 | Analyze and design prestressed concrete structural members and sections subjected to flexure and shear <b>(Cognitive knowledge level: Analyze)</b>   |
| CO 3 | Analyze and design statically indeterminate prestressed concrete beams adopting suitable cable profiles. <b>(Cognitive knowledge level: Analyze)</b> |
| CO 4 | Analyze composite prestressed concrete structural members and sections subjected to flexure and shear. <b>(Cognitive knowledge level: Analyze)</b>   |
| CO 5 | Apply the concept of prestressing in various members <b>(Cognitive knowledge level: Apply)</b>   |

**Mapping of course outcomes with program outcomes:**

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
|------|------|------|------|------|------|------|
| CO 1 | 1    | 2    | 2    | 2    | 2    | 2    |
| CO 2 | 2    | 2    | 2    | 2    | 2    | 2    |
| CO 3 | 2    | 2    | 2    | 2    | 2    | 2    |
| CO 4 | 2    | 2    | 2    | 2    | 2    | 2    |
| CO 5 | 1    | 2    | 2    | 2    | 2    | 2    |

**Assessment Pattern:**

| Course name      | Prestressed concrete        |                  |                                    |
|------------------|-----------------------------|------------------|------------------------------------|
| Bloom's Category | Continuous Evaluation Tests |                  | End Semester Examination (% Marks) |
|                  | Test 1 is (% Marks)         | Test 2 (% Marks) |                                    |
| Remember         |                             |                  |                                    |
| Understand       | 10                          | 10               | 10                                 |
| Apply            | 30                          | 30               | 30                                 |
| Analyse          | 40                          | 40               | 40                                 |
| Evaluate         | 20                          | 20               | 20                                 |
| Create           |                             |                  |                                    |

**Mark distribution**

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 100         | 40        | 60        | 3 Hours      |

|  |   |          |
|--|---|----------|
| <b>Continuous Internal Evaluation Pattern</b>                                  | : |          |
| Seminar*   | : | 10 marks |
| Course based task/Micro Project//Data collection and interpretation/Case study | : | 10 marks |
| Test paper 1 (Module 1 and Module 2)   | : | 10 marks |
| Test paper 2 (Module 3 and Module 4)   | : | 10 marks |

\*Seminar should be conducted in addition to the theory hours. Topics for the seminar should be from recent technologies in the respective course

**End Semester Examination Pattern:** The end semester examination will be conducted by the college. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 4 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 8 marks. Total duration of the examination will be 3 Hrs.

## SYLLABUS

### MODULE 1 (8 hours)

Basic Concept of prestressing -Historical overview of prestressing–Advantages and disadvantages – Materials required – Systems and methods of prestressing

Analysis of sections: Stress concept – Strength concept – Load balancing concept

Effect of tendon profile on deflections – Factors influencing deflections – Calculation of deflections – Short term and long-term deflections (Concepts only) - Losses of prestress- Immediate losses and long term losses (Concept only).

### MODULE 2 (8 hours)

Basic assumptions of flexural design – Permissible stresses in steel and concrete as per I.S.1343 Code – Different types of sections - Design of sections- post-tensioned and pre tensioned beams – Check for flexural capacity based on I.S. 1343 Code – Influence of Layout of cables in post-tensioned beams – Location of wires in pre-tensioned beams – Design for shear based on I.S. 1343 Code.

Anchorage zone reinforcement- Design based on IS Code.

### MODULE 3 (7 hours)

Prestressed continuous beams: Classifications - Methods of achieving continuity- Analysis and design of continuous beams, Concept of linear transformations, concordant cable profile.

### MODULE 4 (7 hours)

Composite Sections: Types – advantages – applications- analysis of stresses for composite sections - Composite beams analysis and design of flexural and shear strength - differential Shrinkage  
Partial prestressing: its advantages and applications.

### MODULE 5 (6 hours)

Role of prestressing in members subjected to Tensile forces and compressive forces - Design of tension and compression members (Basic principles only) – Tanks, pipes and poles – Design of prestressed concrete slab (concepts only).

### References

1. Krishna Raju N., “Prestressed concrete”, 5th Edition, Tata McGraw Hill Company New Delhi, 2012
2. Pandit.G.S. and Gupta.S.P., “Prestressed Concrete”, CBS Publishers and Distributors Pvt. Ltd, 2012
3. Rajagopalan.N, “Prestressed Concrete”, Narosa Publishing House, 2002.

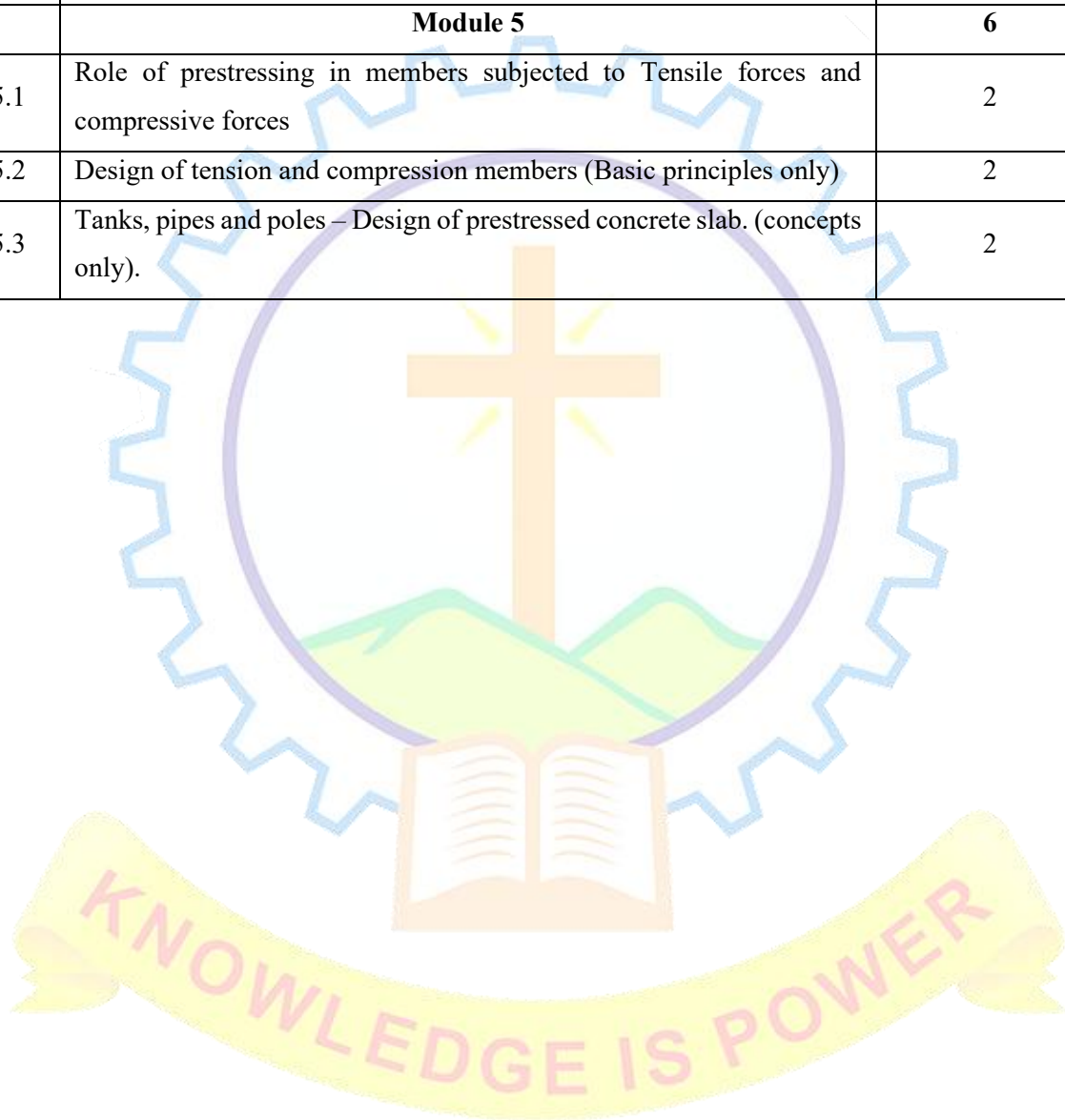
4. Nagarajan, P., Prestressed Concrete Design, Pearson 2013
5. IS 1343:2012, Code of Practice for Prestressed Concrete, Bureau of Indian Standards, New Delhi, 2012
6. IS 3370- Part 3 (1967) (Reaffirmed – 2008) Indian standard Code of practice for concrete structures for the storage of liquids, Bureau of Indian Standards, New Delhi, 2008
7. Lin T.Y. and Ned.H.Burns, “Design of prestressed Concrete Structures”, Third Edition, Wiley India Pvt. Ltd., New Delhi, 2013

### COURSE CONTENTS AND LECTURE SCHEDULE

| No              | Topic  | No. of Lecture/<br>Tutorial hours |
|-----------------|--|-----------------------------------|
| <b>Module 1</b> |  | <b>8</b>                          |
| 1.1             | Basic Concept of prestressing-Historical overview of prestressing– Advantages and disadvantages – Materials required – Systems and methods of prestressing   | 2                                 |
| 1.2             | Analysis of sections – Stress concept – Strength concept – Load balancing concept  | 2                                 |
| 1.3             | Effect of tendon profile on deflections – Factors influencing deflections – Calculation of deflections – Short term and long-term deflections(Concepts only) | 2                                 |
| 1.4             | Losses of prestress- Immediate losses and long-term losses (Concept only).   | 2                                 |
| <b>Module 2</b> |  | <b>8</b>                          |
| 2.1             | Basic assumptions of flexural design – Permissible stresses in steel and concrete as per I.S.1343 Code – Different types of sections                         | 2                                 |
| 2.2             | Design of sections- post-tensioned and pre tensioned beams – Check for flexural capacity based on I.S. 1343 Code   | 3                                 |
| 2.3             | Influence of Layout of cables in post-tensioned beams – Location of wires in pre-tensioned beams – Design for shear based on I.S. 1343 Code.                 | 2                                 |
| 2.4             | Anchorage zone reinforcement- Design based on IS Code.   | 1                                 |
| <b>Module 3</b> |  | <b>7</b>                          |
| 3.1             | Prestressed continuous beams- Classifications - Methods of achieving continuity  | 2                                 |
| 3.2             | Analysis and design of continuous beams  | 3                                 |
| 3.3             | Concept of linear transformations, Concordant cable profile.   | 2                                 |

M Tech in Computer Aided Structural Engineering

| <b>Module 4</b> |   | <b>7</b> |
|-----------------|---|----------|
| 4.1             | Composite Sections – Types – Advantages-applications,                                       | 1        |
| 4.2             | Analysis of stresses for composite sections   | 2        |
| 4.3             | Composite beams- Analysis and design of Flexural and shear strength, Differential Shrinkage | 3        |
| 4.4             | Partial prestressing - its advantages and applications                                      | 1        |
| <b>Module 5</b> |   | <b>6</b> |
| 5.1             | Role of prestressing in members subjected to Tensile forces and compressive forces          | 2        |
| 5.2             | Design of tension and compression members (Basic principles only)                           | 2        |
| 5.3             | Tanks, pipes and poles – Design of prestressed concrete slab. (concepts only).              | 2        |



**Model Question Paper**

**QP CODE:**

Pages: 3

Reg No.: \_\_\_\_\_

Name: \_\_\_\_\_

**MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**FIRST SEMESTER M.TECH DEGREE EXAMINATION, DECEMBER 2024**

**Course Code: M24CE1E104A**

**Course Name: PRESTRESSED CONCRETE**

Max. Marks: 60

Duration: 3 hours

**PART A**

**Answer all Questions. Each question carries 4 Marks**

1. Answer the questions in a few sentences. Give a brief justification in maximum of five sentences for full credit
  - i) Two beams having the same properties are prestressed with straight tendons having the same force and steel area. The first one is concentric and the second one is eccentric with a positive eccentricity. Which beam carries more external load and why? (2 marks)
  - ii) Two identical beams loaded with live load and dead load are prestressed with straight tendons. Both beams are having the same eccentricity but the first one is having a positive eccentricity and the second one is with a negative eccentricity. Which beam will deflect more? Provide a valid argument for full credit. (2 marks)
2. Consideration of transmission length and development length in post tensioned members is meaningless. Justify. Also explain the nature of stresses developed in anchorage of post tensioned members.
3. Indicate whether the following statements are 'TRUE' 'FALSE' or 'MAYBE'. Give a brief justification in maximum of five sentences for full credit

- i) Secondary moments can be eliminated by selecting a proper tendon profile. (2 marks)
  - ii) In a prestressed continuous beam, the resultant moment diagram has a similar shape of the primary moment diagram, which is again similar to the profile of the tendon. (2 marks)
4. Justify the statement with proper reasoning "Composite prestressed concrete member is superior when compared with a reinforced or prestressed concrete member".
5. Explain the design criteria of prestressed concrete pipes.

### PART B

Answer any 5 questions. Each question carries 8 marks

6. A prestressed concrete beam 250mm wide and 400mm deep is prestressed by an eccentric tendon. The span of the beam is 7m and the beam has to support an imposed load of 4.5kN/m. Find the prestressing force necessary so that the tension is just avoided at the soffit of the mid section if the eccentricity is 60mm. Concrete weight is 25kN/m<sup>3</sup>.
7. A beam 10m span having 200mm wide and 300mm deep is post tensioned with parabolic cable having an area of 320mm<sup>2</sup> located at an eccentricity of 50mm at mid-span and zero at supports. Initial stress in the cable is 1000MPa. Calculate the maximum percentage loss of prestress due to friction, if it is stressed from one end. Take  $E_s=2.1 \times 10^5$  MPa,  $E_c=3.5 \times 10^4$  MPa and age of concrete is 28 days and missing data if any can be assumed based on relevant code.
8. The support section of a prestressed concrete beam 100mm wide and 250mm deep is required to support an ultimate shear force of 60kN. The compressive prestress at the centroidal axis is  $f_{cp}=5$ N/mm<sup>2</sup>.  $f_{ck}=40$ N/mm<sup>2</sup> and cover to the tension reinforcement is 50mm. if the characteristic tensile strength of steel in stirrups is 250N/mm<sup>2</sup>. Design suitable shear reinforcement at the section using IS code recommendations.
9. Obtain desirable locations of concordant cable profile for the continuous beam loaded as shown in Figure 1. Take prestressing force as 250kN.

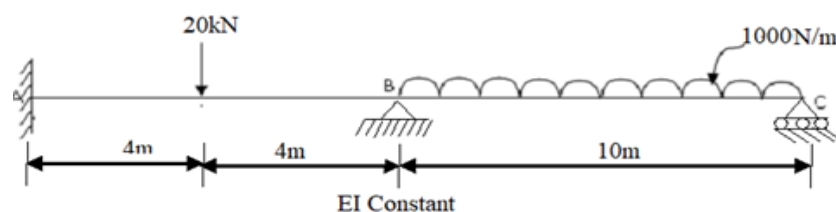


Figure 1

10. A composite beam of rectangular section is made up of a pretensioned inverted T-beam as shown in figure 2 having a slab thickness and width of 150mm and 1000mm respectively. The rib size is 150mm and 850mm. the cast in situ concrete has a thickness and width of 1000mm with a modulus of elasticity of  $30\text{kN/mm}^2$ . If the differential shrinkage is  $100 \times 10^{-6}$  units, estimate the shrinkage stresses developed in the precast and cast in situ units.

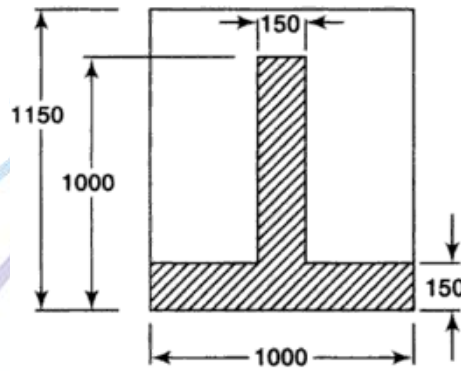


Figure 2

- 11 (i) Explain the design criteria of prestressed circular water tanks. (5 marks)  
 (ii) Sketch the commonly used cross-sections of Prestressed concrete Poles. (3 marks)
12. Design the bearing plate and the end zone reinforcement for the following bonded post-tensioned beam shown in figure 3. The strength of concrete at transfer ( $f_{ci}$ ) is  $50\text{N/mm}^2$ . A prestressing force of  $1055\text{kN}$  is applied by a single tendon symmetrically placed over a mild steel anchor of size  $150\text{mm} \times 200\text{mm}$ . Permissible bending stress for the bearing plate is  $165\text{ N/mm}^2$ . There is no eccentricity of the tendon at the ends. Use Fe250 grade steel for reinforcement.

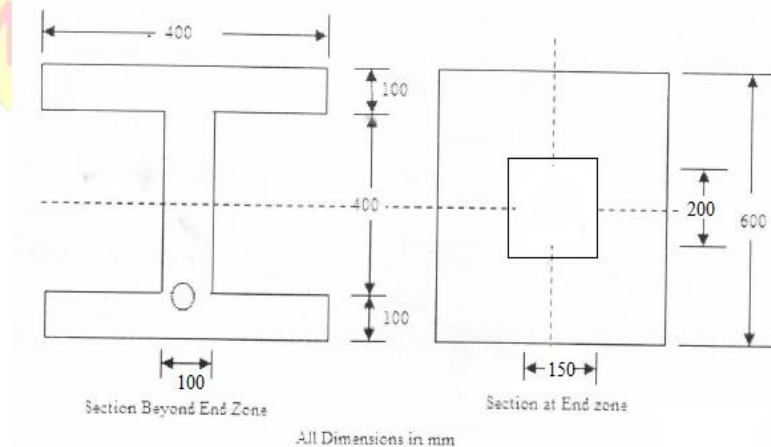


Figure 3

| CODE        | COURSE NAME                          | CATEGORY | L | T | P | S | CREDIT |
|-------------|--------------------------------------|----------|---|---|---|---|--------|
| M24CE2E104B | ANALYSIS AND DESIGN OF SUBSTRUCTURES | ELECTIVE | 3 | 0 | 0 | 3 | 3      |

**Preamble:** The course exposes the students to the concepts of soil structure interaction and design of various sub structures. By the completion of this course the students will be able to analyze and design different types of substructures and retaining walls and thereby develop solutions for real world problems.

**Prerequisite** : Nil

**Course Outcomes** : After the completion of the course the student will be able to

|             |   |
|-------------|---|
| <b>CO 1</b> | Understand and apply the concept of soil-structure interaction to design a shallow foundation. <b>(Cognitive knowledge level: Understand and Apply)</b>       |
| <b>CO 2</b> | Analyze pile foundation for different loads and carryout the structural design of pile and Pile cap. <b>(Cognitive knowledge level: Analyze and Evaluate)</b> |
| <b>CO 3</b> | Analyze and Design different types of Retaining walls. <b>(Cognitive knowledge level: Analyse)</b>  |
| <b>CO 4</b> | Design various components of Well foundation. <b>(Cognitive knowledge level: Understand and Apply)</b>  |
| <b>CO 5</b> | Analysis and Design Machine foundation. <b>(Cognitive knowledge level: Analyse)</b>   |

#### Mapping of course outcomes with program outcomes

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
|-------------|------|------|------|------|------|------|
| <b>CO 1</b> | 1    | 1    | 1    | 2    | 1    | 2    |
| <b>CO 2</b> | 2    | 1    | 2    | 2    | 2    | 2    |
| <b>CO 3</b> | 2    | 1    | 2    | 2    | 2    | 2    |
| <b>CO 4</b> | 2    | 1    | 2    | 2    | 2    | 2    |
| <b>CO 5</b> | 1    | 1    | 2    | 2    | 1    | 2    |

**Assessment Pattern**

| Course Name      | ANALYSIS AND DESIGN OF SUBSTRUCTURES |                  |                                    |
|------------------|--------------------------------------|------------------|------------------------------------|
| Bloom's Category | Continuous Evaluation Tests          |                  | End Semester Examination (% Marks) |
|                  | Test 1 (% Marks)                     | Test 2 (% Marks) |                                    |
| Remember         |                                      |                  |                                    |
| Understand       | 30                                   | 30               | 30                                 |
| Apply            | 30                                   | 30               | 30                                 |
| Analyse          | 30                                   | 30               | 30                                 |
| Evaluate         | 10                                   | 10               | 10                                 |
| Create           |                                      |                  |                                    |

**Mark distribution**

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 100         | 40        | 60        | 3 Hours      |

|  |   |          |
|--|---|----------|
| <b>Continuous Internal Evaluation Pattern</b>                                  | : |          |
| Seminar*   | : | 10 marks |
| Course based task/Micro Project//Data Collection and interpretation/Case study | : | 10 marks |
| Test paper 1 (Module 1 and Module 2)   | : | 10 marks |
| Test paper 2 (Module 3 and Module 4)   | : | 10 marks |

\*Seminar should be conducted in addition to the theory hours. Topics for the seminar should be from recent technologies in the respective course

**End Semester Examination Pattern:** The end semester examination will be conducted by the college. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 4 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 8 marks. Total duration of the examination will be 3 Hrs.

## SYLLABUS

### MODULE 1 (7 hours)

**Soil-structure interaction:** Introduction to soil-structure interaction - Soil-structure interaction problems. Contact pressure distribution beneath rigid and flexible footing on sand and clay. Contact pressure distribution beneath the raft. Selection of foundation.

**Shallow foundations:** Structural design of spread footing, combined footing and raft foundation.

### MODULE 2 (7 hours)

**Pile foundation:** Introduction- load carrying capacity – IS code and IRC code - Settlement of single pile and pile group - Laterally loaded piles-Born's Method-Ultimate lateral resistance of piles-Structural Design of straight prismatic piles and Structural Design of pile cap.

### MODULE 3 (7 hours)

**Retaining walls:** Types- cantilever, counterfort and buttress retaining wall -Stability analysis of cantilever retaining wall against overturning and sliding-Bearing capacity considerations-structural design of retaining walls.

### MODULE 4 (8 hours)

**Well foundation:** Introduction to well foundations-Types-Elements of well foundations-Grip length-depth of scour-load carrying capacity-Design of well cap, well steining, well curb, cutting edge and bottom plug.

### MODULE 5 (7 hours)

**Machine foundation:** Types of machine foundation-Basic principles of design of machine foundation-Dynamic properties of soil-vibration analysis of machine foundation-Design of foundation for reciprocating machines and impact machines-Vibration isolation

### References

1. Bowles. J.E., "Foundation Analysis and Design", McGraw Hill Publishing co., New York, 1997.
2. Swamy Saran, Analysis and Design of substructures, Oxford and IBH Publishing Co. Pvt. Ltd., 2006.
3. Tomilson. M.J, "Foundation Design and Construction" Longman, Sixth Edition, New Delhi-2009.
4. Varghese. P. C, "Design of Reinforced Concrete Foundations"-PHI learning private limited, New Delhi-2009
5. N.P. Kurien, Design of Foundation Systems : Principles & Practices, Narosa

**COURSE CONTENTS AND LECTURE SCHEDULE**

| No. | Topic  | No. of Lecture/<br>Tutorial hours |
|-----|--|-----------------------------------|
|     | <b>Module 1</b>  | <b>7</b>                          |
| 1.1 | Introduction to soil-structure interaction - Soil-structure interaction problems.  | 2                                 |
| 1.2 | Contact pressure distribution beneath rigid and flexible footing on sand and clay. Contact pressure distribution beneath the raft. | 2                                 |
| 1.3 | Types and Selection of foundation- Structural design of spread footing, combined footing and raft foundation.                      | 3                                 |
|     | <b>Module 2</b>  | <b>7</b>                          |
| 2.1 | Pile foundation: Introduction- load carrying capacity - Settlement of single pile  | 2                                 |
| 2.2 | Laterally loaded piles-Born's method-Ultimate lateral resistance of piles  | 2                                 |
| 2.3 | Structural design of straight piles and Structural Design of pile cap  | 3                                 |
|     | <b>Module 3</b>  | <b>7</b>                          |
| 3.1 | Retaining walls-Types-Stability analysis of cantilever retaining wall against overturning and sliding                              | 4                                 |
| 3.2 | Bearing capacity considerations-structural design of retaining Walls   | 3                                 |
|     | <b>Module 4</b>  | <b>8</b>                          |
| 4.1 | Well foundation: Introduction to well foundations-Types- Elements of well foundations  | 2                                 |
| 4.2 | Grip length- depth of scour-load carrying capacity-  | 2                                 |
| 4.3 | Design of well cap, well steining, well curb, cutting edge and bottom plug   | 4                                 |
|     | <b>Module 5</b>  | <b>7</b>                          |
| 5.1 | Machine foundation: Types of machine foundation-Basic principles of design of machine foundation                                   | 2                                 |
| 5.2 | Dynamic properties of soil-vibration analysis of machine Foundation  | 2                                 |
| 5.3 | Design of foundation for reciprocating machines and impact machines-vibration isolation  | 3                                 |

**Model Question Paper**

**QP CODE:**

Pages: 1

Reg. No.: \_\_\_\_\_

Name: \_\_\_\_\_

**MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM  
FIRST SEMESTER M.TECH DEGREE EXAMINATION, DECEMBER 2024  
Course Code: M24CE2E104B**

**Course Name: ANALYSIS AND DESIGN OF SUBSTRUCTURES**

Max. Marks:60

Duration: 3 hours

**PART A**

*Answer all questions. Each question carries 4 marks.*

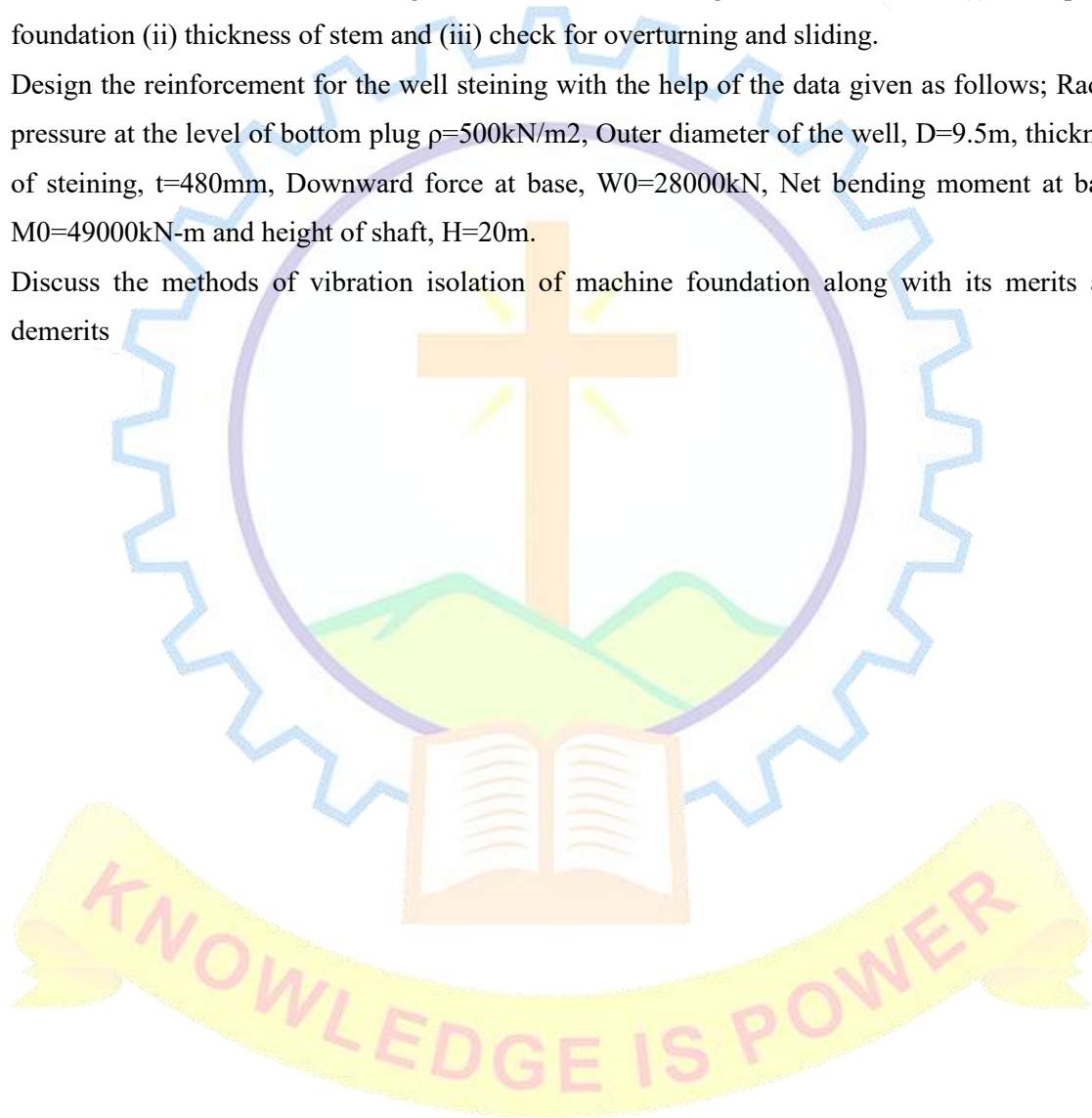
1. Illustrate the limitations of Winkler Model related to soil structure interaction?
2. Examine the load transfer mechanism of pile foundation.
3. Examine how the stability parameters of cantilever retaining wall is checked
4. Outline Scour depth and Grip length
5. Illustrate about rotating type excitation on machine foundation.

**PART B**

*Answer any five questions. Each question carries 8 marks.*

6. A reinforced concrete column 400mm by 400mm supports an axial service load of 1000kN. The safe bearing capacity of the soil at site is 200kN/m<sup>2</sup>. Materials are M20 grade concrete and Fe415 grade HYSD bars. Design a suitable uniform isolated square footing for the column and sketch the details of reinforcements.
7. Design a footing for 250mm thick masonry wall which supports a load of 200kN/m at service state. Consider, unit weight of soil equals 20kN/m<sup>3</sup>, angle of repose as 30°, allowable bearing capacity of soil equals 150kN/m<sup>2</sup>, concrete of grade M20 and steel of grade Fe415.
8. The foundation for a structure comprising eight piles of circular cross section have to support a service load of 4800kN. The piles are driven through a hard stratum and bear on hard rock. Design the reinforcement in the pile assuming the pile to be 6m long and using M20 grade concrete and Fe415 grade HYSD bars.

9. Design a pile cap for a group of two piles spaced 1.5m apart. The piles are 500mm diameter and the column transmits a factored load of 858kN and is of size 300mm by 400mm. Adopt M20 grade concrete and Fe415 grade HYSD bars. Sketch the details of reinforcements.
10. A cantilever retaining wall to retain earth embankment 3m high above ground level. The unit weight of earth is  $18\text{kN/m}^3$  and its angle of repose is  $30^\circ$ . The embankment is horizontal at its top. The safe bearing capacity of soil may be taken as  $100\text{kN/m}^3$  and the coefficient of friction between soil and concrete as 0.5. Use M20 grade concrete and Fe415 grade steel. Find out, (i) the depth of foundation (ii) thickness of stem and (iii) check for overturning and sliding.
11. Design the reinforcement for the well steining with the help of the data given as follows; Radial pressure at the level of bottom plug  $p=500\text{kN/m}^2$ , Outer diameter of the well,  $D=9.5\text{m}$ , thickness of steining,  $t=480\text{mm}$ , Downward force at base,  $W_0=28000\text{kN}$ , Net bending moment at base,  $M_0=49000\text{kN-m}$  and height of shaft,  $H=20\text{m}$ .
12. Discuss the methods of vibration isolation of machine foundation along with its merits and demerits



| CODE        | COURSE NAME        | CATEGORY | L | T | P | S | CREDIT |
|-------------|--------------------|----------|---|---|---|---|--------|
| M24CE2E104C | FRACTURE MECHANICS | ELECTIVE | 3 | 0 | 0 | 3 | 3      |

**Preamble:** The course imparts knowledge about the safety and reliability of structures through the study of failure mechanisms. Special focus is given to principles of fracture mechanics, explaining the relevance, versatility and fundamental concepts. This course improves the understanding of material performance, assists in optimizing structural design and predicts the service life of components.

**Prerequisite** : Theory of Elasticity and Plasticity

**Course Outcomes** : After the completion of the course the student will be able to

|             |   |
|-------------|---|
| <b>CO 1</b> | Understand the fundamentals of Linear Elastic Fracture Mechanics f, toughness measures, stress concentration and stress intensity factors ( <b>Cognitive Knowledge Level: Understand</b> ). |
| <b>CO 2</b> | Identify and analyze fracture types under different loading conditions ( <b>Cognitive Knowledge Level: Apply</b> ).   |
| <b>CO 3</b> | Perform failure analysis and investigate root causes of failure in engineering structures ( <b>Cognitive Knowledge Level: Analyse</b> ).  |
| <b>CO 4</b> | Apply fracture mechanics to concrete, incorporating fracture models ( <b>Cognitive Knowledge Level: Apply</b> ).  |
| <b>CO 5</b> | Analyse fatigue behaviour of concrete and assess lifespan of structures ( <b>Cognitive Knowledge Level: Analyse</b> ).  |

#### Mapping of course outcomes with program outcomes

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
|-------------|------|------|------|------|------|------|
| <b>CO 1</b> | 1    | 2    | 1    | 2    | 2    | 1    |
| <b>CO 2</b> | 1    | 2    | 1    | 1    | 2    | 2    |
| <b>CO 3</b> | 1    | 2    | 2    | 1    | 2    | 2    |
| <b>CO 4</b> | 1    | 2    | 2    | 1    | 2    | 2    |
| <b>CO 5</b> | 1    | 2    | 2    | 1    | 1    | 2    |

**Assessment Pattern**

| Course Name      | FRACTURE MECHANICS          |                  |                                    |
|------------------|-----------------------------|------------------|------------------------------------|
| Bloom's Category | Continuous Evaluation Tests |                  | End Semester Examination (% Marks) |
|                  | Test 1 (% Marks)            | Test 2 (% Marks) |                                    |
| Remember         |                             |                  |                                    |
| Understand       | 20                          | 20               | 20                                 |
| Apply            | 40                          | 40               | 40                                 |
| Analyse          | 40                          | 40               | 40                                 |
| Evaluate         |                             |                  |                                    |
| Create           |                             |                  |                                    |

**Mark distribution**

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 100         | 40        | 60        | 3 Hours      |

**Continuous Internal Evaluation Pattern**

|  |   |          |
|--|---|----------|
| Seminar*   | : | 10 marks |
| Course based task/Micro Project//Data collection and interpretation/Case study | : | 10 marks |
| Test paper 1 (Module 1 and Module 2)   | : | 10 marks |
| Test paper 2 (Module 3 and Module 4)   | : | 10 marks |

\*Seminar should be conducted in addition to the theory hours. Topics for the seminar should be from recent technologies in the respective course

**End Semester Examination Pattern:** The end semester examination will be conducted by the college. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 4 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 8 marks. Total duration of the examination will be 3 Hrs.

## SYLLABUS

### MODULE 1 (7 hours)

**Fracture Mechanics:** Introduction to Fracture Mechanics - Historical aspects of Fracture Mechanics- Basic modes of fracture - Mode I, II and III- Brittle and Ductile Fracture - Introduction to Linear Elastic Fracture Mechanics (LEFM) - Griffith theory of brittle fracture - Irwin's theory - Energy Release Rate(ERR) - Evaluation of ERR-Crack resistance-R-curve

### MODULE 2 (9 hours)

**Stress Intensity Factor:** Introduction to Stress field around crack tip-Stress Intensity Factor(SIF) - Field equations - Classical theoretical analyses based on complex stress function approaches- Airy's stress function-Westergaard's Approach- Stress field around crack tip in Mode I, II and III cracks - Relation between ERR and SIF

### MODULE 3 (8 hours)

Introduction to Crack Tip opening Displacement(CTOD)- Relationship between CTOD, KI, GI for small scale yielding, Computational fracture mechanics- Introduction to J-Integral method- Equivalence between CTOD and J-integral.

**Anelastic Deformation at the Crack Tip:** Crack tip plasticity, Irwin's method of plasticity, Dugdale approach, Methods for evaluating plastic zone-Plane stress,Plane strain problems

### MODULE 4 (6 hours)

**Fracture mechanics in concrete:** Structure and fracture process in concrete, fracture behavior and strain localization of concrete, Mechanism of fracture process zone, various models of fracture, estimation of crack propagation.

### MODULE 5 (6 hours)

**Fatigue failure:** Introduction to Fatigue failure- Crack Propagation - S-N Curve - fatigue test, - endurance limit, fatigue controlling factor-Paris Law, Foreman Law-Effect of an Overload- Variable Amplitude Fatigue Load - Role of Fracture mechanics in determining lifespan of concrete structures

### References

1. Broek, D., Elementary Engineering Fracture Mechanics, Martinus, Nijhoff Publishers, 1982.
2. Anderson, T.L., Fracture Mechanics – Fundamentals and Applications, 2nd Edition, CRC Press, 1995.
3. Kumar, Prashant., Elements of Fracture Mechanics, McGraw Hill Education (India) Private Limited,2009.

4. Shah, S.P., Swartz, S.E., and Ouyang, C., Fracture Mechanics of Concrete: Applications of Fracture Mechanics to Concrete, Rock, and Other Quasi-brittle Materials, John Wiley and Sons, 1994.
5. Karihaloo, B.L., Fracture Mechanics and Structural Concrete, Longman Scientific and Technical, 1995.
6. ACI 446.1 R-91, Fracture Mechanics of Concrete: Concepts, Models and Determination of Material Properties, American Concrete Institute.
7. Kare Hellan, Introduction to Fracture mechanics, McGraw Hill Publications, 1985.

### COURSE CONTENTS AND LECTURE SCHEDULE

| No              | Topic   | No. of Lecture/<br>Tutorial hours |
|-----------------|---|-----------------------------------|
| <b>Module 1</b> |   | <b>7</b>                          |
| 1.1             | Introduction to Fracture Mechanics Introduction to Fracture Mechanics-Historical aspects of Fracture Mechanics                              | 1                                 |
| 1.2             | Modes of fracture - Mode I, II and III  | 1                                 |
| 1.3             | Brittle and Ductile Fracture  | 1                                 |
| 1.4             | Introduction to Linear Elastic Fracture Mechanics (LEFM)  | 1                                 |
| 1.5             | Griffith theory of brittle fracture -Irwin's theory   | 1                                 |
| 1.6             | Energy Release Rate(ERR) - Evaluation of ERR  | 1                                 |
| 1.7             | Crack resistance-R-curve  | 1                                 |
| <b>Module 2</b> |   | <b>9</b>                          |
| 2.1             | Introduction to Stress field around crack tip- Field equations - Classical theoretical analyses based on complex stress function approaches | 1                                 |
| 2.2             | Stress Intensity Factor(SIF)  | 1                                 |
| 2.3             | Introduction to Field equations - Classical theoretical analyses based on complex stress function approaches                                | 1                                 |
| 2.4             | Airy's stress function  | 2                                 |
| 2.5             | Westergaard's Approach  | 2                                 |
| 2.6             | Stress field around crack tip in Mode I, II and III cracks  | 1                                 |
| 2.7             | Relation between ERR and SIF  | 1                                 |
| <b>Module 3</b> |   | <b>8</b>                          |
| 3.1             | Introduction to Crack Tip opening Displacement(CTOD)<br>Introduction to J Integral method- Equivalence between CTOD and J-integral.         | 2                                 |

M Tech in Computer Aided Structural Engineering

|                 |   |          |
|-----------------|---|----------|
| 3.2             | Relationship between CTOD, KI, GI for small scale yielding  | 1        |
| 3.3             | Computational fracture mechanic-, J Integral method, Equivalence between CTOD and J Integral  | 2        |
| 3.4             | Introduction to anelastic deformation at the crack tip  | 1        |
| 3.5             | Crack tip plasticity, Irwin's method of plasticity, Dugdale approach  | 1        |
| 3.6             | Methods for evaluating plastic zone-Plane stress, Plane strain problems   | 1        |
| <b>Module 4</b> |   | <b>6</b> |
| 4.1             | Fracture mechanics in concrete, Structure and fracture process in concrete  | 2        |
| 4.2             | Fracture behavior and strain localization of concrete, Mechanism of fracture process zone, various models of fracture                 | 2        |
| 4.3             | Estimation of crack propagation   | 2        |
| <b>Module 5</b> |   | <b>6</b> |
| 5.1             | Introduction to Fatigue failure- Crack Propagation - fatigue test, endurance limit, fatigue controlling factor-Paris Law, Foreman Law | 2        |
| 5.2             | Effect of an Overload- Fatigue damage theories, Fatigue Crack Propagation, fatigue test, endurance limit                              | 2        |
| 5.3             | Variable Amplitude Fatigue Load - Role of Fracture mechanics in determining lifespan of concrete structures                           | 2        |



**Model Question Paper**

**QP CODE:**

Pages: 2

Reg. No.: \_\_\_\_\_

Name: \_\_\_\_\_

**MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM  
FIRST SEMESTER M. TECH DEGREE EXAMINATION, DECEMBER 2024**

**Course Code: M24CE2E104C**

**Course Name: FRACTURE MECHANICS**

Max. Marks:60

Duration: 3 hours

**PART A**

*Answer all questions. Each question carries 4 marks.*

1. Explain about brittle and ductile fracture.
2. Why does the stress intensity factor play an important role in fracture of a material?
3. Define the J-integral. What are the advantages of J-integral?
4. Enlist the reasons for strain localization behaviour of concrete.
5. Enumerate a typical fatigue crack growth rate curve.

**PART B**

*Answer any five questions. Each question carries 8 marks.*

6. Elucidate Griffith's idea on energy balance in fracture mechanics.
7. Describe the crack resistance curves for brittle and ductile materials.
8. Derive the expression of stress field at the crack tip for biaxial loaded infinite plate
9. A steel tension bar 15mm thick and 50 mm wide with an initial single edge crack of 10 mm long is subjected to a uniaxial stress of 180 MPa
  - (a) Determine the stress intensity factor  $K_I$ . Is the crack stable if  $K_{IC} = 60 \text{ MPa}\sqrt{m}$
  - (b) Determine the critical crack size, and
  - (c) Determine the critical crack load(Hint:  $f(\alpha) = 1.12 - 0.231\alpha + 10.55\alpha^2 - 21.71\alpha^3 + 30.38\alpha^4$ )
10. Derive an expression relating  $G_I$  and  $K_I$ .
11. Determine the approximate plastic zone size and shape for the plane stress problem by using von Mises yield criterion.
12. Elucidate the role of fracture mechanics in determining lifespan of concrete structures.

| CODE        | COURSE NAME                  | CATEGORY | L | T | P | S | CREDIT |
|-------------|------------------------------|----------|---|---|---|---|--------|
| M24CE2E104D | ADVANCED CONCRETE TECHNOLOGY | ELECTIVE | 3 | 0 | 0 | 3 | 3      |

**Preamble:** The course covers the properties of the ingredients of concrete and its influence on the performance of concrete. The course also focuses on developing a strong understanding about the latest developments in the area of concrete technology with a clear knowledge about the fundamental mechanisms.

**Prerequisite** : Basics of Civil Engineering, Concrete Technology

**Course Outcomes** : After the completion of the course the student will be able to

|             |   |
|-------------|---|
| <b>CO 1</b> | Conceive the fundamentals of cement, aggregates, admixtures, and concrete rheology<br>(Cognitive knowledge level: Understand)   |
| <b>CO 2</b> | Design concrete mixes emphasizing particle packing, durability, and strength as per the requirements in the field. (Cognitive knowledge level: Design)  |
| <b>CO 3</b> | Analyze the effects of water-cement ratio, time, and environmental conditions on concrete behavior, including creep, shrinkage, and fresh and hardened concrete properties.<br>(Cognitive knowledge level: Analyse) |
| <b>CO 4</b> | Assess the durability performance of existing concrete structures through the application of non-destructive testing techniques (Cognitive knowledge level: Evaluate)   |
| <b>CO 5</b> | Gain expertise in specialized concrete types, construction techniques and apply them to solve real-life construction problems (Cognitive knowledge level: Apply)  |

#### Mapping of course outcomes with program outcomes

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
|-------------|------|------|------|------|------|------|
| <b>CO 1</b> | 1    | 1    | 1    | 1    | 1    | 1    |
| <b>CO 2</b> | 3    | 1    | 2    | 3    | 2    |      |
| <b>CO 3</b> | 2    | 1    | 3    | 2    | 1    |      |
| <b>CO 4</b> | 1    | 1    | 2    | 1    | 2    | 2    |
| <b>CO 5</b> |      | 1    | 2    | 3    | 3    |      |

**Assessment Pattern**

| Course Name      | ADVANCED CONCRETE TECHNOLOGY |                  |                                    |
|------------------|------------------------------|------------------|------------------------------------|
| Bloom's Category | Continuous Assessment Tests  |                  | End Semester Examination (Marks %) |
|                  | Test 1 (Marks %)             | Test 2 (Marks %) |                                    |
| Remember         | -                            | -                | -                                  |
| Understand       | 20                           | 20               | 20                                 |
| Apply            | 40                           | 40               | 40                                 |
| Analyse          | 30                           | 30               | 30                                 |
| Evaluate         | -                            | -                | -                                  |
| Create           | -                            | -                | -                                  |

**Mark distribution**

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 100         | 40        | 60        | 3 Hours      |

|  |   |          |
|--|---|----------|
| <b>Continuous Internal Evaluation Pattern</b>                                  | : |          |
| Seminar*   | : | 10 marks |
| Course based task/Micro Project//Data collection and interpretation/Case study | : | 10 marks |
| Test paper 1 (Module 1 and Module 2)   | : | 10 marks |
| Test paper 2 (Module 3 and Module 4)   | : | 10 marks |

\*Seminar should be conducted in addition to the theory hours. Topics for the seminar should be from recent technologies in the respective course

**End Semester Examination Pattern:** The end semester examination will be conducted by the college. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 4 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 8 marks. Total duration of the examination will be 3 Hrs.

## SYLLABUS

### MODULE 1 (8 hours)

Cement -Review of manufacturing process- chemical composition, Bogue's compounds, mechanism of hydration-heat of hydration-Aggregate-Review of types, sampling and testing, artificial aggregates – Chemical Admixtures- types, uses, mechanism of action - effects on properties of concrete - Mineral admixtures- types, chemical composition - physical characteristics - effects on properties of concrete - Rheology – basic concepts – Bingham model.

### MODULE 2 (7 hours)

Mix design - nominal mix- design mix – concept of mix design - variables of proportioning - general considerations - factors considered in the design of concrete mix- various methods of mix design - design of concrete mix as per IS 10262-2019, Importance of particle packing, Statistical quality control of concrete – mean strength – standard deviation – coefficient of variation – sampling - testing - acceptance criteria.

### MODULE 3 (7 hours)

Properties of fresh concrete- workability-factors affecting workability - slump test- compaction factor test- Vee Bee consistometer test- Properties of hardened concrete - modulus of elasticity, compressive strength, split tensile strength, flexural strength- effect of water cement ratio – maturity concept- Creep - factors affecting creep - effect of creep- Shrinkage- factors affecting shrinkage - plastic shrinkage, drying shrinkage, autogenous shrinkage, carbonation shrinkage.

### MODULE 4 (7 hours)

Durability of concrete- Factors affecting durability - permeability- cracking-reinforcement corrosion; carbonation, chloride penetration, sulphate attack, acid attack, fire resistance; frost damage, alkali silica reaction, concrete in sea water - Non-destructive testing of concrete- surface hardness test- ultrasonic pulse velocity method - penetration resistance- pull-out test- core cutting - measuring reinforcement cover.

### MODULE 5 (7 hours)

Special concrete - lightweight concrete-heavy weight concrete - high strength concrete – high performance concrete - self compacting concrete -roller compacted concrete– fibre reinforced concrete - polymer concrete-pumped concrete - ready mix concrete - green concrete. Special processes and technology - sprayed concrete; underwater concrete, mass concrete; slip form construction, prefabrication technology- 3D concrete printing.

**References**

1. Neville A.M., "Properties of Concrete", Trans-Atlantic Publications, Inc.; 5e, 2016
2. R. Santhakumar ,”Concrete Technology”, Oxford Universities Press, 2018
3. Shetty M. S., “Concrete Technology”, S. Chand & Co., 2018
4. Mehta and Monteiro, “Concrete-Micro structure, Properties and Materials”, McGraw Hill Professional 2017
5. Neville A. M. and Brooks J. J., “Concrete Technology”, Pearson Education, 2019
6. Lea, “Chemistry of Cement and Concrete”, Butterworth-Heinemann Ltd, 5e, 2017
7. Gambhir, M. L. (2013). *Concrete Technology: Theory and Practice* (5th ed.). McGraw-Hill Education.

**COURSE CONTENTS AND LECTURE SCHEDULE**

| No  | Topic  | No. of Lecture/<br>Tutorial hours |
|-----|--|-----------------------------------|
|     | <b>Module 1</b>  | <b>8</b>                          |
| 1.1 | Cement -Review of manufacturing process- chemical composition  | 1                                 |
| 1.2 | Bogue’s compounds, mechanism of hydration-heat of hydration  | 1                                 |
| 1.3 | Aggregate-Review of types, sampling and testing, artificial aggregates   | 1                                 |
| 1.4 | Chemical Admixtures- types, uses, mechanism of action - effects on properties of concrete                      | 1                                 |
| 1.5 | Mineral admixtures- types, chemical composition - physical characteristics - effects on properties of concrete | 1                                 |
| 1.6 | Rheology – basic concepts  | 2                                 |
| 1.7 | Bingham model  | 1                                 |
|     | <b>Module 2</b>  | <b>7</b>                          |
| 2.1 | Mix design - nominal mix- design mix – concept of mix design   | 1                                 |
| 2.2 | Variables of proportioning - general considerations  | 1                                 |
| 2.3 | Factors considered in the design of concrete mix-various methods of mix design                                 | 1                                 |
| 2.4 | Design of concrete mix as per IS 10262-2019  | 1                                 |
| 2.5 | Statistical quality control of concrete – mean strength – standard deviation                                   | 1                                 |
| 2.6 | Coefficient of variation – sampling - testing -acceptance criteria   | 1                                 |
| 2.7 | Mix design - nominal mix- design mix – concept of mix design   | 1                                 |

M Tech in Computer Aided Structural Engineering

|     |  |          |
|-----|--|----------|
|     | <b>Module 3</b>  | <b>6</b> |
| 3.1 | Properties of fresh concrete- workability-factors affecting workability                    | 1        |
| 3.2 | Slump test-compaction factor test-Vee Bee consistometer test                               | 1        |
| 3.3 | Properties of hardened concrete - modulus of elasticity, compressive strength              | 1        |
| 3.4 | split tensile strength, flexural strength- effect of water cement ratio – maturity concept | 1        |
| 3.5 | Creep - factors affecting creep - effect of creep  | 1        |
| 3.6 | Shrinkage- factors affecting shrinkage - plastic shrinkage, drying shrinkage               | 1        |
| 3.7 | Autogenous shrinkage, carbonation shrinkage.   | 1        |
|     | <b>Module 4</b>  | <b>7</b> |
| 4.1 | Durability of concrete- Factors affecting durability                                       | 1        |
| 4.2 | Permeability- cracking-reinforcement corrosion;carbonation                                 | 1        |
| 4.3 | Chloride penetration, sulphate attack, acid attack,fire resistance                         | 1        |
| 4.4 | Frost damage, alkali silica reaction, concrete in sea water                                | 1        |
| 4.5 | Non-destructive testing of concrete- surface hardness test                                 | 1        |
| 4.6 | Ultrasonic pulse velocity method - penetration resistance                                  | 1        |
| 4.7 | Pull-out test- core cutting - measuring reinforcement cover.                               | 1        |
|     | <b>Module 5</b>  | <b>7</b> |
| 5.1 | Special concretes - lightweight concrete-heavy weight concrete                             | 1        |
| 5.2 | High strength concrete – high performance concrete   | 1        |
| 5.3 | self compacting concrete   | 1        |
| 5.4 | Roller compacted concrete– fibre reinforced concrete - polymer concrete                    | 1        |
| 5.5 | Special processes and technology - sprayed concrete; underwater concrete                   | 1        |
| 5.6 | mass concrete; slip form construction  | 1        |
| 5.7 | Prefabrication technology- 3D concrete printing  | 1        |

**Model Question Paper**

**QP CODE:**

Pages: 1

Reg No.: \_\_\_\_\_

Name: \_\_\_\_\_

**MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM  
FIRST SEMESTER M.TECH DEGREE EXAMINATION, DECEMBER 2024  
Course Code: M24CE2E104D**

**Course Name: *ADVANCED CONCRETE TECHNOLOGY***

Max. Marks:60

Duration: 3 hours

**PART A**

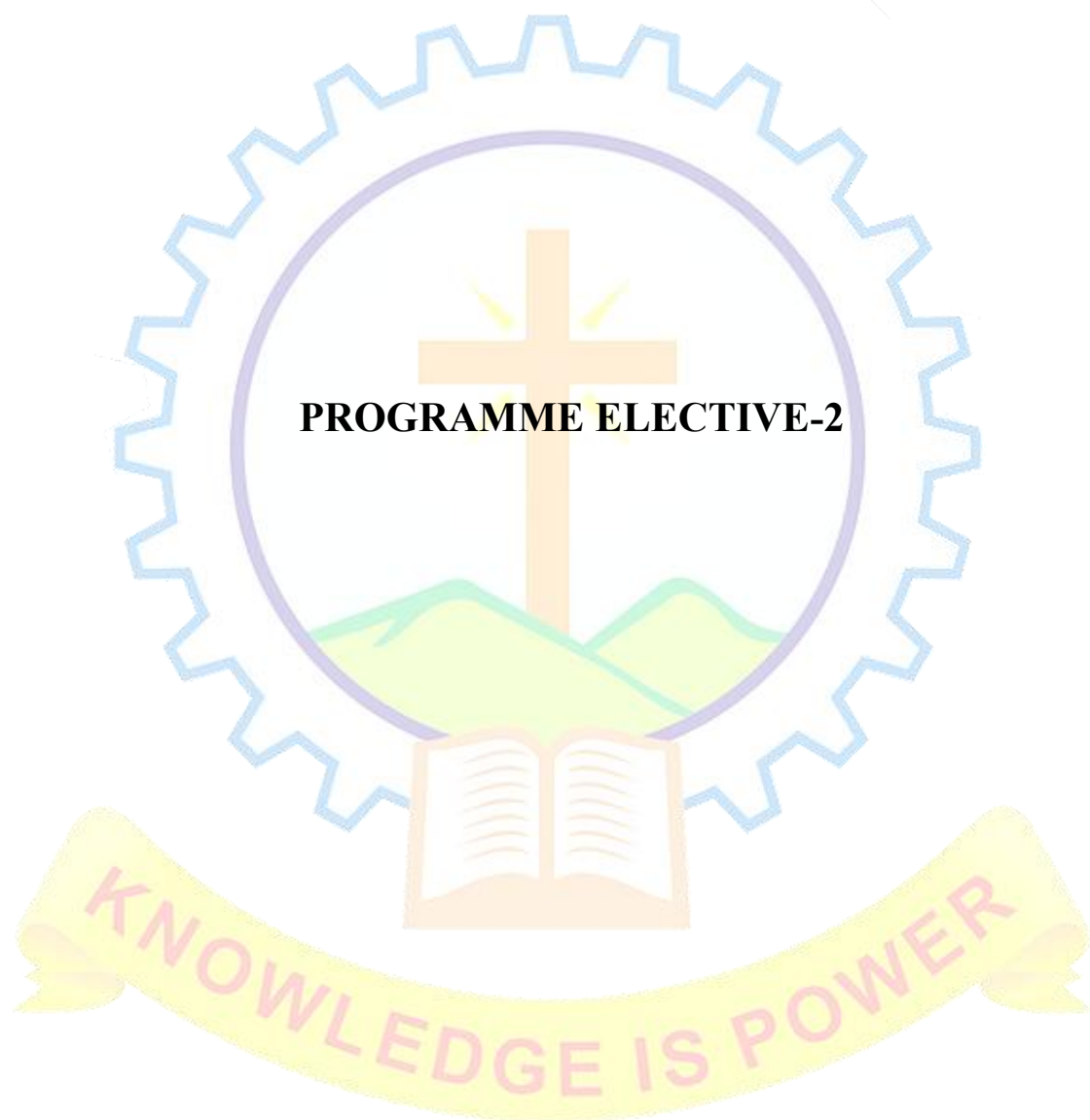
***Answer all questions. Each question carries 4 marks.***

1. Describe the characteristics of hydration products of cement and its influence in the properties of concrete.
2. Explain the influence of various factors affecting the workability of concrete on the rheological parameters.
3. Explain the methods to prevent corrosion of rebars in RCC.
4. Briefly describe the polymer concrete and its advantages and disadvantages.
5. How will the temperature affect the properties of concrete?

**PART B**

***Answer any five questions. Each question carries 8 marks.***

1. What are admixtures in concrete and its classification? Briefly explain superplasticizers and its mechanism of action.
2. Mention the various steps involved in the high strength concrete mix design.
3. What are the transport mechanisms in concrete and describe any one test for each of the mechanism.
4. In a congested reinforced concrete work which type of concrete will you prefer and why? Explain its mix proportioning, properties, advantages and disadvantages.
5. The condition assessment needs to be done in a concrete water tank. Which are the tests you recommend for assessing the quality and strength of concrete. Briefly explain the tests also.
6. Why special concretes are needed and explain any three special concretes based on their application.
7. What is the durability of concrete? Describe the factors affecting the durability of concrete structures.



| CODE        | COURSE NAME         | CATEGORY | L | T | P | S | CREDIT |
|-------------|---------------------|----------|---|---|---|---|--------|
| M24CE1E105A | STRUCTURAL DYNAMICS | ELECTIVE | 3 | 0 | 0 | 3 | 3      |

**Preamble:** The course provides the concepts of structural dynamics and focus on analysis of single and multi-degree freedom systems. This includes introduction to mass distributed systems and earthquake analysis of structures.

**Prerequisite** : Mechanics of Solids, Structural Analysis

**Course Outcomes** : After the completion of the course the student will be able to

|             |   |
|-------------|---|
| <b>CO 1</b> | Model single degree freedom systems for dynamic analysis and develop equations of motion. <b>(Cognitive knowledge level: Apply)</b> |
| <b>CO 2</b> | Perform dynamic analysis of single degree freedom systems. <b>(Cognitive knowledge level: Analyze)</b>                              |
| <b>CO 3</b> | Model multi degree freedom systems for dynamic analysis and develop equations of motion. <b>(Cognitive knowledge level: Apply)</b>  |
| <b>CO 4</b> | Perform dynamic analysis of multi - degree freedom systems. <b>(Cognitive knowledge level: Analyze)</b>                             |
| <b>CO 5</b> | Analyze the dynamics of mass distributed parameter systems <b>(Cognitive knowledge level: Analyze)</b>                              |

**Mapping of course outcomes with program outcomes:**

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
|-------------|------|------|------|------|------|------|
| <b>CO 1</b> | 2    | 2    | 2    | 1    | 2    | 1    |
| <b>CO 2</b> | 2    | 2    | 2    | 1    | 2    | 1    |
| <b>CO 3</b> | 2    | 2    | 2    | 1    | 2    | 1    |
| <b>CO 4</b> | 1    | 2    | 1    | 1    | 2    | 1    |
| <b>CO 5</b> | 1    | 2    | 1    | 1    | 2    | 1    |

**Assessment Pattern:**

| Course Name      | STRUCTURAL DYNAMICS         |                 |                                   |
|------------------|-----------------------------|-----------------|-----------------------------------|
| Bloom's Category | Continuous Evaluation Tests |                 | End Semester Examination (%Marks) |
|                  | Test 1 (%Marks)             | Test 2 (%Marks) |                                   |
| Remember         |                             |                 |                                   |
| Understand       | 20                          | 20              | 20                                |
| Apply            | 40                          | 30              | 40                                |
| Analyse          | 40                          | 50              | 40                                |
| Evaluate         |                             |                 |                                   |
| Create           |                             |                 |                                   |

**Mark distribution:**

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 100         | 40        | 60        | 3 Hours      |

|  |   |          |
|--|---|----------|
| <b>Continuous Internal Evaluation Pattern</b>                                  | : |          |
| Seminar*   | : | 10 marks |
| Course based task/Micro Project//Data collection and interpretation/Case study | : | 10 marks |
| Test paper 1 (Module 1 and Module 2)   | : | 10 marks |
| Test paper 2 (Module 3 and Module 4)   | : | 10 marks |

\*Seminar should be conducted in addition to the theory hours. Topics for the seminar should be from recent technologies in the respective course

**End Semester Examination Pattern:** The end semester examination will be conducted by the college. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 4 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 8 marks. Total duration of the examination will be 3 Hrs.

## SYLLABUS

### MODULE 1 (7 hours)

Vibration studies and its importance to structural engineering applications – Types of dynamic loading – Systems with single degree of freedom – Elements of a vibratory system – Mathematical model for single degree of freedom systems - Equation of motion. Undamped and damped free vibration of a single degree of freedom system. Measurement of damping from free vibration response - Logarithmic decrement.

### MODULE 2 (9 hours)

Response of single degree of freedom systems to harmonic loading, Measurement of damping from forced response – Half power band-width method. Impulse response function, Response of single degree of freedom systems subjected to impulse, periodic and general loading- Duhamel integral. Single degree freedom subjected to support motion. Vibration isolation –Transmissibility.

### MODULE 3 (7 hours)

Multi-degree of freedom systems – Equation of motion. Shear building concept and models for dynamic analysis –Evaluation of natural frequencies and mode shapes by solution of characteristic equation. Co-ordinate coupling - Orthogonality of normal modes.

### MODULE 4 (6 hours)

Forced vibration analysis of multi-degree of freedom systems - Mode superposition method of analysis. Response of multi degree of freedom systems to support motion.

### MODULE 5 (7 hours)

Distributed mass (continuous) systems – differential equation of motion – Axial vibration of rods. Flexural vibration of beams, natural frequencies and mode shapes of simply supported beams. Evaluation of frequencies and mode shapes of cantilever beam and fixed beam (formulation only) – Variational formulation of the equation of motion – Hamilton's principle - Lagrange's equation.

### References

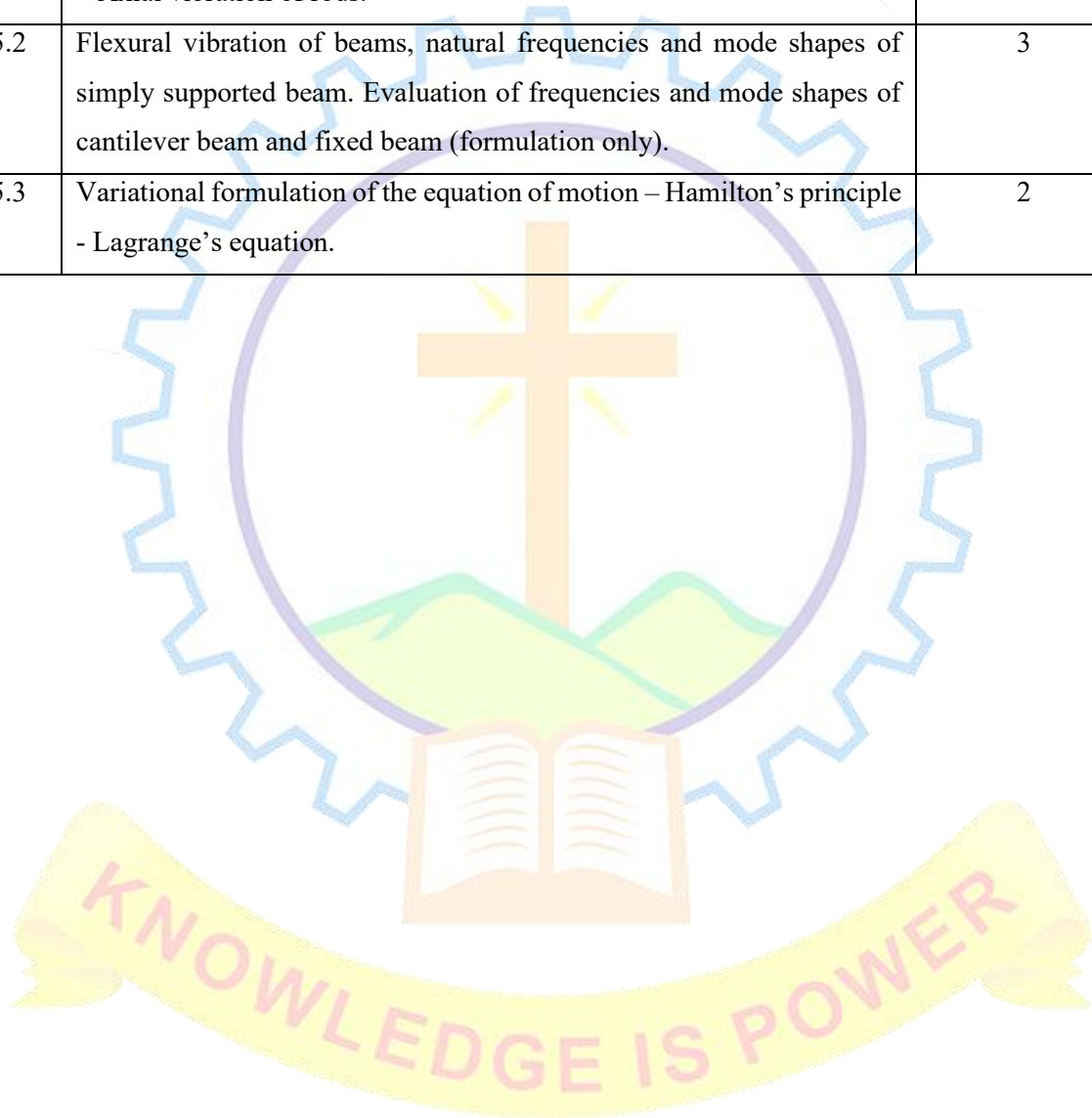
1. Anil K Chopra, "Dynamics of Structures- Theory and Application to Earthquake Engineering", Pearson Education, New Delhi, 5th edition, 2017.
2. Mukhopadhyay M, "Structural Dynamics - Vibrations and Systems", Ane Books India, Delhi, first edition, 2008.
3. Clough R W and Penzien J, "Dynamics of Structures", McGraw Hill, New Delhi, 2nd edition, 1993.

4. Mario Paz, "Structural Dynamics – Theory and Computation", CBS Publishers and Distributors, Delhi, 4th edition, 2004.
5. Weaver W, Timoshenko S P, and Young D H, "Vibration Problems in Engineering", John Wiley and Sons, USA, 4th edition, 1990.
6. "Fundamentals of Structural Dynamics" by Roy R. Craig and Andrew J. Kurdila, 3rd edition, 2021.
7. "Structural Dynamics: Concepts and Applications" by Paul A. Kurowski, first edition, 2000.

### COURSE CONTENTS AND LECTURE SCHEDULE

| No              | Topic  | No. of Lecture/<br>Tutorial hours |
|-----------------|--|-----------------------------------|
| <b>Module 1</b> |  | <b>7</b>                          |
| 1.1             | Vibration studies and its importance to structural engineering applications – Types of dynamic loading – Systems with single degree of freedom – Elements of a vibratory system – Mathematical model for single degree of freedom systems – Equation of motion | 3                                 |
| 1.2             | Undamped and damped free vibration of single degree of freedom system.   | 2                                 |
| 1.3             | Measurement of damping from free vibration response - Logarithmic decrement.   | 2                                 |
| <b>Module 2</b> |  | <b>9</b>                          |
| 2.1             | Response of single degree of freedom systems to harmonic loading, Measurement of damping from forced response – Half power band width method.  | 3                                 |
| 2.2             | Impulse response function, Response of single degree of freedom systems subjected to impulse (rectangular, triangular and half sine wave), periodic and general loading- Duhamel integral.   | 3                                 |
| 2.3             | Single degree freedom subjected to support motion.   | 2                                 |
| 2.4             | Vibration isolation –Transmissibility  | 1                                 |
| <b>Module 3</b> |  | <b>7</b>                          |
| 3.1             | Multi-degree of freedom systems – Equation of motion.  | 2                                 |
| 3.2             | Shear building concept and models for dynamic analysis – Evaluation of natural frequencies and mode shapes by solution of characteristic equation.   | 4                                 |
| 3.3             | Co-ordinate coupling - Orthogonality of normal modes.  | 1                                 |

|     |  |          |
|-----|--|----------|
|     | <b>Module 4</b>  | <b>6</b> |
| 4.1 | Forced vibration analysis of multi-degree of freedom systems -Mode superposition method of analysis.   | 3        |
| 4.2 | Response of multi degree of freedom systems to support motion.   | 3        |
|     | <b>Module 5</b>  | <b>7</b> |
| 5.1 | Distributed mass (continuous) systems – differential equation of motion – Axial vibration of rods.   | 2        |
| 5.2 | Flexural vibration of beams, natural frequencies and mode shapes of simply supported beam. Evaluation of frequencies and mode shapes of cantilever beam and fixed beam (formulation only). | 3        |
| 5.3 | Variational formulation of the equation of motion – Hamilton’s principle - Lagrange’s equation.  | 2        |



**Model Question Paper**

**QP CODE:**

Pages: 3

Reg. No.: \_\_\_\_\_

Name: \_\_\_\_\_

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM  
FIRST SEMESTER M.TECH DEGREE EXAMINATION, DECEMBER 2024**

**Course Code: M24CE1E105A**

**Course Name: STRUCTURAL DYNAMICS**

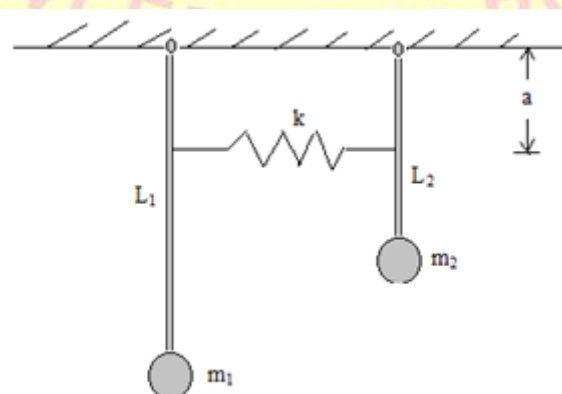
Max. Marks: 60

Duration: 3 hours

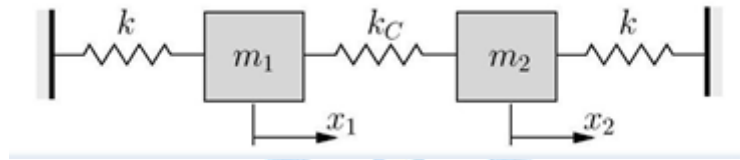
**PART A**

**Answer all questions. Each question carries 4 marks.**

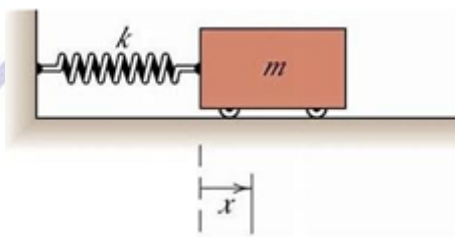
1. Calculate the natural frequency of transverse vibrations of a cantilever beam 40mm diameter circular cross section, carrying a load of 500N at the free end. Span of the cantilever is 800mm.  $E = 200\text{GPa}$ . If a spring of stiffness 52.75kN/m is introduced between the mass and the beam, calculate the change in natural frequency.
2. A sieving machine weighs 2500 kg and when operating at full capacity, it exerts a harmonic force of 3kN amplitude at 20 Hz on its supports. After mounting the machine on spring type vibration isolators, it was found that the harmonic force exerted on the supports had been reduced to a 250N amplitude. Determine the stiffness of the isolator springs. Take  $\zeta = 10\%$ .
3. Two pendulum bobs are suspended from the ceiling using massless rigid bars and the bars are connected using a spring as shown in figure. Derive the equation of motion for small oscillations. Write down the mass and stiffness matrices of the system. Take  $m_1 = 2.0\text{kg}$ ,  $m_2 = 1.5\text{kg}$ ,  $L_1 = 1.5\text{m}$ ,  $L_2 = 1.0\text{m}$ ,  $a = 0.5\text{m}$ ,  $k = 150\text{N/m}$ .



4. Establish the equation of motion for the frame shown in figure, if it is subjected to a suddenly applied constant acceleration  $0.28g$  at its base. Take  $m_1 = 10\text{kg}$ ,  $m_2 = 20\text{kg}$ ,  $k = 1500\text{N/m}$ ,  $k_c = 2000\text{N/m}$ .



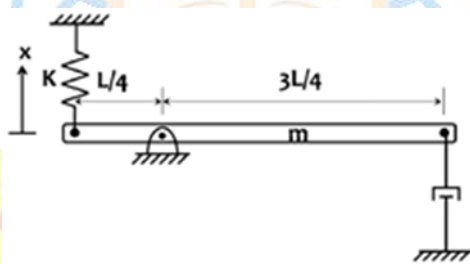
5. Obtain the equation of motion of a SDOF system shown in figure using Lagrange's equation. Take  $m = 10\text{ kg}$  and  $k = 5000\text{N/m}$ .



**PART B**

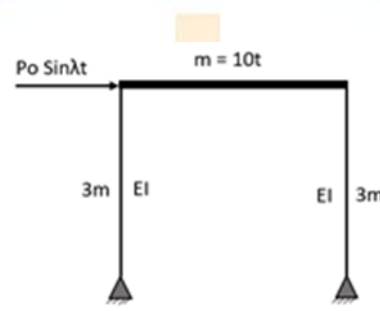
**Answer any five questions. Each question carries 8 marks.**

6. Determine the parameters in an equivalent model of the system as shown in the figure when  $\theta$ , the clockwise angular displacement of the bar from the system's equilibrium position, is used as a generalized coordinate. Assume small  $\theta$ .



7. One of the construction companies hires you to determine the dynamic properties of a frame system for which it has lost the original blueprints. Being a civil engineer, you were assigned to do a free vibration test of the frame system. Supplied with a hydraulic jack, you were able to apply a jacking force to displace the frame. With a jacking force of  $134\text{kN}$ , you noted down that the frame has displaced  $0.76\text{cm}$ . On the first return swing after release, the frame did not come back to the release point but rather it stopped at  $0.64\text{cm}$  towards it. You recorded time between the release and the first return as  $2\text{s}$ . Determine the following;

- a. Weight of the frame
  - b. Natural frequency
  - c. Logarithmic decrement
  - d. Damping ratio
  - e. Damping frequency
  - f. Amplitude of the frame after 6 cycles
8. A frame is subjected to harmonic loading as shown in figure. If  $P_0 = 20\text{kN}$ , calculate the dynamic amplification factor and amplitude of steady state response for the following cases. (i)  $\lambda = 10\text{rad/s}$ , (ii)  $\lambda = 15\text{rad/s}$ , (iii)  $\lambda = 20\text{rad/s}$ . Comment on the results. Take  $\zeta = 5\%$  and  $EI = 1010\text{kNmm}^2$ .



9. Derive the expression for the response of a SDOF system subjected to a rectangular impulse of duration  $t_1$  and magnitude  $P_0$ .
10. State and prove the orthogonality condition of normal modes in a MDOF system.
11. Explain mode superposition method of analysis.
12. Derive the differential equation governing the flexural vibration of beams. How will you find the undamped free vibration solution? Demonstrate for a simply supported beam of span  $L$  having uniform flexural rigidity  $EI$  and  $m$  mass per unit length.

| CODE        | COURSE NAME                       | CATEGORY | L | T | P | S | CREDIT |
|-------------|-----------------------------------|----------|---|---|---|---|--------|
| M24CE2E105B | MECHANICS OF COMPOSITE STRUCTURES | ELECTIVE | 3 | 0 | 0 | 3 | 3      |

**Preamble:** The course provides an in-depth understanding of composite structures, encompassing material properties, analysis techniques, and design principles. By integrating theoretical foundations, practical applications, and emerging trends, students will gain valuable insights into the field of composite structural engineering

**Prerequisite** : Mechanics of Solids, Structural Analysis

**Course Outcomes** : After the completion of the course the student will be able to

|             |  |
|-------------|--|
| <b>CO 1</b> | Comprehend the classification, challenges and application of conventional and modern construction materials ( <b>Cognitive Knowledge Level: Understand</b> ) |
| <b>CO 2</b> | Evaluate the properties of various materials used for construction and its behavior under loading. ( <b>Cognitive Knowledge Level: Analyse</b> )             |
| <b>CO 3</b> | Apply analysis techniques to predict deflections, stresses, and failure modes in composite structures. ( <b>Cognitive Knowledge Level: Apply</b> )           |
| <b>CO 4</b> | Design composite beams, slabs, and columns according to industry standards. ( <b>Cognitive Knowledge Level: Analyse</b> )                                    |
| <b>CO 5</b> | make use of emerging trends and innovations in composite materials for application in real world problems ( <b>Cognitive Knowledge Level: Apply</b> )        |

#### Mapping of course outcomes with program outcomes

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
|-------------|------|------|------|------|------|------|
| <b>CO 1</b> | 1    | 1    | 1    | 1    | 1    | 1    |
| <b>CO 2</b> | 1    | 1    | 1    | 2    | 2    | 1    |
| <b>CO 3</b> | 1    | 1    | 2    | 2    | 2    | 1    |
| <b>CO 4</b> | 2    | 1    | 2    | 2    | 2    | 1    |
| <b>CO 5</b> | 2    | 1    | 2    | 2    | 2    | 2    |

**Assessment Pattern**

| Course Name      | MECHANICS OF COMPOSITE STRUCTURES |                 |                                   |
|------------------|-----------------------------------|-----------------|-----------------------------------|
| Bloom's Category | Continuous Evaluation Tests       |                 | End Semester Examination (%Marks) |
|                  | Test 1 (%Marks)                   | Test 2 (%Marks) |                                   |
| Remember         |                                   |                 |                                   |
| Understand       | 20                                | 20              | 20                                |
| Apply            | 40                                | 40              | 40                                |
| Analyse          | 40                                | 40              | 40                                |
| Evaluate         |                                   |                 |                                   |
| Create           |                                   |                 |                                   |

**Mark distribution**

| Total Marks | CIE Marks | ESE marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 100         | 40        | 60        | 3 Hours      |

|  |   |          |
|--|---|----------|
| <b>Continuous Internal Evaluation Pattern</b>                                  | : |          |
| Seminar*   | : | 10 marks |
| Course based task/Micro Project//Data collection and interpretation/Case study | : | 10 marks |
| Test paper 1 (Module 1 and Module 2)   | : | 10 marks |
| Test paper 2 (Module 3 and Module 4)   | : | 10 marks |

\*Seminar should be conducted in addition to the theory hours. Topics for the seminar should be from recent technologies in the respective course

**End Semester Examination Pattern:** The end semester examination will be conducted by the college. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 4 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 8 marks. Total duration of the examination will be 3 Hrs.

## SYLLABUS

### MODULE 1 (6 hours)

**Introduction to Composite Structures:** Definition and classification of composite materials and structures, Historical background and development of composite structures, Advantages and challenges of composite materials in structural engineering, Types of composite structures: steel-concrete, fibre-reinforced polymers (FRP), carbon fibre composites, Functionally graded composites (FGCs).

### MODULE 2 (7 hours)

**Material Properties of Composite Components:** Mechanical properties of steel and concrete materials, Behaviour of steel and concrete under different loading conditions, Composite action between steel and concrete materials, Bond characteristics between steel and concrete interfaces, Durability considerations and environmental effects on composite materials.

### MODULE 3 (10 hours)

**Analysis Methods for Steel-Concrete Composite Structures:** Introduction to composite action in steel-concrete structures, Mechanisms of load transfer between steel and concrete, Influence of shear connectors on load distribution. Linear analysis methods for composite members, Nonlinear analysis techniques (e.g., moment-curvature analysis) for considering material nonlinearity, Comparison of linear and nonlinear approaches in predicting structural behaviour, Analytical formulations for predicting deflections in composite members, Stress analysis using classical methods (e.g., moment-curvature method, yield line theory), Consideration of composite behaviour under different loading conditions (e.g., gravity loads, lateral loads).

### MODULE 4 (7 hours)

**Design of Steel-Concrete Composite Structures:** Principles of composite beam design: flexural, shear, and torsional behaviour, Design codes and standards for composite structures, Composite slab systems: behaviour, design methods, and construction techniques, Composite columns: axial and flexural behaviour, design considerations, Practical design examples and case studies of steel-concrete composite buildings and bridges.

### MODULE 5 (6 hours)

**Advanced Topics in Composite Structures:** Fire resistance of composite structures: fire behaviour, protection methods, Seismic behaviour of composite structures: seismic design principles, retrofitting techniques, Sustainability aspects of composite materials and structures, Emerging trends and innovations in composite structural engineering, Research developments and future directions in the field of composite structures.

**References**

1. Composite Structures: Theory and Practice, by N. Krishna Raju, first edition, 1997.
2. Design of Steel Structures by N. Subramanian, first edition, 2008.
3. Design of Reinforced Concrete Structures by N. Subramanian, first edition, 2009.
4. Advanced Reinforced Concrete Design by Krishna Raju, first edition, 2009.
5. Structural Analysis by Devdas Menon, first edition, 2008.
6. Composite Structures: Design, Mechanics, Analysis, Manufacturing, and Testing by Vinson and Sierakowski, first edition, 1988.
7. Composite Materials: Science and Engineering by Krishan K. Chawla, third edition, 2013.

**COURSE CONTENTS AND LECTURE SCHEDULE**

| No              | Topic   | No. of Lecture/<br>Tutorial hours |
|-----------------|---|-----------------------------------|
| <b>Module 1</b> |   | <b>6</b>                          |
| 1.1             | Definition and classification of composite materials and structures   | 1                                 |
| 1.2             | Historical background and development of composite structures,  | 1                                 |
| 1.3             | Advantages and challenges of composite materials in structural engineering  | 1                                 |
| 1.4             | Types of composite structures: steel-concrete,  | 2                                 |
| 1.5             | fibre-reinforced polymers (FRP), carbon fibre composites  | 1                                 |
| <b>Module 2</b> |   | <b>7</b>                          |
| 2.1             | Mechanical properties of steel and concrete materials   | 1                                 |
| 2.2             | Behaviour of steel and concrete under different loading conditions  | 1                                 |
| 2.3             | Composite action between steel and concrete materials   | 1                                 |
| 2.4             | Bond characteristics between steel and concrete interfaces  | 2                                 |
| 2.5             | Durability considerations and environmental effects on composite materials  | 2                                 |
| <b>Module 3</b> |   | <b>10</b>                         |
| 3.1             | Introduction to composite action in steel-concrete structures, Mechanisms of load transfer between steel and concrete                                 | 1                                 |
| 3.2             | Influence of shear connectors on load distribution  | 1                                 |
| 3.3             | Linear analysis methods for composite members, Nonlinear analysis techniques (e.g., moment-curvature analysis) for considering material nonlinearity, | 2                                 |

M Tech in Computer Aided Structural Engineering

|                 |  |          |
|-----------------|--|----------|
| 3.4             | Comparison of linear and nonlinear approaches in predicting structural behaviour   | 1        |
| 3.5             | Analytical formulations for predicting deflections in composite members  | 1        |
| 3.6             | Stress analysis using classical methods (e.g., moment-curvature method, yield line theory)   | 2        |
| 3.7             | Consideration of composite behaviour under different loading conditions (e.g., gravity loads, lateral loads). Design considerations for composite connections and joints | 2        |
| <b>Module 4</b> |  | <b>7</b> |
| 4.1             | Principles of composite beam design: flexural, shear, and torsional behaviour  | 1        |
| 4.2             | Design codes and standards for composite structures  | 1        |
| 4.3             | Composite slab systems: behaviour, design methods, and construction techniques   | 1        |
| 4.4             | Composite columns: axial and flexural behaviour, design considerations   | 2        |
| 4.5             | Practical design examples and case studies of steel-concrete composite buildings and bridges   | 2        |
| <b>Module 5</b> |  | <b>6</b> |
| 5.1             | Fire resistance of composite structures: fire behaviour, protection methods  | 1        |
| 5.2             | Seismic behaviour of composite structures: seismic design principles, retrofitting techniques  | 2        |
| 5.3             | Sustainability aspects of composite materials and structures   | 1        |
| 5.4             | Emerging trends and innovations in composite structural engineering  | 1        |
| 5.5             | Research developments and future directions in the field of composite structures   | 1        |

**Model Question Paper**

**QP CODE:**

Pages: 2

Reg No.: \_\_\_\_\_

Name: \_\_\_\_\_

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM  
FIRST SEMESTER M.TECH DEGREE EXAMINATION, DECEMBER 2024**

**Course Code: M24CE2E105B**

**Course Name: MECHANICS OF COMPOSITE STRUCTURES**

Max. Marks:60

Duration: 3 hours

**PART A**

***Answer all questions. Each question carries 4 marks.***

1. Compare and contrast the advantages and challenges of using steel-concrete composite structures versus fibre-reinforced polymers (FRP) in civil engineering applications.
2. Discuss the factors influencing the bond characteristics between steel and concrete interfaces in composite components, and their impact on the structural performance.
3. Describe the load distribution and transfer mechanisms commonly observed in composite structures, highlighting the differences between steel-concrete composites and fibre-reinforced polymers (FRP).
4. Discuss the importance of design codes and standards in the design of steel-concrete composite structures, and how these codes ensure safety, reliability, and performance.
5. Discuss the key factors affecting the fire resistance of composite structures, including their fire behavior, protection methods, and the importance of fire-rated materials in structural design.

**PART B**

***Answer any five questions. Each question carries 8 marks.***

1. a. Discuss the historical development of composite structures and the key milestones that have led to their widespread use in structural engineering today.
2. b. What are the key characteristics of composite materials, and how do they differ from traditional materials like steel and concrete?

## M Tech in Computer Aided Structural Engineering

3. Evaluate the composite action between steel and concrete materials in a composite beam under various loading conditions, and propose design modifications to enhance performance based on your analysis.
4. Conduct a comparative analysis of the durability considerations and environmental effects on composite materials, highlighting the differences between steel-concrete composites and fibre-reinforced polymers (FRP) in terms of degradation mechanisms
5. Compare and contrast linear and nonlinear analysis techniques used for analyzing composite members, discussing their respective advantages and limitations in predicting structural behavior.
6. Consider a composite beam consisting of a steel section with dimensions of 150 mm (height) by 100 mm (width) and a concrete slab with dimensions of 150 mm (height) by 300 mm (width). The beam is subjected to a uniformly distributed load of 10 kN/m over a span of 4 meters. The modulus of elasticity for steel is 200 GPa, and for concrete, it is 30 GPa. Calculate the maximum deflection at the mid-span of the beam using a linear analysis approach.
7. Design a composite slab system for a building with the following specifications: span = 6 meters, uniformly distributed load = 15 kN/m<sup>2</sup>, concrete compressive strength = 30 MPa, steel yield strength = 350 MPa. Calculate the required steel reinforcement area and the maximum deflection at mid-span, considering design codes and standards.
8. Evaluate the sustainability aspects of using composite materials and structures in construction projects, considering factors such as life cycle analysis, recyclability, energy efficiency, and environmental impact mitigation strategies.



| CODE        | COURSE NAME                         | CATEGORY | L | T | P | S | CREDIT |
|-------------|-------------------------------------|----------|---|---|---|---|--------|
| M24CE1E105C | ADVANCED DESIGN OF STEEL STRUCTURES | ELECTIVE | 3 | 0 | 0 | 3 | 3      |

**Preamble:** The course provides an in-depth study of limit state design, encompassing tension and compression members, welded and bolted connections, industrial buildings, light gauge structures, and structures resistant to blast, impact, snow, and fire loads, emphasizing practical design principles and analysis methods for various structural components and systems.

**Prerequisite** : Mechanics of Solids and Design of Steel Structures

**Course Outcomes** : After the completion of the course the student will be able to

|             |  |
|-------------|--|
| <b>CO 1</b> | Comprehend the principles of limit state design to various members and analyze and design welded connections ( <b>Cognitive Knowledge Level: Analyze</b> ) |
| <b>CO 2</b> | Analyze and design bolted connections( <b>Cognitive Knowledge Level: Apply</b> )   |
| <b>CO 3</b> | Design members subjected to lateral loads and axial loads and design light gauge structures ( <b>Cognitive Knowledge Level: Apply</b> )                    |
| <b>CO 4</b> | Design structures to resist blast, impact, and fire loads, ( <b>Cognitive Knowledge Level: Apply</b> )   |
| <b>CO 5</b> | Design industrial buildings and gantry girders( <b>Cognitive Knowledge Level: Apply</b> )  |

**Mapping of course outcomes with program outcomes:**

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
|-------------|------|------|------|------|------|------|
| <b>CO 1</b> | 2    | 2    | 2    | 2    | 2    | 1    |
| <b>CO 2</b> | 1    | 2    | 2    | 2    | 2    | 1    |
| <b>CO 3</b> | 1    | 2    | 2    | 2    | 2    | 1    |
| <b>CO 4</b> | 2    | 2    | 2    | 2    | 2    | 2    |
| <b>CO 5</b> | 2    | 2    | 2    | 2    | 2    | 1    |

**Assessment Pattern:**

| Course Name      | Advanced Design of Steel Structures |                  |                                    |
|------------------|-------------------------------------|------------------|------------------------------------|
| Bloom's Category | Continuous Evaluation Tests         |                  | End Semester Examination (% Marks) |
|                  | Test 1 (% Marks)                    | Test 2 (% Marks) |                                    |
| Remember         |                                     |                  |                                    |
| Understand       | 10                                  | 10               | 10                                 |
| Apply            | 50                                  | 50               | 50                                 |
| Analyze          | 40                                  | 40               | 40                                 |
| Evaluate         |                                     |                  |                                    |
| Create           |                                     |                  |                                    |

**Mark distribution:**

| Total Marks | CIE Marks | ESE marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 100         | 40        | 60        | 3 Hours      |

|  |   |          |
|--|---|----------|
| <b>Continuous Internal Evaluation Pattern</b>                                  | : |          |
| Seminar*   | : | 10 marks |
| Course based task/Micro Project//Data collection and interpretation/Case study | : | 10 marks |
| Test paper 1 (Module 1 and Module 2)   | : | 10 marks |
| Test paper 2 (Module 3 and Module 4)   | : | 10 marks |

\*Seminar should be conducted in addition to the theory hours. Topics for the seminar should be from recent technologies in the respective course.

**End Semester Examination Pattern:** The end semester examination will be conducted by the college. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 4 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 8 marks. Total duration of the examination will be 3 Hrs.

## SYLLABUS

### MODULE 1 (7 hours)

Limit state design: Review: Tension members, compression members and laterally supported and unsupported beams; bolted and welded connections subjected to in-plane and out of plane loading; splice connections.

Welded Connections: Structure and properties of weld metal. Beam-to-column connections and angle seat, Stiffened beam seat connection and web angle and end plate connections and Beam and column welded splices, Tubular connections and Parameters of an in-plane joint. Welds in tubular joints and curved weld length at intersection of tubes and SHS and RHS tubes and design parameters and Weld defects.

### MODULE 2 (7 hours)

Bolted Connections: Classification (Simple, Rigid, Semi rigid), Moment rotation characteristics Failure modes of a joint, Types of bolts, Bearing and High strength bolts Prying force, Beam to Column connections, Design of seat angle Unstiffened, Design of seat angle Stiffened Web angle & end plate connections, Beam and column bolted splices Design of framed beam connection continuous beam to beam connection.

### MODULE 3 (8 hours)

Design of members subjected to lateral loads and axial loads : Principles of analysis and design of industrial buildings and bents – Crane gantry girders and crane columns – Bracing of industrial buildings and bents - Introduction – Shape factors – Moment redistribution Static, Kinematic and uniqueness theorems – Combined mechanisms – Analysis Portal frames. Method of plastic moment distribution – Connections, moment resisting connections.

Design of Light Gauge Structures: Design of light gauge steel structures: Introduction, Types of cross sections, Local and post buckling of thin elements, Stiffened and multiple stiffened compression elements, Tension members, Beams and deflection of beams Combined stresses and connections.

### MODULE 4 (6 hours)

Design of Blast, Impact, Snow and Fire-resistant structures: Blast loads, impact loads, Ice-infested loads on structures, Fire loads, Fire-resistant design, Simple problems in Fire loads calculations. Design of Low-rise multi-storey building steel structure for housing, with and without interior walls and partitions. Planning and structural framing.

### MODULE 5 (8 hours)

Design of Industrial buildings and Gantry girders: Design of members subjected to lateral loads and

## M Tech in Computer Aided Structural Engineering

axial loads sway and non-sway frames, bracings, and bents Rigid frame joints Knees for rectangular frames and pitched roofs - Knees with curved flanges, Valley joints - Rigid joints in multistory buildings, Vierendeel girders. Design of gantry girders, Introduction, Loading consideration, Selection of gantry girder, Position of moving load for maximum effects, profile of gantry girder, limitation on vertical deflection, Design of gantry girders.

### References

1. Punmia B. C., Jain A. K. and Jain A. K., "Design of Steel Structures", Laxmi Publications (P)
2. S. K. Duggal, Design of Steel Structures.
3. Bhavikatti S. S., "Design of Steel Structures: By Limit State Method as Per IS: 800-2007".
4. Srinivasan Chandrasekaran, "Advanced Design of Steel Structures".
5. Ramchandra S and Virendra Gehlot, "Design of Steel Structures Vol. II", Standard Book
6. N.Subramanian, "Steel Structures", Oxford Publication
7. P. Dayaratnam., "Design of Steel Structures", Wheeler Publishing, 2003\
8. IS 800 – 2007, "Code of practice for Structural steel design", BIS
9. IS:875-Part 3-2015 "Design loads for buildings Part 3: Wind loads", BIS

### COURSE CONTENTS AND LECTURE SCHEDULE

| No  | Topic   | No. of Lecture/<br>Tutorial hours |
|-----|---|-----------------------------------|
|     | <b>Module 1</b>   | <b>7</b>                          |
| 1.1 | Review: Tension members, compression members and laterally supported and unsupported beams.   | 2                                 |
| 1.2 | Bolted and welded connections subjected to in-plane and out of plane loading; splice connections.   | 1                                 |
| 1.3 | Structure and properties of weld metal. Beam-to-column connections and Angle seat.  | 1                                 |
| 1.4 | Stiffened beam seat connection and Web angle and end plate connections and Beam and column welded splices   | 1                                 |
| 1.5 | Tubular connections and Parameters of an in-plane joint   | 1                                 |
| 1.6 | Welds in tubular joints and curved weld length at intersection of tubes and SHS and RHS tubes and design parameters and Weld defects.               | 1                                 |
|     | <b>Module 2</b>   | <b>7</b>                          |
| 2.1 | Classification (Simple, Rigid, Semi rigid)  | 1                                 |
| 2.2 | Moment rotation characteristics, Failure modes of a joint, Types of bolts, Bearing and High strength bolts Prying force, Beam to Column connections | 2                                 |

M Tech in Computer Aided Structural Engineering

|                 |   |          |
|-----------------|---|----------|
| 2.3             | Design of seat angle- Unstiffened   | 1        |
| 2.4             | Design of seat angle Stiffened Web angle & end plate connections, Beam and column bolted splices  | 2        |
| 2.5             | Design of framed beam connection continuous beam to beam connection.  | 1        |
| <b>Module 3</b> |   | <b>8</b> |
| 3.1             | Principles of analysis and design of Industrial buildings and bents   | 1        |
| 3.2             | Principles of analysis and design – Crane gantry girders and crane columns – Bracing of industrial buildings and bents.   | 2        |
| 3.3             | Introduction – Shape factors – Moment redistribution Static, Kinematic and uniqueness theorems – Combined mechanisms – Analysis Portal frames. Method of plastic moment distribution – Connections, moment resisting connections. | 2        |
| 3.4             | Design of light gauge steel structures: Introduction, Types of cross sections, Local and post buckling of thin elements   | 1        |
| 3.5             | Stiffened and multiple stiffened compression elements, Tension members, Beams and deflection of beams Combined stresses and connections.  | 2        |
| <b>Module 4</b> |   | <b>6</b> |
| 4.1             | Blast loads, impact loads, Ice-infested loads on structures, Fire loads   | 2        |
| 4.2             | Fire-resistant design, Simple problems in Fire loads calculations.  | 2        |
| 4.3             | Design of Low rise multi-storey building steel structure for housing, with and without interior walls and partitions. Planning and structural framing   | 2        |
| <b>Module 5</b> |   | <b>8</b> |
| 5.1             | Design of members subjected to lateral loads and axial loads Sway and non-sway frames, bracings, and bents.   | 3        |
| 5.2             | Rigid frame joints Knees for rectangular frames and pitched roofs - Knees with curved flanges, Valley joints - Rigid joints in multistory buildings, Vierendeel girders.  | 2        |
| 5.3             | Design of gantry girders, Introduction, Loading consideration, Selection of gantry girder, Position of moving load for maximum effects, profile of gantry girder, limitation on vertical deflection, Design of gantry girders.    | 3        |

**Model Question Paper**

**QP CODE:**

Pages: 2

Reg. No.: \_\_\_\_\_

Name: \_\_\_\_\_

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM  
FIRST SEMESTER M.TECH DEGREE EXAMINATION, DECEMBER 2024**

*Course Code: M24CE1E105C*

*Course Name: ADVANCED DESIGN OF STEEL STRUCTURES*

Max. Marks:60

Duration: 3 hours

**PART A**

*Answer all questions. Each question carries 4 marks.*

1. Apply the principles of limit state design to distinguish between tension and compression members, and utilize knowledge of weld metal properties in designing welded connections.
2. Identify the factors that influence the moment-rotation characteristics and failure modes of bolted joints.
3. Outline the considerations for designing light gauge steel structures to prevent local and post-buckling.
4. Analyze how blast, impact, snow, and fire loads influence the design of structures, and propose strategies to mitigate these effects.
5. Elucidate the process of designing gantry girders and industrial buildings to manage lateral and axial loads.

**PART B**

*Answer any five questions. Each question carries 8 marks.*

6. Design a tension member made of a steel flat section subjected to an axial tensile force of 200 kN. The member length is 3 meters. Assume the steel grade is Fe410 and use the limit state design method to determine the required cross-sectional area and size of the flat section. Provide necessary calculations and justify your choices with appropriate figures.
7. Design a welded beam-to-column connection for a steel frame structure. The beam carries an end moment of 40 kNm and a shear force of 60 kN. Use E70 electrodes and assume the column

is an ISHB 300 section. Provide a detailed design of the weld size and length, including necessary calculations and a sketch of the connection.

8. Design a bolted beam-to-column end-plate connection for a steel frame. The beam is an ISMB 400 and the column is an ISHB 450. The connection must resist a moment of 50 kNm and a shear force of 80 kN. Use M20 bolts of grade 8.8. Provide a detailed design, including bolt arrangement, end-plate thickness, and a sketch of the connection with dimensions.
9. Analyse the moment-rotation characteristics and failure modes of a semi-rigid bolted joint in a steel structure. The joint consists of an end-plate connection with 4 bolts (M16, grade 8.8). Discuss how the bolt pretension, connection geometry, and material properties influence the joint's behavior.
10. Design a light gauge steel C-section beam for a span of 4 meters subjected to a uniformly distributed load of 2 kN/m. Ensure that local and post-buckling behavior is considered in your design. Provide detailed calculations, selection of the C-section, and a diagram of the beam with loading conditions and dimensions.
11. Design a fire-resistant steel column for a multi-story building. The column is subjected to an axial load of 500 kN and must have a fire resistance rating of 2 hours. Select appropriate fireproofing materials and methods, and calculate the required column dimensions. Provide a detailed design and a diagram showing the column, fireproofing layers, and loading conditions.
12. Evaluate the structural design of an industrial building subjected to blast loads. Assume the building has a steel frame with a height of 8 meters and a span of 20 meters. Discuss the impact of blast loads on the design and propose strategies for blast mitigation. Include relevant calculations and a schematic diagram of the building's frame.



| CODE        | COURSE NAME                            | CATEGORY | L | T | P | S | CREDIT |
|-------------|--|----------|---|---|---|---|--------|
| M24CE2E105D | CHARACTERIZATION OF BUILDING MATERIALS | ELECTIVE | 3 | 0 | 0 | 3 | 3      |

**Preamble:** The course offers a comprehensive understanding of material characterization, emphasizing its critical role in engineering and construction. It provides an in-depth exploration of a range of characterization techniques, enabling students to analyze the physical, mechanical, and chemical properties of construction materials. This also covers fundamental property assessment utilizing spectroscopic and nondestructive testing techniques. By integrating these approaches, the course equips students with the advanced analytical skills necessary for selecting materials for various construction projects.

**Prerequisite** : NIL

**Course Outcomes** : After the completion of the course the student will be able to

|      |   |
|------|---|
| CO 1 | Understand the chemical and physical properties of various materials used for construction<br>(Cognitive Knowledge Level: Understand)   |
| CO 2 | Analyze different materials utilising various macroscopic and microscopic techniques.<br>(Cognitive Knowledge Level: Analyse)   |
| CO 3 | Analyse the chemical parameters of different materials with the help of various spectroscopy techniques (Cognitive Knowledge Level: Analyse)  |
| CO 4 | Analyse the mechanical properties of various materials under consideration utilizing different nondestructive testing techniques. (Cognitive Knowledge Level: Analyse)                                  |
| CO 5 | Analyse the pore structure of different construction materials enabling students to effectively select materials based on the requirements during construction.<br>(Cognitive Knowledge Level: Analyse) |

#### Mapping of course outcomes with program outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
|------|------|------|------|------|------|------|
| CO 1 | 1    | 1    | 1    | 2    | 2    | 1    |
| CO 2 | 2    | 1    | 2    | 2    | 2    | 1    |
| CO 3 | 2    | 1    | 2    | 2    | 2    | 1    |
| CO 4 | 1    | 1    | 2    | 2    | 2    | 1    |
| CO 5 | 1    | 1    | 1    | 1    | 2    | 1    |

**Assessment Pattern**

| Course Name      | Characterization of Building Materials |                 |                                   |
|------------------|--|-----------------|-----------------------------------|
| Bloom's Category | Continuous Evaluation Tests            |                 | End Semester Examination (%Marks) |
|                  | Test 1 (%Marks)                        | Test 2 (%Marks) |                                   |
| Remember         | -                                      | -               | -                                 |
| Understand       | 10                                     | 10              | 10                                |
| Apply            | 20                                     | 20              | 20                                |
| Analyse          | 70                                     | 70              | 70                                |
| Evaluate         | -                                      | -               | -                                 |
| Create           | -                                      | -               | -                                 |

**Mark distribution**

| Total Marks | CIE Marks | ESE marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 100         | 40        | 60        | 3 Hours      |

|  |   |          |
|--|---|----------|
| <b>Continuous Internal Evaluation Pattern</b>                                  | : |          |
| Seminar*   | : | 10 marks |
| Course based task/Micro Project//Data collection and interpretation/Case study | : | 10 marks |
| Test paper 1 (Module 1 and Module 2)   | : | 10 marks |
| Test paper 2 (Module 3 and Module 4)   | : | 10 marks |

\*Seminar should be conducted in addition to the theory hours. Topics for the seminar should be from recent technologies in the respective course

**End Semester Examination Pattern:** The end semester examination will be conducted by the college. There will be two parts; Part A and Part B. Part A contain 5 questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 4 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 8 marks. Total duration of the examination will be 3 Hrs.

## SYLLABUS

### MODULE 1 (6 hours)

Importance of Material characterization - Classification of techniques for characterization - Physical Properties of Building Materials: Density, porosity, specific gravity, Thermal conductivity and specific heat capacity - Mechanical properties: strength, elasticity, and toughness - Chemical Properties of Building Materials - Overview of Structure of construction materials.

### MODULE 2 (8 hours)

Material characterization using macroscopic and microscopic techniques: visual examination - optical microscopy: types of optical microscopy, features and functions - scanning electron microscopy: Features and functions, working principle - Analysis of cementitious systems.

### MODULE 3 (8 hours)

Spectroscopic Techniques for chemical analysis: UV-Visual (UV-VIS), IR, Fourier Transform Infrared Spectroscopy, Nuclear Magnetic Resonance Spectroscopy, Atomic absorption spectrometer (AAS), Atomic Emission spectroscopy (AES).

X-ray diffraction method: Brags Law - introduction to X Rays and crystallography - crystal systems and history of XRD - determination of crystal structure - lattice parameter, crystallite size - merits and demerits.

### MODULE 4 (7 hours)

Strain measurement: surface properties and pore structure – significance of pore distribution – NDT: advantages, disadvantages - Fundamental principles of the techniques: Ultrasonic pulse velocity Method, Rebound Hammer, Core sampling technique, Pullout experiment, acoustic emission and electromagnetic method and their application to construction materials.

### MODULE 5 (7 hours)

Surface Area Measurement Techniques: Gas Sorption Techniques, Mercury Intrusion Porosimetry, Wagner Turbidimeter, Permeability Methods, Small Angle X-Ray Scattering (SAXS) and Small Angle Neutron Scattering (SANS), Image Analysis.

Characterization of material behavior: Rheology and viscoelasticity - rheological behavior of concrete - different types of rheometers.

**References**

1. Karen Scrivener, Ruben Snellings, Barbara Lothenbach, A Practical Guide to Microstructural Analysis of Cementitious Materials, CRC Press, 2015.
2. V. S. Ramachandran and James J. Beaudoin, Eds., Handbook of Analytical Techniques in Concrete Science and Technology, William Andrew Publishing, New York, 2001.
3. D A St. John, A. W. Poole, and I. Sims, Concrete Petrography “A Handbook of Investigative Techniques”, Arnold Publishing. London, 1998.
4. William D. Callister, Materials Science and Engineering: An Introduction, Sixth Edition, John Wiley and Sons, 2003.
5. Jan Skalny, Editor, Materials Science of Concrete, Volumes I “VII, American Ceramic Society, 1989 “2005.
6. J. M. Illston and P. L. J. Domone, Construction Materials “Their Nature and Behaviour, Third Edition, Spon Press, 2001.
7. J.F. Young, S. Mindess, R.J. Gray and A. Bentur, The Science and Technology of Civil Engineering Materials, Prentice Hall, 1998.

**COURSE CONTENTS AND LECTURE SCHEDULE**

| No              | Topic  | No. of Lecture/<br>Tutorial hours |
|-----------------|--|-----------------------------------|
| <b>Module 1</b> |  | <b>6</b>                          |
| 1.1             | Importance of Material characterization, Classification of techniques for characterization | 1                                 |
| 1.2             | Physical Properties of Building Materials- Density, porosity and specific gravity          | 1                                 |
| 1.3             | Thermal conductivity and specific heat capacity  | 1                                 |
| 1.4             | Mechanical properties: strength, elasticity, and toughness                                 | 1                                 |
| 1.5             | Chemical Properties of Building Materials  | 1                                 |
| 1.6             | Overview of Structure of construction materials  | 1                                 |
| <b>Module 2</b> |  | <b>8</b>                          |
| 2.1             | Material characterization using macroscopic and microscopic techniques: visual examination | 1                                 |
| 2.2             | optical microscopy - Types of optical microscopy, features and functions                   | 1                                 |
| 2.3             | Scanning electron microscopy – Features and functions, working principle                   | 3                                 |
| 2.4             | Analysis of cementitious systems   | 3                                 |

M Tech in Computer Aided Structural Engineering

|     |  |          |
|-----|--|----------|
|     | <b>Module 3</b>  | <b>8</b> |
| 3.1 | Spectroscopic Techniques for chemical analysis: UV-Visual (UV-VIS), IR   | 1        |
| 3.2 | Fourier Transform Infrared Spectroscopy, Nuclear Magnetic Resonance Spectroscopy                                     | 2        |
| 3.3 | Atomic absorption spectrometer (AAS), Atomic Emission spectroscopy (AES)   | 1        |
| 3.4 | X-ray diffraction method: Brags Law, introduction to X Rays and crystallography                                      | 2        |
| 3.5 | Crystal systems and history of XRD, determination of crystal structure   | 1        |
| 3.6 | Lattice parameter, crystallite size, merits and demerits   | 1        |
|     | <b>Module 4</b>  | <b>7</b> |
| 4.1 | Strain measurement   | 1        |
| 4.2 | surface properties and pore structure – significance of pore distribution  | 1        |
| 4.3 | NDT-advantages, disadvantages  | 1        |
| 4.4 | Fundamental principles of the techniques- Ultrasonic pulse velocity Method, Rebound Hammer                           | 2        |
| 4.5 | Core sampling technique, Pullout experiment  | 1        |
| 4.6 | Acoustic emission and electromagnetic method and the application of various NDT techniques to construction materials | 1        |
|     | <b>Module 5</b>  | <b>7</b> |
| 5.1 | Surface Area Measurement Techniques - Gas Sorption Techniques, Mercury Intrusion Porosimetry                         | 2        |
| 5.2 | Wagner Turbidimeter, Permeability Methods  | 1        |
| 5.3 | Small Angle X-Ray Scattering (SAXS) and Small Angle Neutron Scattering (SANS), Image Analysis                        | 2        |
| 5.4 | Characterization of material behaviour: Rheology and viscoelasticity   | 1        |
| 5.5 | Rheological behavior of concrete, different types of rheometers  | 1        |

**Model Question Paper**

**QP CODE:**

Pages: 1

Reg No.: \_\_\_\_\_

Name: \_\_\_\_\_

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM  
FIRST SEMESTER M.TECH DEGREE EXAMINATION, DECEMBER 2024**

**Course Code: M24CE2E105D**

**Course Name: CHARACTERIZATION OF BUILDING MATERIALS**

Max. Marks:60

Duration: 3 hours

**PART A**

*Answer all questions. Each question carries 4 marks.*

1. What is the need for characterisation?
2. What is optical microscopy? Explain the types of optical microscopy.
3. Analyse Atomic Absorption spectroscopy.
4. Inspect the significance of pore distribution.
5. Outline the rheological behavior of concrete.

**PART B**

*Answer any five questions. Each question carries 8 marks.*

6. Compare the various techniques used for characterization of construction materials.
7. Analyse the operation and working principle of scanning electron microscopy.
8. Analyse Fourier Transform Infrared Spectroscopy and Nuclear Magnetic Resonance Spectroscopy.
9. Categorize the advantages and disadvantages of nondestructive testing and the various techniques involved in it.
10. Compare the various techniques of surface area measurement.
11. Explain the discovery of X ray diffraction and the merits and demerits of X ray diffraction method.
12. Analyse the technique of Image analysis and the steps involved in it.

| CODE       | COURSE NAME                         | CATEGORY | L | T | P | S | CREDIT |
|------------|-------------------------------------|----------|---|---|---|---|--------|
| M24CE1L107 | ADVANCED STRUCTURAL ENGINEERING LAB | LAB      | 0 | 0 | 3 | 3 | 2      |

**Preamble:** This course provides practical experience in advanced concrete technology and structural testing. Students will conduct experiments including mix designs for high-strength, self-compacting, and fiber-reinforced concrete, as well as flexural and slab testing. Additionally, non-destructive evaluations, corrosion measurements, sorptivity tests, and modulus of elasticity determination will be performed. This hands-on course reinforces theoretical concepts and equips students with essential skills for modern structural engineering practices.

**Prerequisite:** Material Testing Laboratory II

**Course Outcomes:** After the completion of the course the student will be able to

|             |  |
|-------------|--|
| <b>CO 1</b> | Develop different grades of high-performance concrete mixes.<br>(Cognitive knowledge level: Apply)                       |
| <b>CO 2</b> | Identify the failure mechanisms of RC structural members in flexure.<br>(Cognitive knowledge level: Apply)               |
| <b>CO 3</b> | Evaluate the material characteristics of existing structures using NDT methods.<br>(Cognitive knowledge level: Evaluate) |
| <b>CO 4</b> | To identify the corrosion in a reinforced concrete system.<br>(Cognitive knowledge level: Apply)                         |
| <b>CO 5</b> | Evaluate the durability characteristics of the concrete.<br>(Cognitive knowledge level: Evaluate)                        |

**Mapping of course outcomes with program outcomes**

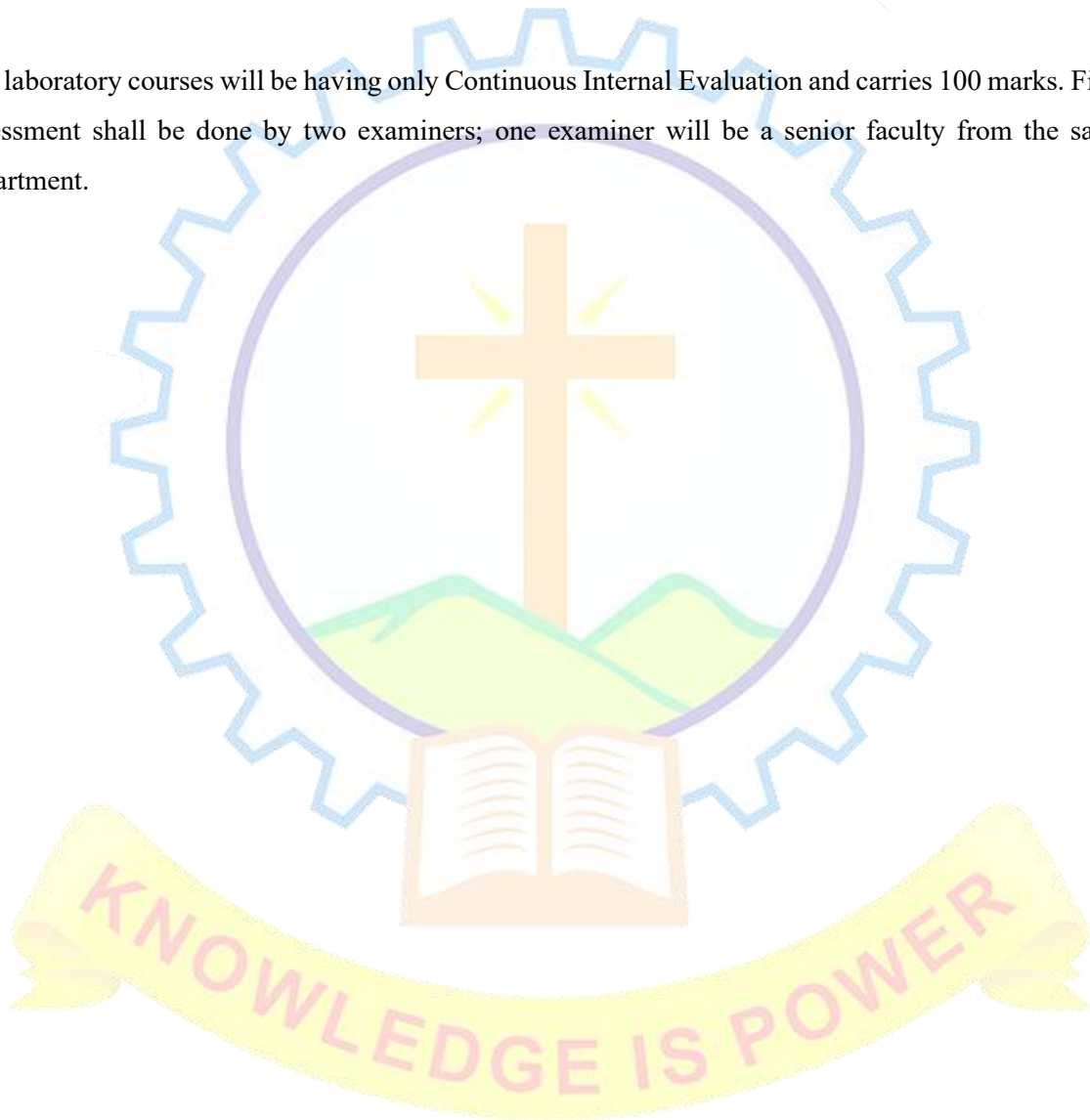
|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
|-------------|------|------|------|------|------|------|
| <b>CO 1</b> | 2    |      | 2    | 3    | 2    | 2    |
| <b>CO 2</b> | 2    |      | 2    | 3    | 2    | 2    |
| <b>CO 3</b> | 2    |      | 2    | 3    | 2    | 2    |
| <b>CO 4</b> | 2    |      | 2    | 3    | 2    | 2    |
| <b>CO 5</b> | 2    |      | 2    | 3    | 2    | 2    |

**Mark distribution**

| <b>Total Marks</b> | <b>CIE Marks</b> | <b>ESE Marks</b> |
|--------------------|------------------|------------------|
| 100                | 60               | 40               |

|   |   |          |
|---|---|----------|
| <b>Continuous Internal Evaluation Pattern</b> | : |          |
| Lab work and Viva-voce                        | : | 60 marks |
| Final assessment Test and Viva voice          | : | 40 marks |

The laboratory courses will be having only Continuous Internal Evaluation and carries 100 marks. Final assessment shall be done by two examiners; one examiner will be a senior faculty from the same department.



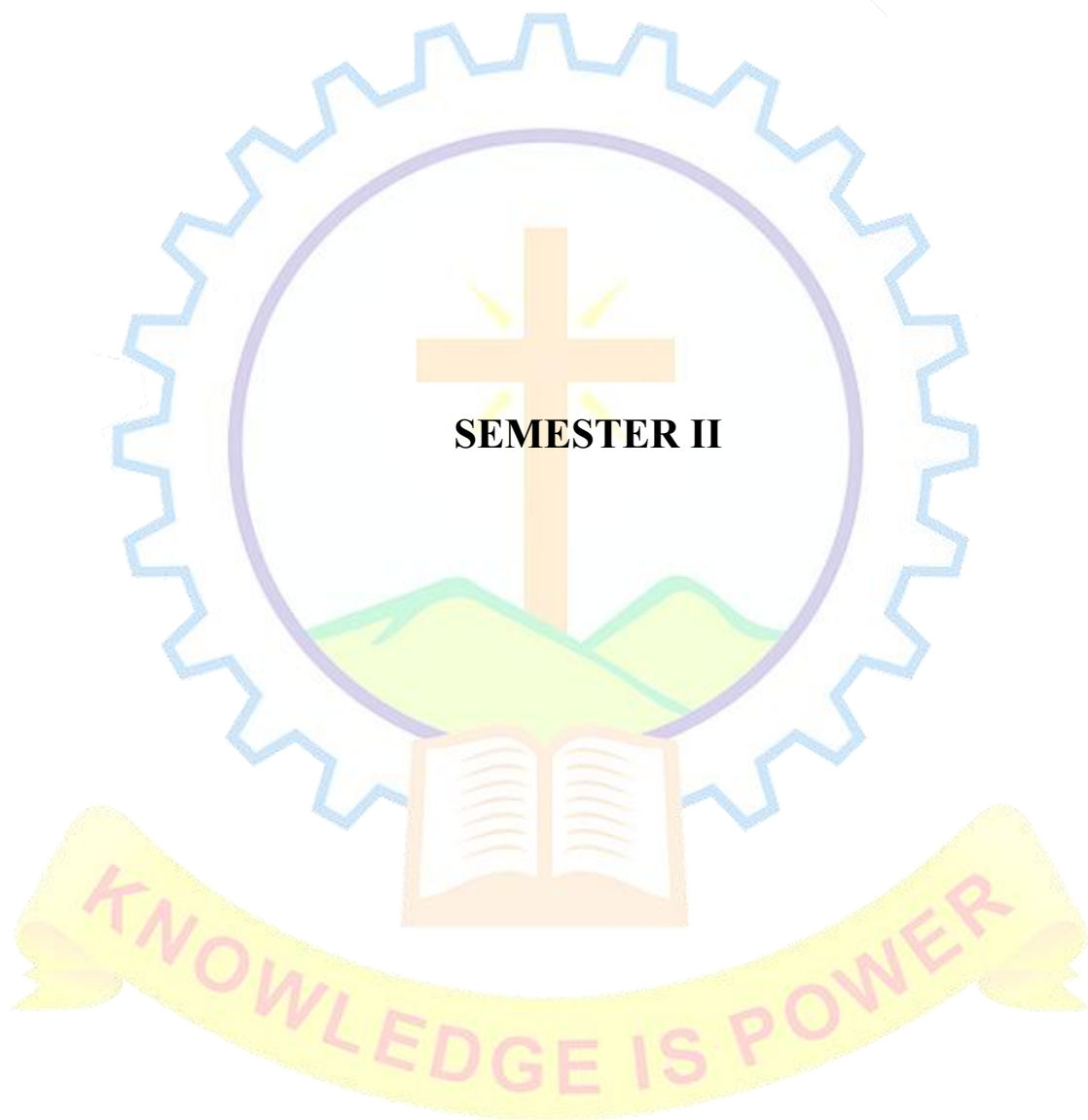
**SYLLABUS**

**LIST OF EXPERIMENTS**

|    |   |
|----|---|
| 1  | Marsh cone and mini slump   |
| 2  | Mix design for high strength concrete   |
| 3  | Mix design of self-compacting concrete  |
| 4  | Determine mechanical properties like Flexure, compressive strength, split tensile strength, Modulus of elasticity of high strength concrete |
| 5  | Non-destructive evaluation by ultrasonic pulse velocity equipment, rebound hammer, and rebar locator  |
| 6  | Corrosion measurements using a half-cell potentiometer  |
| 7  | Sorptivity test on concrete   |
| 8  | Mix design for fiber-reinforced concrete and determination of fracture toughness.   |
| 9  | Sorptivity test and water permeability test on concrete   |
| 10 | Study of shrinkage-Drying   |

**References**

1. H.G. Harris and G.M. Sabnis, "Structural Modeling and Experimental Techniques", 2nd Ed, CRC Press, 1999.
2. E. Bray and R. K. Stanley, "Non Destructive Evaluation", CRC Press, 2002.
3. J.W. Dally and W.F. Riley, "Experimental Stress Analysis", McGraw Hill, 3rd Ed, 1991.
4. J.F. Doyle, "Modern Experimental Stress Analysis", John Wiley and Sons, 2004.
5. P.C. Aitcin, "High-Performance Concrete", E & FN SPON, 1998.



| CODE       | COURSE NAME                            | CATEGORY | L | T | P | S | CREDIT |
|------------|--|----------|---|---|---|---|--------|
| M24CE1T201 | ADVANCED DESIGN OF CONCRETE STRUCTURES | CORE     | 4 | 0 | 0 | 4 | 4      |

**Preamble:** The course covers the fundamental design principles of advanced concrete elements, including continuous beams, slender columns, flat slabs, grid floors, reinforced concrete footings, and pile caps. It emphasizes critical considerations such as deflection and cracking control and detailing for ductility, in structural members. Through this course, students will acquire an in-depth understanding of advanced concrete design principles and their practical applications in real-world scenarios.

**Prerequisite :** Understanding of structural analysis and the design of concrete structures.

**Course Outcomes:** After the completion of the course the student will be able to

|             |  |
|-------------|--|
| <b>CO 1</b> | Analyze and design continuous beams and portal frames considering moment redistribution. <b>(Cognitive Knowledge Level: Analyse)</b>                                     |
| <b>CO 2</b> | Apply the design of slender columns and shear walls under various loading conditions. <b>(Cognitive Knowledge Level: Apply)</b>  |
| <b>CO 3</b> | Apply the yield line method for the analysis and design of slabs, and to design floor systems like grid floors and flat slabs. <b>(Cognitive Knowledge Level: Apply)</b> |
| <b>CO 4</b> | Apply the design reinforced concrete footings and pile caps subjected to bending in real world scenarios. <b>(Cognitive Knowledge Level: Apply)</b>                      |
| <b>CO 5</b> | Examine the deflection and cracking in concrete structures and ensure detailing for ductility and fire resistance. <b>(Cognitive Knowledge Level: Analyse)</b>           |

#### Mapping of course outcomes with program outcomes

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
|-------------|------|------|------|------|------|------|
| <b>CO 1</b> | 2    | 1    | 2    | 2    | 2    | 2    |
| <b>CO 2</b> | 2    | 1    | 2    | 2    | 2    | 2    |
| <b>CO 3</b> | 2    | 1    | 2    | 2    | 2    | 2    |
| <b>CO 4</b> | 2    | 1    | 2    | 2    | 2    | 2    |
| <b>CO 5</b> | 2    | 1    | 2    | 2    | 2    | 2    |

**Assessment Pattern**

| Course Name      | Advanced Design of Concrete Structures |                 |                                   |
|------------------|--|-----------------|-----------------------------------|
| Bloom's Category | Continuous Evaluation Tests            |                 | End Semester Examination (%Marks) |
|                  | Test 1 (%Marks)                        | Test 2 (%Marks) |                                   |
| Remember         |  |                 |                                   |
| Understand       | 20                                     | 20              | 20                                |
| Apply            | 50                                     | 50              | 50                                |
| Analyse          | 30                                     | 30              | 30                                |
| Evaluate         |  |                 |                                   |
| Create           |  |                 |                                   |

**Mark distribution**

| Total Marks | CIE Marks | ESE marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 100         | 40        | 60        | 3 Hours      |

**Continuous Internal Evaluation Pattern**

|                                      |   |          |
|--------------------------------------|---|----------|
| Micro project/Course based project   | : | 10 marks |
| Course based task/Seminar/Quiz       | : | 10 marks |
| Test paper 1 (Module 1 and Module 2) | : | 10 marks |
| Test paper 2 (Module 3 and Module 4) | : | 10 marks |

**End Semester Examination:** The end semester examination will be conducted by the college. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 4 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 8 marks. Total duration of the examination will be 3 Hrs.

## SYLLABUS

### MODULE 1 (10 hours)

Introduction to continuous beams, definition and significance in structural engineering, analysis of loading conditions for maximum moment, overview of IS code provisions and design coefficients, design problems and practical applications, redistribution of moments and its implications in design.

Introduction to portal frames, basic concepts and structural behavior, analysis and design of portal frames, design problems and real-world examples.

### MODULE 2 (9 hours)

Introduction to Slender columns, characteristics and significance in structural design, analysis of additional moments due to slenderness, behavior of columns under axial compression, uniaxial, and biaxial bending, generation and application of P-M interaction diagrams, design examples.

Introduction to shear walls, classification, importance in lateral load resistance, Basic concepts and design considerations, design examples.

### MODULE 3 (11 hours)

Yield line method of analysis of slabs, characteristic features of yield lines, analysis by virtual work method. Introduction to grid floors, design concepts and example.

### MODULE 4 (12 hours)

Introduction to flat slabs, components, IS code provisions for design, design examples of exterior and interior panel. Control of deflection, immediate and long-term deflection, control of cracking, detailing for ductility .

### MODULE 5 (6 hours)

Introduction to footings, classifications, design of isolated square and rectangular footing,

Introduction to pile, and pile cap, classifications, design of end-bearing piles, Design of piles cap for two, three and four piles.

### References

1. Pillai S. U. and Menon D., "Reinforced Concrete Design", Tata McGraw-Hill (2016).
2. Arthur H. Nilson, David Darwin & Charles W. Dolan, "Design of Concrete Structures", Tata McGraw Hill, 2004
3. Park R. & Paulay T., "Design of Concrete Structures", John Wiley & Sons, New York, 1975
4. Varghese P.C., "Advanced Reinforced Concrete Design", Prentice Hall of India, 2005.
5. Punmia B.C. , Ashok k. Jain, Arun k. Jain. Reinforced Concrete Structures Vol. II. Laxmi

Publications, 10th edition, 2021.

6. Advanced R.C.C. Design (R.C.C. Volume-II). By S. S. Bhavikatti, [New Age International \(P\) Limited](#), 3rd edition, 2018.
7. IS456-2000 (2000) Indian Standard Plain and Reinforced Concrete Code of Practice. Bureau of Indian Standards, New Delhi.

### COURSE CONTENTS AND LECTURE SCHEDULE

| No              | Topic  | No. of Lecture/<br>Tutorial hours |
|-----------------|--|-----------------------------------|
| <b>Module 1</b> |  | <b>10</b>                         |
| 1.1             | Introduction to continuous beams, loading conditions for maximum moment, IS code provisions and design coefficients, | 2                                 |
| 1.2             | Design problems  | 3                                 |
| 1.3             | Redistribution of moments, design after redistribution   | 2                                 |
| 1.4             | Portal frames design problems  | 3                                 |
| <b>Module 2</b> |  | <b>9</b>                          |
| 2.1             | Slender columns, design concepts and failure mode.   | 2                                 |
| 2.2             | Column under axial compression, and uniaxial and biaxial bending, design examples.                                   | 3                                 |
| 2.3             | Generation of P-M interaction diagram  | 1                                 |
| 2.4             | Classification of shear wall and loading conditions.   | 1                                 |
| 2.5             | Design of shear wall.  | 2                                 |
| <b>Module 3</b> |  | <b>8</b>                          |
| 3.1             | Yield line method of analysis of slabs, characteristic features of yield lines                                       | 2                                 |
| 3.2             | Analysis by virtual work method  | 2                                 |
| 3.3             | Introduction to Grid floors, design concepts and example   | 4                                 |
| <b>Module 4</b> |  | <b>8</b>                          |
| 4.1             | Introduction to flat slabs, components, IS code provisions for design  | 1                                 |
| 4.2             | Design examples of exterior and interior panel   | 4                                 |
| 4.3             | Control of deflection  | 1                                 |
| 4.4             | Immediate and long-term deflection, control of cracking  | 1                                 |
| 4.5             | Detailing for ductility  | 1                                 |

M Tech in Computer Aided Structural Engineering

|     | <b>Module 5</b>                                     | <b>10</b> |
|-----|---|-----------|
| 5.1 | Introduction to footings, and classifications.      | 1         |
| 5.2 | Design of isolated square and rectangular footing   | 3         |
| 5.3 | Introduction to pile, and pile cap, classifications | 1         |
| 5.4 | Design of end-bearing piles                         | 2         |
| 5.5 | Design of piles cap for two, three and four piles.  | 3         |



**Model Question Paper**

**QP CODE:**

Pages: 2

Reg No.: \_\_\_\_\_

Name: \_\_\_\_\_

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM  
SECOND SEMESTER M.TECH DEGREE EXAMINATION, MAY 2025**

**Course Code: M24CE1T201**

**Course Name: ADVANCED DESIGN OF CONCRETE STRUCTURES**

Max. Marks: 60

Duration: 3 hours

**PART A**

**Answer all questions. Each question carries 4 marks.**

1. How can codal provisions applied for the concept of redistribution of moments.
2. Compare ordinary RCC wall and shear wall with sketches.
3. Enumerate the limitations of yield line theory.
4. Outline the design considerations of pile caps.
5. Compare the short-term deflection and long-term deflection in reinforced concrete flexural members.

**PART B**

**Answer any five questions. Each question carries 8 marks.**

6. a. A continuous beam of a multi-storied frame has three equal spans of 8m each. The characteristic DL is 10 kN/m and the characteristic LL is 15 kN/m. Design the critical section of the beams using the limit state method. Use M20 Concrete and Fe 500 grade steel.

(4 marks)

- b. Design a portal frame hinged at the base to suit the following data

Spacing of portal frame = 4m

Height of column = 4m

Distance between the column centers = 10m

LL on roof = 1.5kN/m<sup>2</sup>

RCC Slab continues over the portal frame

SBC = 200 kN/m<sup>2</sup>

Adopt M20 concrete and Fe 415 steel

(4 marks)

7. a. A shear wall 200mm x 600mm is subjected to an axial load of 12000 kN and a moment of 11000kNm. Design considering the following.
- using interaction charts
  - using elastic stress distribution, design end portion 600mm length
  - Assuming end zones to resist moments. Consider two 500x 500 mm column are centrally available in the end zone (4 marks)
- b. Design a braced column of size 400x 300 mm bent in double curvature with the following values  $f_{ck} = 30 \text{ N/mm}^2$  and  $f_y = 415 \text{ N/mm}^2$ .  $L_0 = 7\text{m}$   $L_{ex}$ (on major axis)= 6m,  $L_{ey}$ = on minor axis)= 5m. the ultimate moments at top  $M_x = 40\text{kNm}$  and  $M_y = 30 \text{ kNm}$  , at bottom  $M_x = 22.5 \text{ kNm}$ ,  $M_y = 20\text{kNm}$ ,  $P_u = 1500 \text{ kN}$ . (4 marks)
8. a. A rectangular slab with a size of 3m x 5m is simply supported along its circumference and subjected to a concentrated load at its center. Using the virtual work method, derive an expression for the collapse load. (4 marks)
- b. RC grid floor is designed to cover a floor area of 12m x 18m. The spacing of ribs in a mutually perpendicular direction is 1.5m c/c LL on the floor is  $2\text{kN/m}^2$ . Analyze the grid floor by the IS456 method. Design the suitable reinforcement (Only for flexure). (4 marks)
9. a. How does one (a) check for deflection for the two-way slab and (b) control crack width in the two-way slab? (4 marks)
- b. Calculate the short-term deflection in a cantilever beam of cross section 250 mm x 400 mm and span 3m. The maximum bending moment in the beam under service loads is 150 kNm. The beam is reinforced with 3, 16 mm diameter bars on the tension side. Assume M20 concrete and Fe 415 steel. (4 marks)
10. Design the interior panel of a flat slab with a panel size 5m x 5m with drop and column head. It has to carry a live load of  $4\text{kN/m}^2$  and a floor finish load of  $1\text{kN/m}^2$ . The column supporting the system is 450mm x 450mm. Use M25 concrete and Fe415 steel and sketch the reinforcement details.
11. a. Design a pile cap a system of three piles of diameter 400mm supporting a column 500mm which is carrying an axial load 600 kN, piles are placed at the vertex of an equilateral triangle of size 1200mm adopt M 20 concrete and Fe 415 steel. (4 marks)
- b. Design a pile under a column transmitting an axial load of 800 kN. The pile is to be driven to hard strata available at a depth of 8m using M20 concrete and Fe 415 steel. (4 marks)
12. The foundation for a structure consists of 12 piles to carry a load of 6000kN. The piles are spaced 2m centre to centre. They are driven through a hard stratum available at a depth of 5m. Design one of the piles and sketch the details of reinforcement. Adopt M20 concrete and Fe415 steel.

| CODE       | COURSE NAME  | CATEGORY | L | T | P | S | CREDIT |
|------------|--|----------|---|---|---|---|--------|
| M24CE2T202 | ANALYSIS AND DESIGN OF EARTHQUAKE RESISTANT STRUCTURES | CORE     | 4 | 0 | 0 | 4 | 4      |

**Preamble:** The course offers a comprehensive understanding of the fundamental principles behind the earthquake-resistant design of structures. It introduces engineering aspects of earthquakes, including their characterization and impacts. The syllabus encompasses the design and detailing in accordance with the Indian Standards. Additionally, the course covers earthquake-resistant construction techniques for masonry structures and methods for retrofitting existing buildings.

**Prerequisite:** An understanding of structural dynamics and design of concrete structures is preferable

**Course Outcomes:** After the completion of the course the student will be able to

|      |  |
|------|--|
| CO 1 | understand the fundamentals of earthquake occurrence, its effects and the engineering aspects of earthquake resistance. <b>(Cognitive Knowledge Level: Understand)</b>       |
| CO 2 | Analysis and design earthquake-resistant structures. <b>(Cognitive Knowledge Level: Apply)</b>   |
| CO 3 | Analyze real-life structures using static and dynamic seismic analysis techniques to evaluate the seismic forces acting on them. <b>(Cognitive Knowledge Level: Analyze)</b> |
| CO 4 | Apply construction techniques for earthquake resistance in masonry and reinforced concrete structure. <b>(Cognitive Knowledge Level: Apply)</b>                              |
| CO 5 | Execute seismic response reduction, repair and rehabilitation techniques for existing buildings. <b>(Cognitive Knowledge Level: Apply)</b>                                   |

#### Mapping of course outcomes with program outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
|------|------|------|------|------|------|------|
| CO 1 | 1    | 1    | 2    | 1    | 1    | 1    |
| CO 2 | 2    | 1    | 2    | 2    | 2    |      |
| CO 3 | 1    | 1    | 2    | 3    | 2    | 2    |
| CO 4 | 1    | 1    | 2    | 3    | 3    | 1    |
| CO 5 | 1    |      | 3    | 3    | 3    | 1    |

**Assessment Pattern**

| Course Name      | Analysis and Design of Earthquake Resistant Structures |                  |                                    |
|------------------|--|------------------|------------------------------------|
| Bloom's Category | Continuous Evaluation Tests                            |                  | End Semester Examination (% Marks) |
|                  | Test 1 (% Marks)                                       | Test 2 (% Marks) |                                    |
| Remember         |  |                  |                                    |
| Understand       | 20   | 20               | 20                                 |
| Apply            | 50   | 50               | 50                                 |
| Analyse          | 30   | 30               | 30                                 |
| Evaluate         |  |                  |                                    |
| Create           |  |                  |                                    |

**Mark distribution**

| Total Marks | CIE Marks | ESE marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 100         | 40        | 60        | 3 Hours      |

|   |   |          |
|---|---|----------|
| <b>Continuous Internal Evaluation Pattern</b> | : |          |
| Micro project/Course based project            | : | 10 marks |
| Course based task/Seminar/Quiz                | : | 10 marks |
| Test paper 1 (Module 1 and Module 2)          | : | 10 marks |
| Test paper 2 (Module 3 and Module 4)          | : | 10 marks |

**End Semester Examination Pattern:** The end semester examination will be conducted by the college. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 4 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 8 marks. Total duration of the examination will be 3 Hrs.

## SYLLABUS

### MODULE 1 (9 hours)

Introduction to earthquakes and earthquake engineering, Mechanism of earthquake, seismic waves, effects of earthquakes. Measurement of earthquakes, intensity and magnitude and seismographs. Strong motion characteristics, response spectrum, Fourier spectrum. Characteristics of response spectrum, Design spectrum, construction of tripartite response spectrum.

### MODULE 2 (9 hours)

Effect of architectural features and structural irregularities. Damages of structures during past earthquakes, principles of earthquake resistant construction.

Philosophy of earthquake resistant design. Code provisions as per IS: 1893-2016 and IS: 4326.

### MODULE 3 (10 hours)

Design seismic force calculation in multi storied frames by equivalent static method, Dynamic analysis, Introduction to response spectrum analysis – theoretical aspects, Modal combination rules.

Design seismic force calculation in multi storied frames using response spectrum method.

### MODULE 4 (7 hours)

Torsion – code provisions, Shear walls – design force calculation, Design of shear wall, Design and detailing for earthquake resistance – Discussion of code provisions in IS 13920

Ductility – Significance, Ductility factors. Ductile detailing considerations as per IS:13920. Reinforcement detailing in joints.

### MODULE 5 (10 hours)

Masonry Buildings: Performance during earthquakes, Methods of improving performance of masonry walls, box action, influence of openings, role of horizontal and vertical bands, rocking of masonry piers. Repair and rehabilitation, Methods, Disaster mitigation, Response reduction techniques, Base isolation.

### References

1. Pankaj Agarwal and Manish Shrikhande, “Earthquake Resistant Design of Structures”, Prentice Hall of India Private Limited, New Delhi, India, First Edition, 2006.
2. Anil K. Chopra, “Dynamics of Structures”. Theory and Applications to Earthquake Engineering, Pearson Education, India, 6th Edition, 2022,.
3. Bruce A. Bolt, “Earth quakes”, W.H. Freeman and Company, New York, 5th Edition, 2003.
4. Steven L. Kramer, “Geotechnical Earthquake Engineering”, Pearson Education, India, 2nd Edition, 2020.

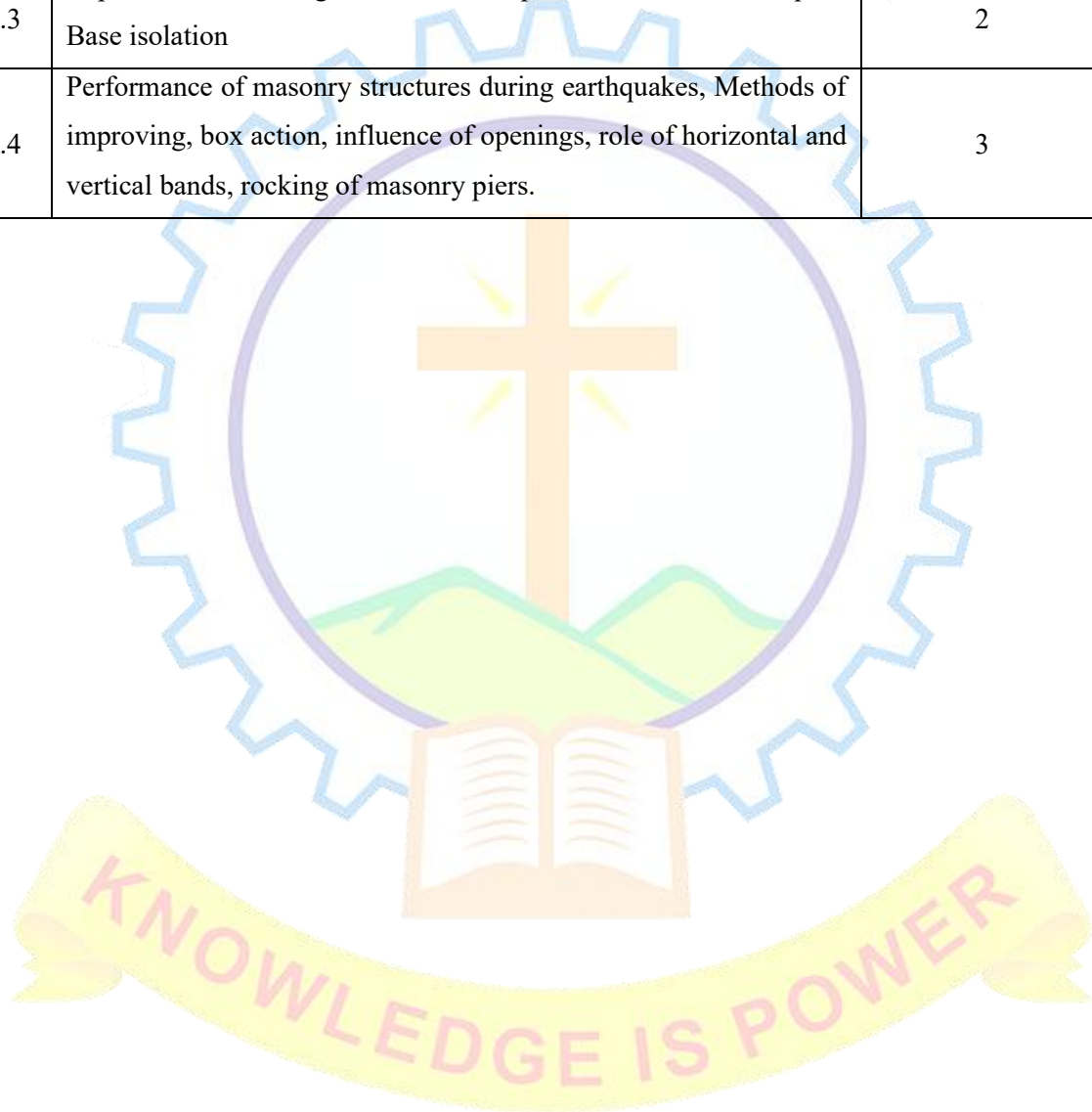
5. S. K. Duggal, “Earthquake Resistant Design of Structures”, Oxford University Press, New Delhi, 4th Edition, 2022.
6. Datta T.K., “Seismic Analysis of Structures”, John Wiley & Sons (Asia) Pte. Ltd, 2nd Edition, 2021.
7. Murthy C. V. R, “Earthquake tips, Building Materials and Technology Promotion Council”, New Delhi, India, 2021

### COURSE CONTENTS AND LECTURE SCHEDULE

| No   | Topic   | No. of Lecture/<br>Tutorial hours |
|--|---|-----------------------------------|
| <b>Module 1, Earthquakes and Response Spectrum</b>                                     |   | <b>9</b>                          |
| 1.1  | Earthquakes, Mechanism, Elastic rebound theory. Seismic waves, Effects of earthquakes   | 3                                 |
| 1.2  | Size of earthquake – intensity & magnitude, concept of Richter scale, saturation, moment magnitude. Measurement of earthquakes – seismographs and accelerograph | 2                                 |
| 1.3  | Strong motion characteristics, response spectrum, Fourier spectrum  | 2                                 |
| 1.4  | Characteristics of response spectrum, design spectrum, construction of tripartite response spectrum   | 2                                 |
| <b>Module 2 Earthquake Effects and Philosophy of Earthquake Resistant Construction</b> |   | <b>9</b>                          |
| 2.1  | Structural irregularities, Effect of architectural features, Damages during past earthquakes.   | 3                                 |
| 2.2  | Concept of capacity design, Strong Column and weak beam   | 3                                 |
| 2.3  | Philosophy of earthquake resistant construction. Principle of earthquake resistant construction   | 3                                 |
| <b>Module 3 Design Seismic Force Computation</b>                                       |   | <b>10</b>                         |
| 3.1  | Seismic force computation using IS code provisions  | 2                                 |
| 3.2  | Static method of analysis   | 3                                 |
| 3.3  | Response spectrum analysis – theoretical aspects,   | 2                                 |
| 3.4  | Seismic force computation using Response spectrum method  | 3                                 |
| <b>Module 4 Ductility Aspects and Ductile Detailing</b>                                |   | <b>7</b>                          |
| 4.1  | Ductility – significance in earthquake resistant design,  |                                   |
|  | Ductility factors.  | 2                                 |

M Tech in Computer Aided Structural Engineering

|     |   |           |
|-----|---|-----------|
| 4.2 | Ductile detailing considerations as per IS:13920  | 3         |
| 4.3 | Detailing of structural members & joints  | 2         |
|     | <b>Module 5 Torsion and Shear Walls</b>   | <b>10</b> |
| 5.1 | Torsion – code provisions, Design eccentricity computation and distribution of forces   | 2         |
| 5.2 | Shear walls – Types and design  | 3         |
| 5.3 | Repair and retrofitting – methods, Response reduction techniques, Base isolation  | 2         |
| 5.4 | Performance of masonry structures during earthquakes, Methods of improving, box action, influence of openings, role of horizontal and vertical bands, rocking of masonry piers. | 3         |



**Model Question Paper**

**QP CODE:**

Pages: 2

Reg No.: \_\_\_\_\_

Name: \_\_\_\_\_

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM  
SECOND SEMESTER M.TECH DEGREE EXAMINATION, MAY 2025**

*Course Code: M24CE2T202*

*Course Name: ANALYSIS AND DESIGN OF EARTHQUAKE RESISTANT STRUCTURES*

Max. Marks:60

Duration: 3 hours

**PART A**

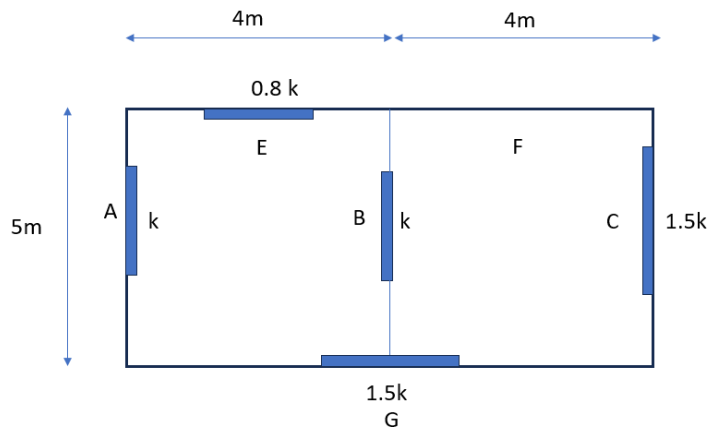
*Answer all questions. Each question carries 4 marks.*

1. Distinguish between *magnitude* and *intensity* of earthquake.
2. Explain the philosophy of earthquake resistant design.
3. Can the exact value of maximum seismic response of a multi-degree of freedom be determined using response spectrum analysis? Explain.
4. Explain the significance of ductility in earthquake resistant design.
5. What do you mean by retrofitting of structures? Explain the retrofitting methods used for RC columns.

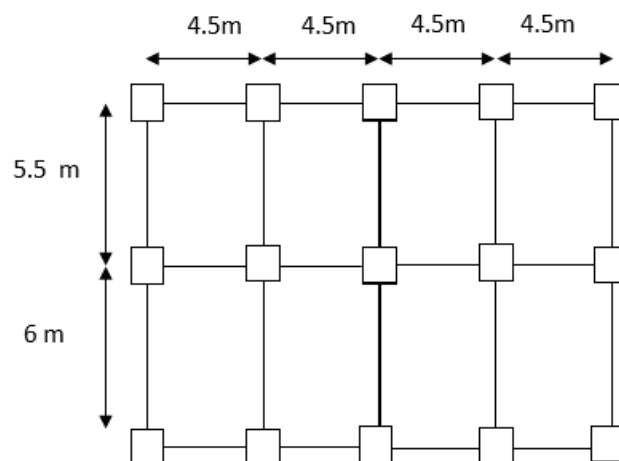
**PART B**

*Answer any five questions. Each question carries 8 marks.*

- 6 Explain the impact of different seismic waves on the structure during an earthquake.
- 7 How does a soft storey influence the response of structure during earthquake?
- 8 Find out the force resisted by the walls in shear in a single storeyed building with shear walls as shown in the figure given below. The centre of mass is at the geometric center of the building. The earthquake load is 260kN in the Y-direction. Assume that mass is uniformly distributed.



9. Calculate the design seismic force (base shear) and base shear distribution in the strong direction of a four storey (assume the storey height to be 3.3 meters) hospital building shown in Figure below. The building is located in Zone 4. The soil condition is medium stiff. The RC frame is infilled with brick masonry. The lumped weight due to dead load is 10 kN/m<sup>2</sup> on floors and 8 kN/m<sup>2</sup> on roof. Assume live load of 4kN/m<sup>2</sup> on floors and 1.5kN/m<sup>2</sup> on roofs. Assume any relevant data if needed.



10. Describe the ductile detailing as per IS 13920 2016 for beams, columns and joints in an RC framed structure, complemented by a clear diagram.
11. a) Explain the seismic evaluation methods for an RC building. (4Marks)  
 b) Explain retrofitting methods for a beam with the help of sketches. (4 Marks)
12. A slender shear wall of length 6 m and thickness 200 mm carries an axial load of 1200 kN. The wall is reinforced with 10# bars at 180 mm c/c in two layers. If M25 concrete and Fe415 steel are used, estimate the moment of resistance of the wall.

| CODE       | COURSE NAME                    | CATEGORY        | L | T | P | S | CREDIT |
|------------|--------------------------------|-----------------|---|---|---|---|--------|
| M24CE1S205 | BUILDING INFORMATION MODELLING | INDUSTRY COURSE | 3 | 0 | 0 | 3 | 3      |

**Preamble:** The course provides a structured framework for understanding and implementing BIM principles, incorporating real-world examples and practical exercises to enhance student learning. This course ensures a solid foundation and practical proficiency in BIM methodologies, preparing students to integrate BIM into their professional practice for enhanced efficiency and collaboration in the architecture, engineering, and construction industry.

**Prerequisite** : Nil

**Course Outcome** : After the completion of the course the student will be able to

|      |  |
|------|--|
| CO 1 | Understand the fundamental principles of Building Information Modeling (BIM) and assess the advantages associated with its implementation.<br><b>(Cognitive Knowledge Level: Understand)</b>                     |
| CO 2 | Analyse different data exchange models and standardize product data models for Interoperability and to understand the roles and responsibilities of stake holders<br><b>(Cognitive Knowledge Level: Analyse)</b> |
| CO 3 | Develop a comprehensive BIM execution plan.<br><b>(Cognitive Knowledge Level: Create)</b>  |
| CO 4 | Comprehend the principles of Integrated Project Delivery and to empower students to establish an Integrated Project Team for the seamless execution of projects.<br><b>(Cognitive Knowledge Level: Apply)</b>    |
| CO 5 | Solve real life examples using advanced softwares.<br><b>(Cognitive Knowledge Level: Analyse)</b>  |

#### Mapping of course outcomes with program outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
|------|------|------|------|------|------|------|
| CO 1 | 1    | 1    | 2    | 1    | 1    | 2    |
| CO 2 | 2    | 1    | 2    | 2    | 2    | 2    |
| CO 3 | 2    | 1    | 2    | 2    | 2    | 2    |
| CO 4 | 1    | 1    | 2    | 2    | 2    | 2    |
| CO 5 | 2    | 1    | 2    | 2    | 2    | 2    |

**Assessment Pattern**

| Course Name      | BUILDING INFORMATION MODELLING |                  |                                    |
|------------------|--------------------------------|------------------|------------------------------------|
| Bloom's Category | Continuous Evaluation Tests    |                  | End Semester Examination (% marks) |
|                  | Test 1 (% Marks)               | Test 2 (% Marks) |                                    |
| Remember         |                                |                  |                                    |
| Understand       | 20                             | 20               | 20                                 |
| Apply            | 35                             | 35               | 35                                 |
| Analyse          | 25                             | 25               | 25                                 |
| Evaluate         | 20                             | 20               | 20                                 |
| Create           |                                |                  |                                    |

**Mark Distribution**

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 100         | 40        | 60        | 3 hours      |

|   |   |          |
|---|---|----------|
| <b>Continuous Internal Evaluation Pattern</b>                           | : |          |
| Seminar   | : | 10 marks |
| Course based task/Seminar/Data collection and interpretation/Case study | : | 10marks  |
| Test paper 1 (Module 1 and Module 2)                                    | : | 10 marks |
| Test paper 2 (Module 3 and Module 4)                                    | : | 10 marks |

**End Semester Examination**

The examination will be conducted by the College with the question paper provided by the Industry. The examination will be for 3 Hrs and will contain 7 questions, with minimum one question from each module of which student should answer any five. Each question can carry 12 marks. The valuation of the answer scripts shall be done by the expert in the Industry handling the course.

## SYLLABUS

### **Module 1: (7 hours)**

Introduction to BIM - Understanding the Evolution of Building Information Modeling (BIM) - Exploring the Transition from Traditional AEC Business Models to BIM- Differentiating BIM from 3D and 2D Approaches- LOD

Conceptualizing BIM as both a Product and a Process- Emphasizing BIM as a Lifecycle Platform- Assessing the Incentives and Benefits of BIM: Technical, Financial, and Sustainable Examining Object-Based Parametric Modeling and its Role in BIM- Ensuring BIM Model Quality through Model Checking Processes

### **Module 2: (7 hours)**

Collaboration, Interoperability, and Roles: Exploring Stakeholder Engagement in BIM: Owners, Facility Managers, Government Institutions, Architects, Engineers, Contractors, Subcontractors, and Fabricators.

Understanding BIM Adoption and Maturity Levels- Reviewing BIM Guides from Leading Countries (e.g., Finland, Denmark, Belgium)

Analyzing Data Exchange Methods: File-based, Cloud-based, and Local - Standardizing Product Data Models for Interoperability. Implementing File-Based Exchange and BIM Servers: Industry Foundation Classes (IFC), COBie

### **Module 3: (7 hours)**

BIM Execution Planning: Developing a Comprehensive BIM Execution Plan (BEP) - Establishing Project Modeling Goals and Objectives - Selecting Model Uses for Different Project Phases - Designing the BIM Process Workflow - Defining Information Exchanges among Project Stakeholders - Planning Infrastructure for Effective BIM Implementation - Implementing the BEP for Successful Project Execution - Adapting BIM Project Execution Planning Procedures for Organizational Contexts

### **Module 4: (7 hours)**

Integrated Project Delivery (IPD): Understanding the Principles of Integrated Project Delivery (IPD) - Cultivating Collaboration and Mutual Respect among Project Stakeholders - Establishing an Integrated Project Team and Defining Roles - Implementing Early Involvement of Key Participants and Goal Definition - Utilizing Technology for Open Communication and Collaborative Decision Making - Building an Integrated Project Team for Seamless Project Execution - Redefining Project Phases for Enhanced Integration and Efficiency

**Module 5: (8 hours)**

**BIM Software Training:** Hands-on Training with BIM Software (e.g., Revit, ArchiCAD, Tekla, Navisworks)

Creating Modeling Views and Architectural, Structural, MEP, and Construction Modeling - Project Management Tools and Techniques within BIM Software - Utilizing Revit Families for Efficient Model Development - Conducting Design Analysis (Energy, Solar, Area, etc.) and Generating Schedules - Enhancing Design Visualization with Rendering and Walkthroughs - Documenting and Presenting Designs Effectively

Note: (Topics in Module 5 have to be discussed and demonstrated with the help of software at the Laboratory. Each topic will be an assignment in each week. Theory classes may progress with the other modules.)

**References**

1. "Building Information Modeling: Planning and Managing Construction Projects with 4D CAD and Simulations" by Willem Kymmell (McGraw-Hill Construction Series) 2007.
2. "BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers and Contractors" by Chuck Eastman, Paul Teicholz, Rafael Sacks, and Kathleen Liston first edition 2008.
3. "BIM and Integrated Design: Strategies for Architectural Practice" by Randy Deutsch 2011.
4. "Building Information Modeling: Framework for Structural Design" by Rafael Sacks, Chuck Eastman, and Ghang Lee 2012.
5. "Implementing BIM: A Guide to BIM Management in Construction Projects" by Richard Garbe 2014.
6. "BIM for Facility Managers" by Kathleen Liston and Paul Teicholz 2013.
7. "Integrated Project Delivery: An Action Guide for Leaders" by Ed Friedrichs and Iris Tommelein 2023.

**Course Contents and Lecture Schedule**

(Topics in Module 5 have to be discussed and demonstrated with the help of software at the Laboratory. Each topic will be an assignment in each week. Theory classes may progress with the other modules.)

| No  | Topic  | No. of Lecture |
|-----|--|----------------|
|     | <b>Module 1</b>  | <b>7</b>       |
| 1.1 | Introduction to BIM<br>- Ensuring BIM Model Quality through Model Checking Processes | 1              |
| 1.2 | - Understanding the Evolution of Building Information Modeling (BIM)                 | 1              |

M Tech in Computer Aided Structural Engineering

|   |  |          |
|---|--|----------|
| 1.3   | - Exploring the Transition from Traditional AEC Business Models to BIM   | 1        |
| 1.4   | - Differentiating BIM from 3D and 2D Approaches-LOD-<br>- Conceptualizing BIM as both a Product and a Process  | 1        |
| 1.5   | - Emphasizing BIM as a Lifecycle Platform<br>- Assessing the Incentives and Benefits of BIM: Technical, Financial, and Sustainable                                 | 1        |
| 1.6   | - Examining Object-Based Parametric Modeling and its Role in BIM   | 1        |
| 1.7   | - Examining Object-Based Parametric Modeling and its Role in BIM   | 1        |
| <b>Module 2</b>                                   |  | <b>7</b> |
| <b>Collaboration, Interoperability, and Roles</b> |  |          |
| 2.1   | - Exploring Stakeholder Engagement in BIM: Owners, Facility Managers, Government Institutions, Architects, Engineers, Contractors, Subcontractors, and Fabricators | 1        |
| 2.2   | - Understanding BIM Adoption and Maturity Levels   | 1        |
| 2.3   | - Reviewing BIM Guides from Leading Countries (e.g., Finland, Denmark, Belgium)  | 1        |
| 2.4   | - Analyzing Data Exchange Methods: File-based, Cloud-based, and Local  | 1        |
| 2.5   | - Standardizing Product Data Models for Interoperability   | 1        |
| 2.6   | - Implementing File-Based Exchange and BIM Servers: Industry Foundation Classes (IFC), COBie   | 2        |
| <b>Module 3</b>                                   |  | <b>7</b> |
| <b>BIM Execution Planning</b>                     |  |          |
| 3.1   | - Developing a Comprehensive BIM Execution Plan (BEP)<br>- Establishing Project Modeling Goals and Objectives  | 1        |
| 3.2   | - Selecting Model Uses for Different Project Phases  | 1        |
| 3.3   | - Designing the BIM Process Workflow   | 1        |
| 3.4   | - Defining Information Exchanges among Project Stakeholders  | 1        |
| 3.5   | - Planning Infrastructure for Effective BIM Implementation   | 1        |
| 3.6   | - Implementing the BEP for Successful Project Execution  | 1        |
| 3.7   | - Adapting BIM Project Execution Planning Procedures for Organizational Contexts   | 1        |
| <b>Module 4</b>                                   |  | <b>7</b> |
| 4.1   | <b>Integrated Project Delivery (IPD)</b>   | 1        |

## M Tech in Computer Aided Structural Engineering

|     |   |          |
|-----|---|----------|
|     | - Understanding the Principles of Integrated Project Delivery (IPD)   |          |
| 4.2 | - Cultivating Collaboration and Mutual Respect among Project Stakeholders   | 1        |
| 4.3 | - Establishing an Integrated Project Team and Defining Roles  | 1        |
| 4.4 | - Implementing Early Involvement of Key Participants and Goal Definition  | 1        |
| 4.5 | - Utilizing Technology for Open Communication and Collaborative Decision Making   | 1        |
| 4.6 | - Building an Integrated Project Team for Seamless Project Execution  | 1        |
| 4.7 | - Redefining Project Phases for Enhanced Integration and Efficiency   | 1        |
|     | <b>Module 5</b>   | <b>8</b> |
|     | <b>BIM Software Training</b>  |          |
| 5.1 | - Hands-on Training with BIM Software (e.g., Revit, ArchiCAD, Tekla) Creating Modeling Views and Architectural Modeling | 1        |
| 5.2 | Structural Modeling ,   | 1        |
| 5.3 | MEP Modeling  | 1        |
| 5.4 | Construction Modeling   | 1        |
| 5.5 | Project Management Tools and Techniques within BIM Software - Utilizing Revit Families for Efficient Model Development  | 1        |
| 5.6 | Conducting Design Analysis (Energy, Solar, Area, etc.) and Generating Schedules   | 1        |
| 5.7 | Enhancing Design Visualization with Rendering and Walkthroughs  | 1        |
| 5.8 | Documenting and Presenting Designs Effectively  | 1        |

Note: (Topics in Module 5 have to be discussed and demonstrated with the help of software at the Laboratory. Each topic will be an assignment in each week. Theory classes may progress with the other modules.)

**Model Question Paper**

**QP CODE:**

Pages: 2

Reg No.: \_\_\_\_\_

Name: \_\_\_\_\_

**MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**SECOND SEMESTER M.TECH DEGREE EXAMINATION, MAY 2025**

*Course Code: M24CE1S205*

*Course Name: BUILDING INFORMATION MODELLING*

Max. Marks:60

Duration: 3 hours

*Answer any five questions. Each question carries 12 marks.*

1. (a) Elucidate in detail the technical and financial incentives of using BIM? (9 Marks)  
(b) How is BIM different from 2D and 3D CAD (3 Marks)
2. With respect to its 5 phases, elaborate on BIM Modelling. (12 Marks)
3. Differentiate between File based, Cloud based and Local Data exchange methods in BIM (12 Marks)
4. Illustrate the role of each stakeholders - Owners, Facility Managers and Government Institutions, Architects and Engineers, Contractors, Subcontractors and Fabricators in BIM (12 Marks)
5. (a) List out the importance of developing a BIM Project Execution Plan (3 Marks)  
(b) Outline and discuss the 5 step procedure to develop a detailed BEP. (9 Marks)
6. Explain in detail how the Information Exchange worksheet is designed? (12 Marks)
7. Elucidate the principles of integrated project delivery (12 Marks)

| CODE       | COURSE NAME  | CATEGORY | L | T | P | S | CREDIT |
|------------|--------------|----------|---|---|---|---|--------|
| M24CE1P206 | MINI PROJECT | PROJECT  | 0 | 0 | 3 | 3 | 2      |

**Preamble:** Mini project can help to strengthen the understanding of student's fundamentals through application of theoretical concepts and to boost their skills and widen the horizon of their thinking. The aim of an engineering student is to resolve a problem by applying theoretical knowledge. Doing more projects increases problem solving skills.

The introduction of mini projects ensures preparedness of students to undertake dissertation. Students should identify a topic of interest in consultation with PG Programme Coordinator that should lead to their dissertation/research project. Demonstrate the novelty of the project through the results and outputs. The progress of the mini project is evaluated based on three reviews, two interim reviews and a final review. A report is required at the end of the semester.

Evaluation Committee - Programme Coordinator, One Senior Professor and Guide.

| Sl. No      | Type of evaluations             | Mark | Evaluation criteria  |
|-------------|---------------------------------|------|--|
| 1           | Interim evaluation 1            | 20   |  |
| 2           | Interim evaluation 2            | 20   |  |
| 3           | Final evaluation by a Committee | 35   | Will be evaluating the level of completion and demonstration of functionality/ specifications, clarity of presentation, oral examination, work knowledge and involvement |
| 4           | Report                          | 15   | The committee will be evaluating for the technical content, adequacy of references, templates followed and permitted plagiarism level( not more than 25% )               |
| 5           | Supervisor/Guide                | 10   |  |
| Total Marks |                                 | 100  |  |

## SYLLABUS

### LIST OF EXPERIMENTS

- I. Using **ETABS/STAAD** perform Static and Dynamic analysis ,design and detailing of :

Note:Consider the loads dead load, live load, wind load and earthquake load.

|   |  |
|---|--|
| 1 | G + 5 residential building with shear wall.                      |
| 2 | Overhead rectangular water tank with staging.                    |
| 3 | Ribbed slab floor system.  |
| 4 | Raft Foundation.   |
| 5 | Simply supported slab bridge of spans less than or equal to 6 m. |
| 6 | Single storey steel building with truss.                         |
| 7 | Multi-storey steel building.                                     |

- II. Using **ABAQUS / ANSYS** perform Modelling and Analysis of :

|    |  |
|----|--|
| 8  | Beams, Frames and Trusses(Static).   |
| 9  | Plane Stress and Plane Strain problems in Plate(Static).   |
| 10 | Free Vibration of Cantilever beam and simply supported beam subjected to harmonic load.(Dynamic) |
| 11 | Crack Pattern Detection in RCC Beam.   |
| 12 | Three storied building frame subjected to harmonic base Motion.(Dynamic)                         |

**Out of 12 any 8 experiments are mandatory**

#### References:

1. **IS 456:2000:** "*Code of Practice for Plain and Reinforced Concrete*"
2. **IS 800:2007:** "*General Construction in Steel – Code of Practice*"
3. **IS 875 Part 1:1987:** "*Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures – Part 1: Dead Loads – Unit Weights of Building Materials and Stored Materials*"
4. **IS 875 Part 2:1987:** "*Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures – Part 2: Live Loads*"
5. **IS 875 Part 3:2015:** "*Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures – Part 3: Wind Loads*"
6. **IS 3370 Part 1:2009:** "*Code of Practice for Concrete Structures for Retaining Aqueous Liquids*"

– Part 1: General Requirements"

7. **IS 3370 Part 2:2009:** "Code of Practice for Concrete Structures for Retaining Aqueous Liquids – Part 2: Plain and Reinforced Concrete"
8. **IS 3370 Part 3:2021:** "Code of Practice for Concrete Structures for Retaining Aqueous Liquids – Part 3: Prestressed Concrete"
9. **IS 3370 Part 4:2021:** "Code of Practice for Concrete Structures for Retaining Aqueous Liquids – Part 4: Design Considerations for Retaining Structures"
10. **IS 1893 (Part 1):2016:** "Criteria for Earthquake Resistant Design of Structures – Part 1: General Provisions and Buildings"
11. **IS 1893 (Part 2):2014:** "Criteria for Earthquake Resistant Design of Structures – Part 2: Industrial Structures including Stack, Silo, and Chimney"
12. **IS 1893 (Part 3):2014:** "Criteria for Earthquake Resistant Design of Structures – Part 3: Design Requirements for Structures including Bridges and Other Structures"
13. **IS 1893 (Part 4):2005:** "Criteria for Earthquake Resistant Design of Structures – Part 4: Design and Construction of Foundations"
14. **IS 1893 (Part 6):2022:** "Criteria for Earthquake Resistant Design of Structures – Part 6: Requirements for Special Structures, including Seismic Isolation and Damping"
15. **IRC 6:2017:** "Standard Specifications and Code of Practice for Road Bridges – Section II: Loads and Load Combinations"
16. **IRC 21:2000:** "Standard Specifications and Code of Practice for Road Bridges – Section I: General Design and Documentation"
17. **IS 13920:2016:** "Code of Practice for Ductile Detailing of Reinforced Concrete Structures Subjected to Seismic Forces"
18. Manuals of ETABS, STAAD, ANSYS, ABAQUS.



KNOWLEDGE IS POWER



| CODE        | COURSE NAME       | CATEGORY | L | T | P | S | CREDIT |
|-------------|-------------------|----------|---|---|---|---|--------|
| M24CE1E203A | DESIGN OF BRIDGES | ELECTIVE | 3 | 0 | 0 | 3 | 3      |

**Preamble:** The course covers the concepts and design of concrete and steel bridges as per the Indian Road Congress (IRC) and Indian Railway Standard (IRS) specifications. The students will be exposed to real-life bridge design and construction practices enabling them to independently plan, analyse, design, and detail various types and components of bridges.

**Prerequisite** : Analysis of Structures

**Course Outcomes** : After the completion of the course the student will be able to

|             |  |
|-------------|--|
| <b>CO 1</b> | Decide the structural form for a bridge depending on the functional requirements and site conditions. Identify various structural components of the chosen bridge form. <b>(Cognitive Knowledge Level: Understand)</b> |
| <b>CO 2</b> | Design various components of bridges based on relevant IRC and Indian railway loading standards. <b>(Cognitive Knowledge Level: Apply)</b>   |
| <b>CO 3</b> | Design various components of T beam bridge. <b>(Cognitive Knowledge Level: Analyse)</b>  |
| <b>CO 4</b> | Comprehend the design principles of long span bridges. <b>(Cognitive Knowledge Level: Evaluate)</b>  |
| <b>CO 5</b> | Design bearings, piers and abutments for bridges. <b>(Cognitive Knowledge Level: Analyse)</b>  |

#### Mapping of course outcomes with program outcomes

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
|-------------|------|------|------|------|------|------|
| <b>CO 1</b> | 1    | 1    | 2    | 2    | 2    | 1    |
| <b>CO 2</b> | 1    | 1    | 2    | 2    | 2    | 1    |
| <b>CO 3</b> | 1    | 1    | 2    | 2    | 2    | 1    |
| <b>CO 4</b> | 1    | 1    | 2    | 2    | 2    | 1    |
| <b>CO 5</b> | 1    | 1    | 2    | 2    | 2    | 1    |

**Assessment Pattern**

| Course Name      | Design of Bridges           |                  |                                    |
|------------------|-----------------------------|------------------|------------------------------------|
| Bloom's Category | Continuous Evaluation Tests |                  | End Semester Examination (% marks) |
|                  | Test 1 (% marks)            | Test 2 (% marks) |                                    |
| Remember         |                             |                  |                                    |
| Understand       | 10                          |                  | 10                                 |
| Apply            | 40                          | 40               | 40                                 |
| Analyse          | 30                          | 40               | 30                                 |
| Evaluate         | 20                          | 20               | 20                                 |
| Create           |                             |                  |                                    |

**Mark distribution**

| Total Marks | CIE Marks | ESE marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 100         | 40        | 60        | 3 Hours      |

|  |   |          |
|--|---|----------|
| <b>Continuous Internal Evaluation Pattern</b>                                  | : |          |
| Seminar*   | : | 10 marks |
| Course based task/Micro Project//Data collection and interpretation/Case study | : | 10 marks |
| Test paper 1 (Module 1 and Module 2)   | : | 10 marks |
| Test paper 2 (Module 3 and Module 4)   | : | 10 marks |

\*Seminar should be conducted in addition to the theory hours. Topics for the seminar should be from recent technologies in the respective course

**End Semester Examination Pattern:** the end semester the college will conduct examination. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 4 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 8 marks. Total duration of the examination will be 3 Hrs.

## SYLLABUS

### MODULE 1 (6 hours)

#### Planning of bridge

Classification and components of bridges - Investigation for bridges– need for investigation– selection of site– economical span– subsoil exploration– investigation report– importance for proper investigation– Structural forms of bridge decks.

### MODULE 2 (8 hours)

#### Design standard for bridges

Standard specifications for bridges: IRC loadings for road bridges: IRC class AA, class A and class B, loading standard- standards for railway bridges: loading standards - design of RC slab bridge, box culverts.

### MODULE 3 (9 hours)

#### Design of girder bridges

T-beam bridges– Analysis and design of interior slab, exterior slab and cantilever slab, longitudinal girders and cross girders–Pigeaud’s method– Courbon’s method– prestressed concrete bridges (simply supported case only): Introduction, Concepts, advantages, and applications, Design of Prestressed Concrete Bridges.

### MODULE 4 (7 hours)

Design of plate girder bridges - steel truss bridges - Introduction to long span bridges: cable stayed bridges and suspension bridges: Structural system and components – instability: Buckling of bridge components, Measures to prevent instability.

### MODULE 5 (6 hours)

Design of elastomeric bearings–Abutments – General features, Loads on abutments, Stability analysis of abutments–Piers – Types, Loads on Piers, Stability analysis of Piers.

### References

1. E.C. Hambly, Bridge deck behaviour, Taylor & Francis, London, 1991.
2. P. Nagarajan, Design of Concrete Bridges, Wiley Publications, 2020.
3. E J O’Brien and D L Keogh, Bridge deck analysis, E& FN spon, New York , 1999
4. D.Johnson Victor, Essentials of bridge engineering, Oxford & IBH publishing Co. Ltd., New Delhi, 2017.
5. N.Krishna Raju, Design of bridges, Oxford & IBH publishing Co. Ltd., New Delhi, 2009.

6. Jaikrishna and O.P Jain, Plain and reinforced concrete-Vol.II, Nemchand & Bros,Roorkee, 2007.
7. Relevant IRC and IRS codes.

**COURSE CONTENTS AND LECTURE SCHEDULE**

| No.             | Topic  | No. of Lecture/<br>Tutorial hours |
|-----------------|--|-----------------------------------|
| <b>Module 1</b> |  | <b>6</b>                          |
| 1.1             | Classification and components of bridges   | 2                                 |
| 1.2             | Investigation for bridges– need for investigation – selection of site  | 2                                 |
| 1.3             | economical span– subsoil exploration– investigation report   | 1                                 |
| 1.4             | Structural forms of bridge decks   | 1                                 |
| <b>Module 2</b> |  | <b>8</b>                          |
| 2.1             | IRC loadings for road bridges - IRC class AA, class A and class B  | 1                                 |
| 2.2             | loading standard   | 1                                 |
| 2.2             | Standards for railway bridges- loading standards   | 2                                 |
| 2.3             | Design of box culverts   | 2                                 |
| 2.4             | Design of RC slab bridge   | 2                                 |
| <b>Module 3</b> |  | <b>9</b>                          |
| 3.1             | Design of T beam bridges– Analysis and design of interior slab, exterior slab and cantilever slab  | 3                                 |
| 3.2             | Longitudinal girders and cross girders – Pigeaud’s method – Courbon’s method   | 4                                 |
| 3.3             | Prestressed concrete bridges( simply supported case only)- Introduction, Concepts, advantages, and applications, Design of Prestressed Concrete Bridges. | 2                                 |
| <b>Module 4</b> |  | <b>7</b>                          |
| 4.1             | Design of plate girder bridges   | 2                                 |
| 4.2             | Design of Steel truss bridges  | 2                                 |
| 4.3             | Introduction to long span bridges: cable stayed bridges and suspension bridges - Structural system and components  | 2                                 |
| 4.4             | instability :Buckling of bridge components, Measures to prevent instability  | 1                                 |

|     | <b>Module 5</b>   | <b>6</b> |
|-----|---|----------|
| 5.1 | Design of elastomeric bearings  | 2        |
| 5.2 | Abutments – General features, Loads on abutments, Stability analysis of abutments | 2        |
| 5.3 | Piers – Types, Loads on Piers, Stability analysis of Piers.                       | 2        |



**Model Question Paper**

**QP CODE:**

Pages: 3

Reg No.: \_\_\_\_\_

Name: \_\_\_\_\_

**MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**SECOND SEMESTER M.TECH DEGREE EXAMINATION, MAY 2025**

**Course Code: M24CE1E203A**

**Course Name: DESIGN OF BRIDGES**

Max. Marks:60

Duration: 3 hours

**PART A**

*Answer all questions. Each question carries 4 marks.*

1. Comment on impact factors? How do these factors vary with respect to the type of loading, span, and type of bridge?
2. How to apply the effective width procedure for finding moments due to concentrated loads acting on one-way slabs.
3. With an example, justify Courbon's method to tabulate the reaction factors in a T beam girder bridge.
4. Examine the causes of the instability in long span bridges.
5. Importance of bearing in bridges and its classification.

**PART B**

*Answer any five questions. Each question carries 8 marks.*

6. a. How the bridges can be classified in accordance with IS code. (4 marks)  
b. Discuss the importance of site investigation in bridge engineering. (4 marks)
7. Design an RCC slab culvert for a state highway the following data.(Design of kerb is not expected)  
Clear span = 7m  
Width of carriageway = 7.5m  
Thickness of wearing coat = 80mm  
Kerbs 600 mm wide are provided on either side.  
Loading: IRC Class A  
Materials: M25 concrete and Fe 415 steel  
Sketch the reinforcement details.
8. Design an interior cross girder for a T beam bridge for the following data:

## M Tech in Computer Aided Structural Engineering

Effective span = 16 m, Live load – IRC Class 70R tracked; Materials – M25 concrete and Fe 415 steel; spacing of cross girders 5 m c/c; width of carriage way 7.5m; thickness of wearing coat = 80 mm; kerbs on either side = 600 mm wide × 300 mm deep; width of main girder = 300 mm; width of cross girder = 300 mm; spacing of main girders = 2.5 m c/c. Sketch reinforcement details.

9. Design the longitudinal girders and interior panel of a T-beam and slab bridge for the following data:(shear calculations are not expected)

Effective span = 12m

Carriage way width = 7.8m

Cross beams are spaced at 4m c/c

Kerbs 600 mm wide are provided on either side.

Loading: IRC Class AA tracked vehicle

Materials: M25 concrete and Fe 415 steel

Sketch the reinforcement details.

10. Sketch and explain various parts and their functions of suspension bridge and cable stayed bridge.
11. Design a welded deck type plate girder bridge for a BG track to suit the following data: Effective span = 40 m; Dead load of track = 10 kN/m; Equivalent uniformly distributed load for bending moment calculations/track = 3498 kN; Equivalent uniformly distributed load for shear force calculations/track = 3815 kN. Take CDA = 0.324. Use plates of Fe410 grade.
12. Design an elastomeric bearing as per IRC 83 Part 2:2018 with the following data.

Maximum vertical design force = 1009 kN

Minimum vertical design force = 666 kN

Horizontal force along span direction = 10.39 kN

Horizontal force along width direction = 41.56 kN

Resultant of all horizontal forces = 42.84 kN

Relative displacement in the direction of dimension 'a' = 3.77 mm

Relative displacement in the direction of dimension 'b' = 1.88 mm

Angle of rotation across the width 'a' of bearing = 0.00381

Angle of rotation across the length 'b' of bearing = 0.001

Adopt an elastomeric bearing (based on International Standards) of dimension 250 mm(a) × 400 mm(b) Yield strength of steel laminate = 500 MP.

| CODE        | COURSE NAME                                    | CATEGORY | L | T | P | S | CREDIT |
|-------------|--|----------|---|---|---|---|--------|
| M24CE2E203B | EXPERIMENTAL METHODS IN STRUCTURAL ENGINEERING | ELECTIVE | 3 | 0 | 0 | 3 | 3      |

**Preamble:** The course is expected to enhance and strengthen the knowledge on advanced testing and evaluation of structures. It also deals with the various systems that capture the realistic and complex behaviour of structures.

**Prerequisite** : Nil

**Course Outcomes** : After the completion of the course the student will be able to

|     |  |
|-----|--|
| CO1 | Understand the structure, purpose and characteristics of a measurement system. <b>(Cognitive Knowledge Level: Understand)</b>  |
| CO2 | Analyse the working of strain gauges and force transducers. <b>(Cognitive Knowledge Level: Analyse)</b>  |
| CO3 | Analyse the working of potentiometers and accelerometers. <b>(Cognitive Knowledge Level: Analyse)</b>  |
| CO4 | Analyse the properties of various materials under consideration utilizing different nondestructive testing techniques. <b>(Cognitive Knowledge Level: Analyse)</b>                 |
| CO5 | Apply two-dimensional photoelasticity in analysing stress or strain and working of recording instruments like chart recorders and CROs. <b>(Cognitive Knowledge Level: Apply )</b> |

#### Mapping of course outcomes with program outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
|------|------|------|------|------|------|------|
| CO 1 | 1    | 1    | 2    | 2    | 2    | 1    |
| CO 2 | 1    | 1    | 2    | 2    | 2    | 1    |
| CO 3 | 1    | 1    | 2    | 2    | 2    | 1    |
| CO 4 | 1    | 1    | 2    | 2    | 2    | 1    |
| CO 5 | 1    | 1    | 2    | 2    | 2    | 1    |

**Assessment Pattern**

| Course Name      | EXPERIMENTAL METHODS IN STRUCTURAL ENGINEERING |                 |                                   |
|------------------|--|-----------------|-----------------------------------|
| Bloom's Category | Continuous Evaluation Tests                    |                 | End Semester Examination (%Marks) |
|                  | Test 1 (%Marks)                                | Test 2 (%Marks) |                                   |
| Remember         | -  | -               | -                                 |
| Understand       | 10   | 10              | 10                                |
| Apply            | 40   | 40              | 40                                |
| Analyse          | 50   | 50              | 50                                |
| Evaluate         | -  | -               | -                                 |
| Create           | -  | -               | -                                 |

**Mark distribution**

| Total Marks | CIE Marks | ESE marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 100         | 40        | 60        | 3 Hours      |

|  |   |          |
|--|---|----------|
| <b>Continuous Internal Evaluation Pattern</b>                                  | : |          |
| Seminar*   | : | 10 marks |
| Course based task/Micro Project//Data Collection and interpretation/Case study | : | 10 marks |
| Test paper 1 (Module 1 and Module 2)   | : | 10 marks |
| Test paper 2 (Module 3 and Module 4)   | : | 10 marks |

\*Seminar should be conducted in addition to the theory hours. Topics for the seminar should be from recent technologies in the respective course

**End Semester Examination Pattern:** The end semester examination will be conducted by the college. There will be two parts; Part A and Part B. Part A contain 5 questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 4 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question carry 8 marks. Total duration of the examination will be 3 Hrs.

## SYLLABUS

### MODULE 1 (6 hours)

**Measurement System:** Structure, purpose, components - Static Characteristics: Accuracy, Precision, Repeatability/Reproducibility, Threshold, Resolution, Sensitivity, Discrimination, Static error, Tolerance, Span, Range, Dead space, Hysteresis, Drift, Linearity – Calibration: Standards and evaluation.

### MODULE 2 (8 hours)

**Measurement of Strain and Force transducers:** Strain gauge: Ideal characteristics, Types: Mechanical, Electrical resistance, Optical gauges - Electrical resistance strain gauges: working and types - Gauge materials: foils, backing, adhesives - Gauge construction: gauge factor - Vibrating wire strain gauges: working - Strain gauge bridges: Potentiometric and Wheatstone bridge, strain sensitivity, forms of wheat stone bridge.

Strain gauge Rosette: two elements, three elements – rectangular, star, delta - Force transducers: working principle – Load cells: different types - Pressure transducer: working, types.

### MODULE 3 (8 hours)

**Measurement of displacement and acceleration:** Potentiometers: principle, working, different types: linear, rotary - Linear variable differential transformer: principle, working, advantages.

Accelerometers: Application - Characteristics of Accelerometers - Working of Piezoelectric and Piezoresistive accelerometer - Working of Capacitive accelerometer - Working of LVDT Type accelerometer - Working of potentiometric accelerometer.

### MODULE 4 (6 hours)

**Non Destructive Testing Methods and Statistical Analysis :** Uses - advantages and disadvantages of NDT methods - Principle, working, advantages and disadvantages of Ultrasonic pulse velocity Method - Hardness methods: Rebound Hammer and Core sampling technique and correlation of each method with quality of concrete - Pullout experiment: principle, working, advantages and disadvantages - Detection of embedded reinforcement by using rebar locator- Errors in measurement: Systematic and Random - Uncertainties in measurement: Types - Normal Distribution - Confidence level determination.

### MODULE 5 (8 hours)

**Photo elasticity and Indicating & recording elements :** Uses of polarised light - Maxwell's stress optic law – Two dimensional photo elasticity – Polariscope: use, components, working and types -

Photo elastic model materials: properties - Isoclinics and Isochromatics: properties - Moire fringe method of stress or strain analysis: techniques and its use - Advantages and disadvantages of Moire fringe method - Chart recorders: types, working - Cathode ray oscilloscope: principle, components, working.

### References

1. Bently JP - Principles of Measurement Systems – Longman, 1995
2. Nakra B. C. & Chaudhry - Instrumentation Measurement & Analysis - Tata McCraw Hill, 2004
3. Adams L F - Engineering Measurements and Instrumentation – English University Press, 1975
4. Doebelin E O - Measurement Systems Application & Design - McGraw Hill, 2003
5. Dalley JW & Riley WF – Experimental stress Analysis - McGraw Hill, 1991
6. Harris and Sabnis., “ Structural Modelling and Experimental Techniques”, CRC Press, 1999.
7. Sadhu Singh, “Experimental stress analysis”, Khanna Publishers, 1981.

### COURSE CONTENTS AND LECTURE SCHEDULE

| No              | Topic  | No. of Lecture/Tutorial hours |
|-----------------|--|-------------------------------|
| <b>Module 1</b> |  | <b>6</b>                      |
| 1.1             | Measurement System: Structure, purpose, components   | 1                             |
| 1.2             | Static Characteristics - Accuracy, Precision, Repeatability / Reproducibility , Threshold,                     | 1                             |
| 1.3             | Static Characteristics - Resolution, Sensitivity, Discrimination, Static error ,Tolerance                      | 1                             |
| 1.4             | Static Characteristics - Span, Range, Dead space, Hysteresis, Drift, Linearity                                 | 2                             |
| 1.5             | Calibration -Standards and evaluation  | 1                             |
| <b>Module 2</b> |  | <b>8</b>                      |
| 2.1             | Strain gauge – Ideal characteristics – Types: Mechanical, Electrical resistance, Optical gauges;               | 1                             |
| 2.2             | Electrical resistance strain gauges: working and types.  | 1                             |
| 2.3             | Gauge materials: foils, backing, adhesives. Gauge construction – gauge factor                                  | 1                             |
| 2.4             | Vibrating wire strain gauges- working  | 1                             |
| 2.5             | Strain gauge bridges – Potentiometric and Wheatstone bridge – strain sensitivity; forms of wheat stone bridge. | 1                             |

M Tech in Computer Aided Structural Engineering

|                 |  |          |
|-----------------|--|----------|
| 2.6             | Strain gauge Rosette – two elements, three elements – rectangular, star, delta.  | 1        |
| 2.7             | Force transducers: working principle – Load cells: different types   | 1        |
| 2.8             | Pressure transducer: working- types.   | 1        |
| <b>Module 3</b> |  | <b>8</b> |
| 3.1             | Potentiometers – principle, working, different types- linear, rotary   | 1        |
| 3.2             | Linear variable differential transformer – principle, working, advantages  | 1        |
| 3.3             | Accelerometers – Application- Characteristics of Accelerometers  | 1        |
| 3.4             | Working of Piezo electric and Piezo resistive accelerometer  | 2        |
| 3.5             | Working of Capacitive accelerometer  | 1        |
| 3.6             | Working of LVDT Type accelerometer   | 1        |
| 3.7             | Working of potentiometric accelerometer  | 1        |
| <b>Module 4</b> |  | <b>6</b> |
| 4.1             | Uses- advantages and disadvantages of NDT methods - Ultrasonic pulse velocity Method- principle, working, advantages and disadvantages, correlation of each method with quality of concrete:   | 1        |
| 4.2             | Hardness methods - Rebound Hammer - principle, working, advantages and disadvantages, correlation of each method with quality of concrete - Core sampling technique- principle, working, advantages and disadvantages, correlation of each method with quality of concrete | 1        |
| 4.3             |  | 1        |
| 4.4             | Pullout experiment - principle, working, advantages and disadvantages - Detection of embedded reinforcement by using rebar locator   | 2        |
| 4.5             | Errors in measurement: Systematic and Random - Uncertainties in measurement- Types; Normal Distribution - Confidence level-determination.  | 1        |
| <b>Module 5</b> |  | <b>8</b> |
| 5.1             | Uses of polarised light - Maxwell's stress optic law – Two-dimensional photo elasticity  | 1        |
| 5.2             | Polariscopes – use, components, working and Types  | 1        |
| 5.3             | Photo elastic model materials- properties; Isoclinics and Isochromatics – properties   | 1        |

M Tech in Computer Aided Structural Engineering

|     |  |   |
|-----|--|---|
| 5.4 | Moire fringe method of stress or strain analysis- techniques and its use. Advantages and disadvantages of Moire fringe method. | 2 |
| 5.5 | Chart recorders – Types, working   | 1 |
| 5.6 | Cathode ray oscilloscope – principle, components, working.   | 2 |



**Model Question Paper**

**QPCODE:**

Pages: 2

Reg No.: \_\_\_\_\_

Name: \_\_\_\_\_

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM  
SECOND SEMESTER M.TECH DEGREE EXAMINATION, MAY 2025**

**Course Code: M24CE2E203B**

**Course Name: EXPERIMENTAL METHODS IN STRUCTURAL ENGINEERING**

Max.Marks:60

Duration:3 hours

**PART A**

***Answer all questions. Each question carries 4 marks.***

1. What are the standards of calibration.
2. Explain ideal characteristics of a strain gauge.
3. Give a brief description of the types of potentiometers.
4. List out the advantages and disadvantages of nondestructive testing method.
5. Analyse functioning and application of polariscopes. Outline the different types of polariscopes available.

**PART B**

***Answer any five questions. Each question carries 8 marks.***

6. Explain any seven static performance characteristics of a measurement system.
7. Elaborate on how vibrating wire resistance strain gauges operate, including a diagram, their benefits, and drawbacks.
8. Analyse the principle, working and different types of potentiometers.
9. Analyse the principle, operation, benefits and drawbacks of LVDT with the help of a diagram.
10. Discuss the principles, operation, benefits and limitations of the Ultrasonic Pulse Velocity method and its relevance to assessing concrete quality.
11. Analyse the Moire fringe method for stress or strain analysis, covering its benefits and drawbacks.
12. Explain the principle, components and working of Cathode ray oscilloscope.

| CODE        | COURSE NAME                  | CATEGORY        | L | T | P | S | CREDIT |
|-------------|------------------------------|-----------------|---|---|---|---|--------|
| M24CE1E203C | STRUCTURAL HEALTH MONITORING | ELECTIVE COURSE | 3 | 0 | 0 | 3 | 3      |

**Preamble:** The course focuses on the assessment, evaluation, and technical diagnosis of strategically important structural systems. It equips students with the skills to assess the risk and reliability of critical structures. Covering both basic and advanced applications of Structural Health Monitoring (SHM), the course includes detailed case studies to provide practical insights and real-world applications.

**Prerequisite** : Nil

**Course Outcomes** : After the completion of the course the student will be able to

|             |  |
|-------------|--|
| <b>CO 1</b> | Exhibit understanding of the concepts and methods of Structural Health Monitoring. <b>(Cognitive Knowledge Level: Understand)</b>  |
| <b>CO 2</b> | Apply non-destructive techniques and sensor technologies for effective health monitoring of structure. <b>(Cognitive Knowledge Level: Apply)</b>                             |
| <b>CO 3</b> | Demonstrate techniques for damage identification, detection, and assessment in various structural systems. <b>(Cognitive Knowledge Level: Apply)</b>                         |
| <b>CO 4</b> | Analyze case studies of SHM applications in bridges, buildings, and offshore structures to understand real-world implementation. <b>(Cognitive Knowledge Level: Analyse)</b> |
| <b>CO 5</b> | Evaluate the integration of SHM with emerging technologies such as Building Information Modeling (BIM), digital twins, and IoT. <b>(Cognitive Knowledge Level: Evaluate)</b> |

#### Mapping of course outcomes with program outcomes

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
|-------------|------|------|------|------|------|------|
| <b>CO 1</b> | 1    | 1    | -    | 1    | 1    | -    |
| <b>CO 2</b> | 1    | 1    | 1    | 2    | 2    | 2    |
| <b>CO 3</b> | 2    | 1    | 2    | 3    | 2    | 2    |
| <b>CO 4</b> | 1    | 1    | 2    | 3    | 2    | 2    |
| <b>CO 5</b> | 2    | 1    | 3    | 3    | 2    | 2    |

**Assessment Pattern**

| Course Name      | Structural Health Monitoring |                |                                  |
|------------------|------------------------------|----------------|----------------------------------|
| Bloom's Category | Continuous Evaluation Tests  |                | End Semester Examination (Marks) |
|                  | Test 1 (Marks)               | Test 2 (Marks) |                                  |
| Remember         |                              |                |                                  |
| Understand       | 20                           | 20             | 20                               |
| Apply            | 50                           | 50             | 50                               |
| Analyse          | 30                           | 30             | 30                               |
| Evaluate         |                              |                |                                  |
| Create           |                              |                |                                  |

**Mark distribution**

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 100         | 40        | 60        | 3 Hours      |

|  |   |          |
|--|---|----------|
| <b>Continuous Internal Evaluation Pattern</b>                                    | : |          |
| Seminar*   | : | 10 marks |
| Course based task/Micro Project//Data collection and interpretation/Case study : | : | 10 marks |
| Test paper 1 (Module 1 and Module 2)   | : | 10 marks |
| Test paper 2 (Module 3 and Module 4)   | : | 10 marks |

\*Seminar should be conducted in addition to the theory hours. Topics for the seminar should be from recent technologies in the respective course

**End Semester Examination Pattern:** The end semester examination will be conducted by the college. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 4 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 8 marks. Total duration of the examination will be 3 Hrs.

## SYLLABUS

### MODULE 1 (6 hours)

Introduction to Structural Health Monitoring (SHM), Overview of SHM: Definition, importance, and objectives

Historical development of SHM, Basic concepts and components of SHM systems, Overview of methods and techniques used in SHM.

### MODULE 2 (8 hours)

Non-destructive techniques in SHM: Overview and applications, Static and vibration-based health monitoring methods

Sensor technologies used in SHM: Types, selection criteria, and deployment strategies Introduction to SHM using Artificial Intelligence (AI): Machine learning and data-driven approaches.

### MODULE 3 (8 hours)

Damage Identification and Assessment, Fundamentals of damage identification in SHM, Techniques for damage detection and localization, Damage assessment methods: Quantitative and qualitative approaches, Case studies: Examples of damage identification in real-world structures.

### MODULE 4 (7 hours)

Applications of SHM in Infrastructure, SHM applications in bridges: Monitoring strategies, sensors, and case studies, SHM applications in buildings: Structural assessment, performance evaluation, and case studies, SHM in offshore structures: Challenges, sensor technologies, and case studies.

### MODULE 5 (7 hours)

Applications of structural control strategies in SHM, Integration of SHM with building information modeling (BIM) and digital twins, Future trends in SHM: Smart materials, autonomous systems, and IoT integration, Challenges and opportunities in the advancement of SHM technology.

### References

1. Maierhofer C, Reinhardt H and Dobmann G, Non-destructive Evaluation of Reinforced Concrete Structures: Volume 1: Deterioration Processes and Standard Test Methods, 1st Edition, Woodhead Publishing (2010).
2. Mehta P K and Monteiro P J M, Concrete: Microstructure, Properties and Materials, 4th Edition, McGraw-Hill Education (2014).
3. Hellier C, Handbook of Non-destructive Evaluation, 3rd Edition, Mc-Graw Hill Education (2020).

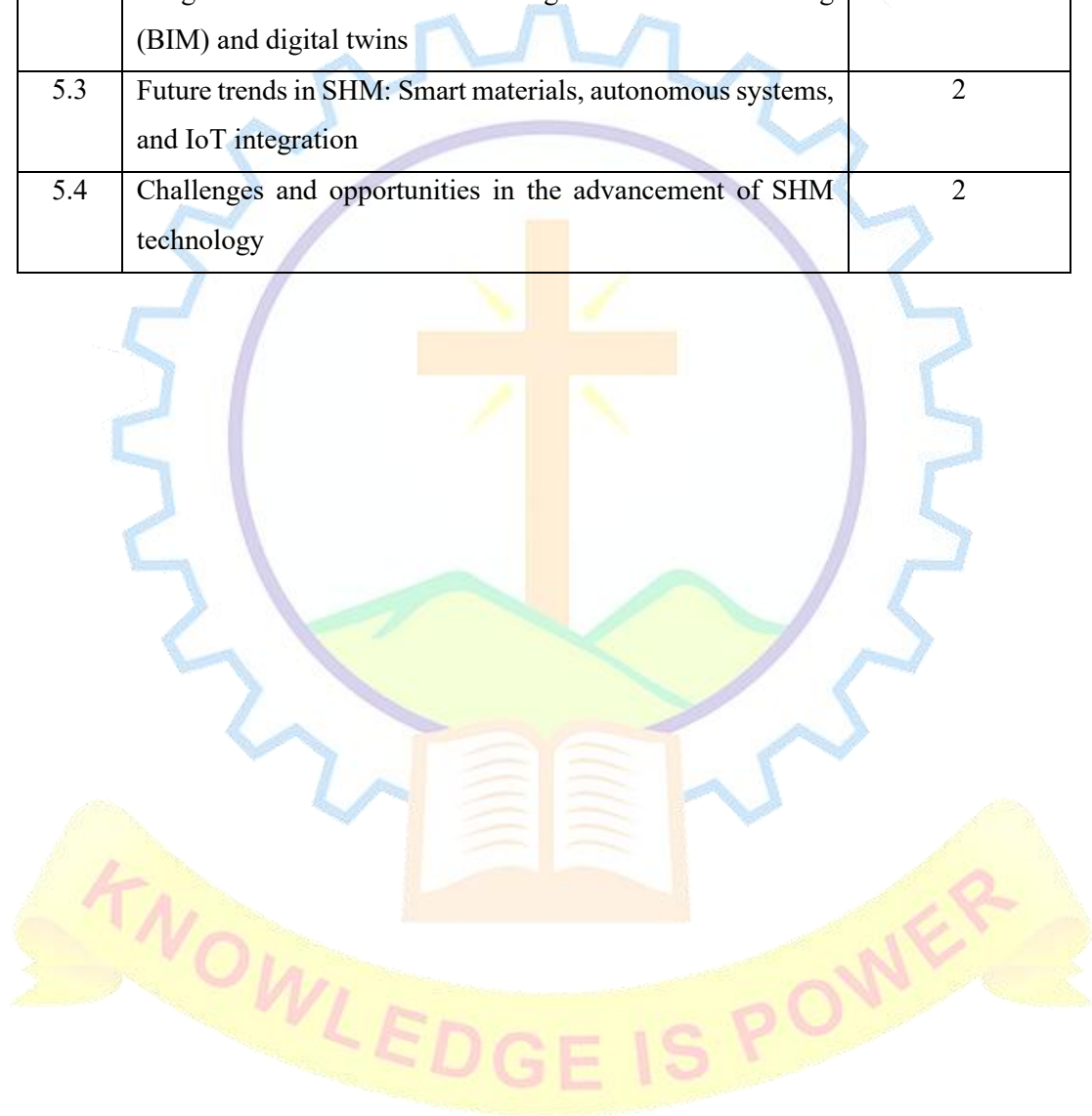
4. Emmons P H, Concrete Repair and Maintenance Illustrated, 1st Edition, R.S. Means Company Inc. (2002).
5. Wieslaw Ostachowicz, Alfredo Güemes, New Trends in Structural Health Monitoring (2013).
6. Daniel Balageas, Claus-Peter Fritzen, Alfredo Güemes, Structural Health Monitoring (2010).
7. Vistasp M. Karbhari, Farhad Ansari Structural Health Monitoring of Civil Infrastructure Systems (2009).

**COURSE CONTENTS AND LECTURE SCHEDULE**

| No              | Topic  | No. of Lecture/<br>Tutorial hours |
|-----------------|--|-----------------------------------|
| <b>Module 1</b> |  | <b>6</b>                          |
| 1.1             | Introduction to Structural Health Monitoring (SHM)   | 1                                 |
| 1.2             | Overview of SHM: Definition, importance, and objectives  | 1                                 |
| 1.3             | Historical development of SHM  | 1                                 |
| 1.4             | Basic concepts and components of SHM systems   | 1                                 |
| 1.5             | Overview of methods and techniques used in SHM.  | 2                                 |
| <b>Module 2</b> |  | <b>8</b>                          |
| 2.1             | Non-destructive techniques in SHM: Overview and applications   | 1                                 |
| 2.2             | Static and vibration-based health monitoring methods   | 2                                 |
| 2.3             | Sensor technologies used in SHM: Types, selection criteria and deployment strategies                 | 2                                 |
| 2.4             | Introduction to SHM using Artificial Intelligence (AI): Machine learning and data-driven approaches. | 3                                 |
| <b>Module 3</b> |  | <b>8</b>                          |
| 3.1             | Damage Identification and Assessment   | 1                                 |
| 3.2             | Fundamentals of damage identification in SHM   | 1                                 |
| 3.3             | Techniques for damage detection and localization   | 2                                 |
| 3.4             | Damage assessment methods: Quantitative and qualitative approaches                                   | 2                                 |
| 3.5             | Case studies: Examples of damage identification in real-world structures.                            | 2                                 |
| <b>Module 4</b> |  | <b>7</b>                          |
| 4.1             | Applications of SHM in Infrastructure  | 1                                 |
| 4.2             | SHM applications in bridges: Monitoring strategies, sensors, and case studies                        | 2                                 |

M Tech in Computer Aided Structural Engineering

|                 |  |          |
|-----------------|--|----------|
| 4.3             | SHM applications in buildings: Structural assessment, performance evaluation, and case studies | 2        |
| 4.4             | SHM in offshore structures: Challenges, sensor technologies, and case studies.                 | 2        |
| <b>Module 5</b> |  | <b>7</b> |
| 5.1             | Applications of structural control strategies in SHM   | 1        |
| 5.2             | Integration of SHM with building information modeling (BIM) and digital twins                  | 2        |
| 5.3             | Future trends in SHM: Smart materials, autonomous systems, and IoT integration                 | 2        |
| 5.4             | Challenges and opportunities in the advancement of SHM technology                              | 2        |



**Model Question Paper**

**QP CODE:**

Pages:1

Reg No.:\_\_\_\_\_

Name:\_\_\_\_\_

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM  
SECOND SEMESTER M.TECH DEGREE EXAMINATION, MAY 2025**

**Course Code: M24CE1E203C**

**Course Name: STRUCTURAL HEALTH MONITORING**

Max. Marks:60

Duration: 3 hours

**PART A**

***Answer all questions. Each question carries 4 marks.***

1. Classify Structural Health Monitoring (SHM) systems in detail.
2. Explain the process and importance of anchor cable tests in structural health monitoring.
3. Elucidate the design principles and working mechanisms used in non-destructive testing (NDT) evaluations.
4. Compare active and passive monitoring systems with suitable examples.
5. Discuss the significance of concrete cracking, the major causes of cracking in concrete, and prevention methods

**PART B**

***Answer any five questions. Each question carries 8 marks.***

6. Identify the techniques used for long-term health monitoring of structures.
7. Outline the procedure for assessing structural conditions in reinforced concrete (RCC) structures.
8. Interpret the failure mechanisms in structural systems and how they can be controlled.
9. Detail the procedure for assessing corrosion in the reinforcement of RCC elements.
10. Examine in detail a case study of structural failure and the lessons learned from it.
11. Discuss the use of stress history tests as a monitoring technique
12. Assess the role of sensors and sensing technology in structural monitoring.

| CODE        | COURSE NAME              | CATEGORY | L | T | P | S | CREDIT |
|-------------|--------------------------|----------|---|---|---|---|--------|
| M24CE2E203D | DESIGN OF TALL BUILDINGS | ELECTIVE | 3 | 0 | 0 | 3 | 3      |

**Preamble:** The course provides a comprehensive understanding of the design philosophy and various structural systems adopted for tall structures. Students will explore fundamental principles and methodologies essential for analyzing and designing tall buildings.

**Prerequisite** : Structural Analysis

**Course Outcomes** : After the completion of the course the student will be able to

|             |   |
|-------------|---|
| <b>CO 1</b> | Understand the design philosophy and structural behavior of high-rise buildings. <b>(Cognitive Knowledge Level: Understand)</b>   |
| <b>CO 2</b> | Analyze the behavior of different structural systems <b>(Cognitive Knowledge Level: Analyse)</b>  |
| <b>CO 3</b> | Analyze the stability of tall buildings using advanced tools. <b>(Cognitive Knowledge Level: Analyse)</b>   |
| <b>CO 4</b> | Illustrate the dynamic response of tall structures to wind and seismic forces. <b>(Cognitive Knowledge Level: Analyse)</b>  |
| <b>CO 5</b> | Apply performance-based design principles to tall building projects, considering stability and structural control mechanisms. <b>(Cognitive Knowledge Level: Apply)</b> |

#### Mapping of course outcomes with program outcomes

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
|-------------|------|------|------|------|------|------|
| <b>CO 1</b> | 1    | 1    | 1    | 1    |      | 1    |
| <b>CO 2</b> | 2    | 1    | 1    | 1    |      | 1    |
| <b>CO 3</b> | 2    | 1    | 2    | 2    | 1    | 2    |
| <b>CO 4</b> | 2    | 1    | 2    | 2    | 2    | 1    |
| <b>CO 5</b> | 2    | 1    | 2    | 2    | 1    | 1    |

**Assessment Pattern**

| Course Name      | DESIGN OF TALL BUILDINGS    |                  |                                    |
|------------------|-----------------------------|------------------|------------------------------------|
| Bloom's Category | Continuous Evaluation Tests |                  | End Semester Examination (% Marks) |
|                  | Test 1 (% Marks)            | Test 2 (% Marks) |                                    |
| Remember         |                             |                  |                                    |
| Understand       | 20                          | 20               | 20                                 |
| Apply            | 40                          | 40               | 40                                 |
| Analyse          | 40                          | 40               | 40                                 |
| Evaluate         |                             |                  |                                    |
| Create           |                             |                  |                                    |

**Mark distribution**

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 100         | 40        | 60        | 3 Hours      |

|  |   |          |
|--|---|----------|
| <b>Continuous Internal Evaluation Pattern</b>                                  | : |          |
| Seminar*   | : | 10 marks |
| Course based task/Micro Project//Data collection and interpretation/Case study | : | 10 marks |
| Test paper 1 (Module 1 and Module 2)   | : | 10 marks |
| Test paper 2 (Module 3 and Module 4)   | : | 10 marks |

\*Seminar should be conducted in addition to the theory hours. Topics for the seminar should be from recent technologies in the respective course

**End Semester Examination Pattern:** The end semester examination will be conducted by the college. There will be two parts; Part A and Part B. Part A contains 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 4 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 8 marks. Total duration of the examination will be 3 Hrs.

## SYLLABUS

### **Module 1: Design Philosophy and Structural Loading (6 hours)**

Design Philosophy: Materials Selection and Properties-Creep and Shrinkage Effects-Temperature Effects on Structures-Fire Resistance and Safety, Structural Loading: Gravity Loading-Sequential Loading-Impact Loading-Wind Loading-Earthquake Loading-Blast Loading.

### **Module 2: Structural Systems and Behaviour (6 hours)**

Behaviour of Structural Systems: Factors Affecting Growth, Height, and Structural Form- Behaviour of Various Structural System: Rigid Frames, Braced Frames, Infilled Frames, Shear Walls, Coupled Shear Walls, and Wall Frames, Tubular Systems, Cores, Outriggers, Braced, and Hybrid Mega Systems, - Significance of Symmetry and Regularity - Symmetry and Regularity in Plan-Regularity in Elevation-Effect of Openings.

### **Module 3: Analysis methods (8 hours)**

Analysis methods: Modeling for Approximate Analysis-Accurate Analysis and Reduction Techniques-Analysis of Building as a Total Structural System-Interaction of Major Subsystems - Analysis for Forces and Stability, Member Forces, Drift, and Twist Analysis-Computerized General Three-Dimensional Analysis.

### **Module 4: Dynamic Response to wind and earthquake (10 hours)**

Dynamic Response to Wind and Earthquake-Wind Load: Sensitivity, Characteristics, Codal Provisions-Dynamic Structural Response to Wind Forces-Along-Wind and Cross-Wind Response-Introduction to Wind Tunnel Engineering - Earthquake Load: Behaviour of Tall Buildings Under Earthquakes-Design for Ductility and Energy Dissipation-Damping Systems for Tall Buildings- Performance Based Design: Design Philosophy.

### **Module 5: Foundations and Stability of tall buildings (6 hours)**

Foundations for Tall Structures: Pile Foundations-Mat Foundations-Foundation and Superstructure Interaction, Stability of Tall Buildings: Overall Buckling Analysis of Frames-P-Delta Analysis-Translational and Torsional Instability-Out-of-Plumb Effects-Effect of Foundation Rotation.

### **References**

1. Brayan Stafford Smith, Alexcoull, Tall Building Structures, Analysis and Design, John Wiley and Sons, 1991
2. Bungale S Taranath, Structural Analysis and Design of Tall Buildings, Tata McGraw

Hill,1988.

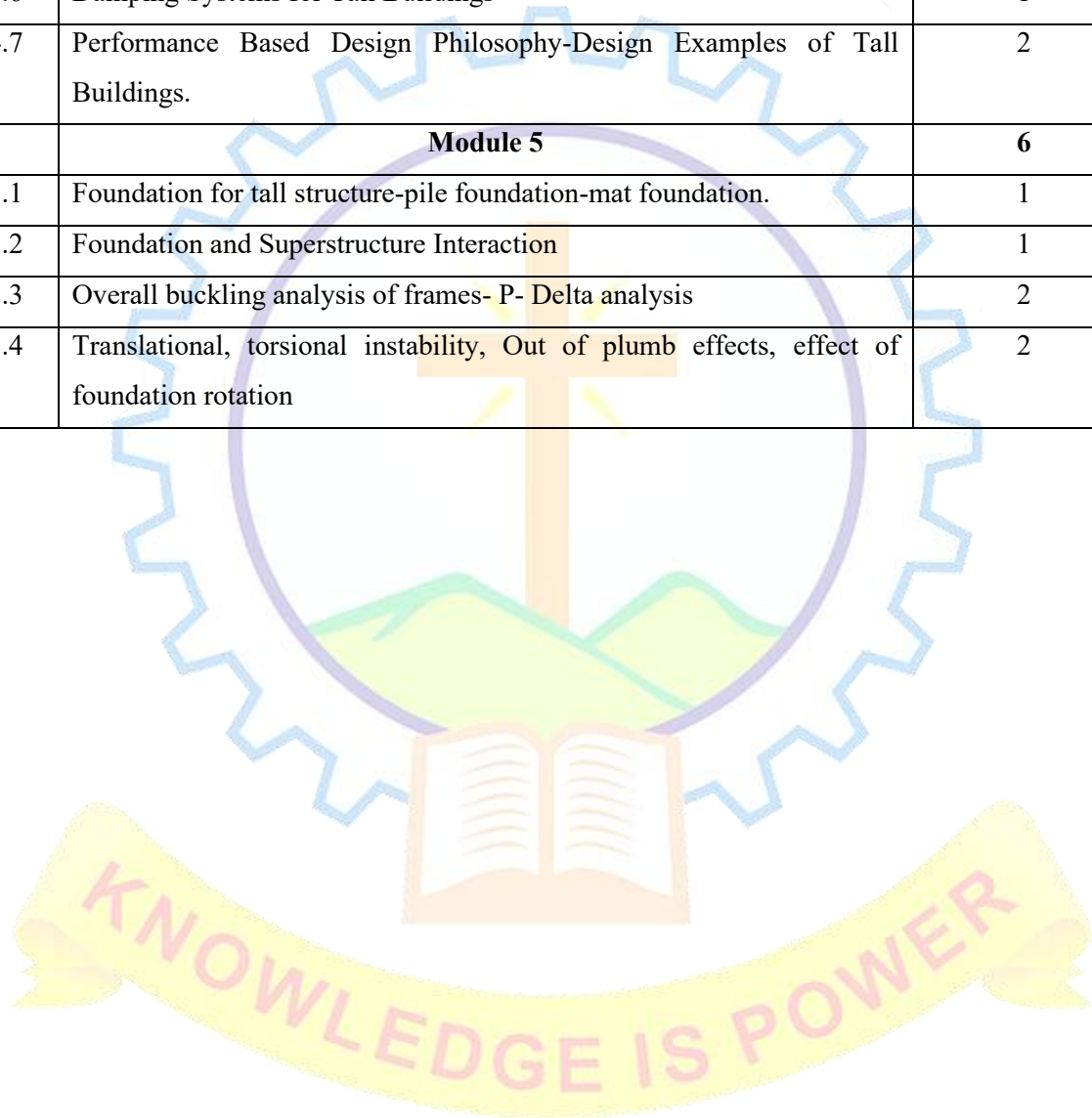
3. Taranath , B.S., Structural Analysis and design of Tall Building, Tata McGraw Hill., 1988.
4. Wilf gang Schuller, High Rise Building Structures, John Wiley and Sons, 1977.
5. Lynn S. Beedle, Advances in Tall Buildings, CBS Publishers and Distributors, Delhi, 1981.
6. Robert L Wiegel, Earthquake Engineering. Prentice Hall, 1970.
7. IS Codes: IS:456, IS:875, IS:1893, IS:4326, IS:13920, IS: 3370, IS: 4995 (I & II), SP:16, SP:34.

### COURSE CONTENTS AND LECTURE SCHEDULE

| No              | Topic   | No. of Lecture/<br>Tutorial hours |
|-----------------|---|-----------------------------------|
| <b>Module 1</b> |   | <b>6</b>                          |
| 1.1             | Design Philosophy - Materials Selection and Properties-Creep and Shrinkage Effects-Temperature Effects on Structures-Fire Resistance and Safety | 1                                 |
| 1.2             | Loading- Gravity Loading, Sequential Loading, Impact Loading  | 2                                 |
| 1.3             | Wind Loading  | 2                                 |
| 1.4             | Earthquake Loading-Blast Loading.   | 1                                 |
| <b>Module 2</b> |   | <b>6</b>                          |
| 2.1             | Factors Affecting Growth, Height, and Structural Form   | 2                                 |
| 2.2             | Behaviour of Various Structural System: Rigid Frames, Braced Frames, Infilled Frames-Shear Walls,   | 1                                 |
| 2.3             | Coupled Shear Walls, and Wall Frames-Tubular Systems, Cores   | 1                                 |
| 2.4             | Outriggers, Braced, and Hybrid Mega Systems   | 1                                 |
| 2.5             | Symmetry and Regularity in Plan-Regularity in Elevation-Effect of Openings  | 1                                 |
| <b>Module 3</b> |   | <b>8</b>                          |
| 3.1             | Modeling for Approximate Analysis-Accurate Analysis and Reduction Techniques  | 1                                 |
| 3.2             | Analysis of Building as a Total Structural System-Interaction of Major Subsystems   | 2                                 |
| 3.3             | Member Forces, Drift, and Twist Analysis  | 2                                 |
| 3.4             | Three-Dimensional Analysis of tall building using any software  | 3                                 |
| <b>Module 4</b> |   | <b>10</b>                         |
| 4.1             | Dynamic Response Due to Wind and Earthquake-Wind Load: Sensitivity, Characteristics, Codal Provisions   | 1                                 |

M Tech in Computer Aided Structural Engineering

|     |   |          |
|-----|---|----------|
| 4.2 | Dynamic Structural Response to Wind Forces-Along-Wind and Cross-Wind Response             | 1        |
| 4.3 | Introduction to Wind Tunnel Engineering-Worked Examples of Wind Load Analysis             | 2        |
| 4.4 | Behaviour of Tall Buildings Under Earthquakes   | 2        |
| 4.5 | Design for Ductility and Energy Dissipation   | 1        |
| 4.6 | Damping Systems for Tall Buildings  | 1        |
| 4.7 | Performance Based Design Philosophy-Design Examples of Tall Buildings.                    | 2        |
|     | <b>Module 5</b>   | <b>6</b> |
| 5.1 | Foundation for tall structure-pile foundation-mat foundation.                             | 1        |
| 5.2 | Foundation and Superstructure Interaction   | 1        |
| 5.3 | Overall buckling analysis of frames- P- Delta analysis                                    | 2        |
| 5.4 | Translational, torsional instability, Out of plumb effects, effect of foundation rotation | 2        |



**Model Question Paper**

**QP CODE:**

Pages: 1

Reg No.: \_\_\_\_\_

Name: \_\_\_\_\_

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**SECOND SEMESTER M.TECH DEGREE EXAMINATION, MAY 2025**

**Course Code: M24CE2E203D**

**Course Name: DESIGN OF TALL BUILDINGS**

Max. Marks:60

Duration: 3 hours

**PART A**

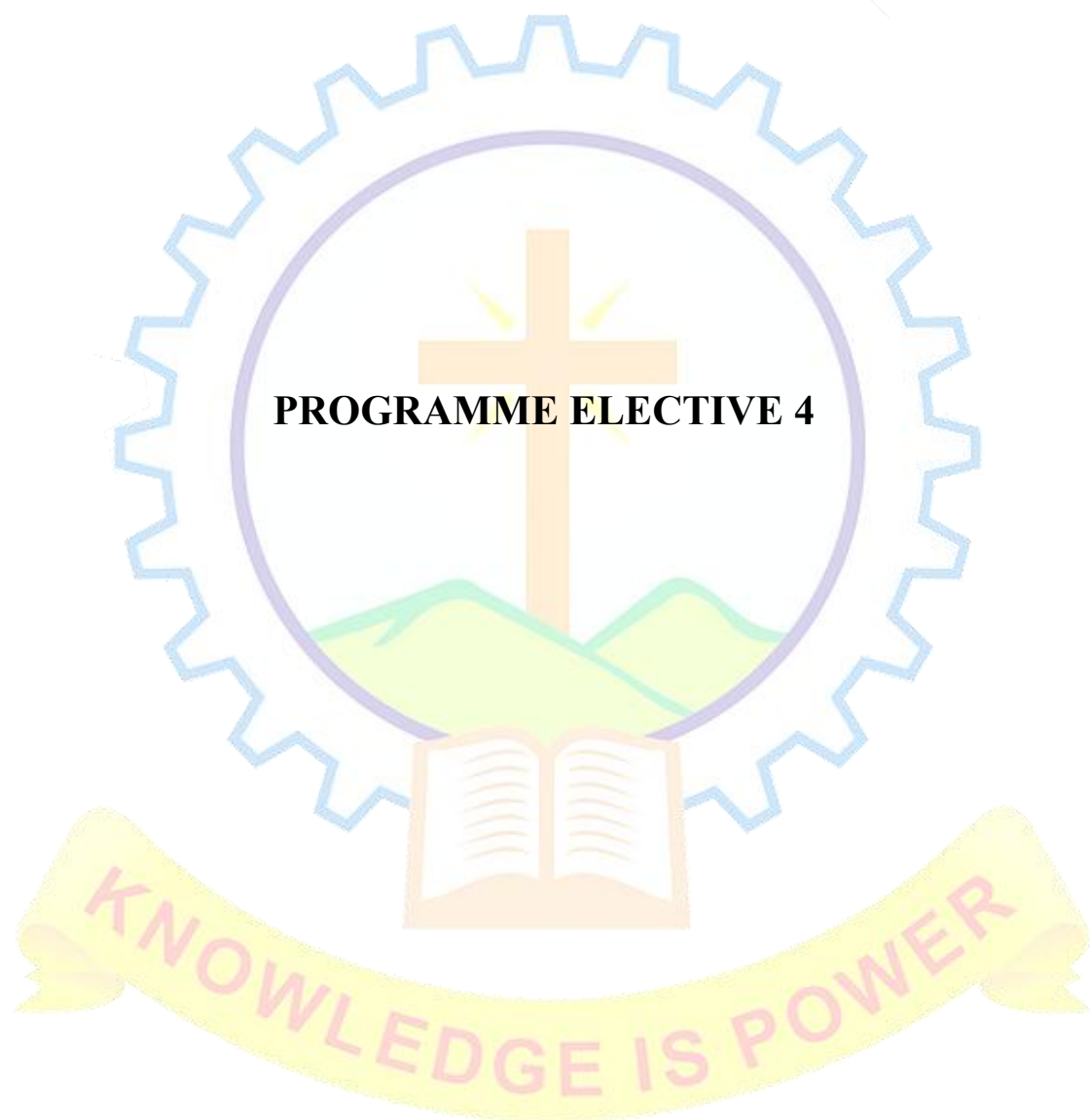
**Answer all questions. Each question carries 4 marks.**

1. Outline the sequential loading process in a skyscraper.
2. Illustrate the infill wall patterns and how it fails under lateral loading.
3. Elucidate the methods used for approximate analysis of high-rise buildings.
4. Describe how the braced frame structural form which is utilized in tall buildings behaves. Also list out the various bracing systems.
5. “P-Delta is a second-order effect that is mostly manifested in tall buildings when subjected to lateral sway”. Justify the statement.

**PART B**

**Answer any five questions. Each question carries 8 marks.**

6. List out the various software's for structural analysis. What is the difference between high-rise and low-rise buildings?
7. Analyse the performance of framed structure by the insertion of a bracing mechanism. Draw the sketch of the numerous bracing systems that are utilized in buildings.
8. Briefly explain the structural system of the tallest building in the world.
9. Outline the purpose of the wind tunnel test. Suggest any two experiments conducted for tall buildings.
10. With the help of neat sketches explain the types of foundation suitable for high rise buildings.
11. Provide examples of how subsystem interactions can affect the overall structural performance.
12. Evaluate the effects of various types of loads on high-rise structures.



| CODE        | COURSE NAME           | CATEGORY | L | T | P | S | CREDIT |
|-------------|-----------------------|----------|---|---|---|---|--------|
| M24CE1E204A | FINITE ELEMENT METHOD | ELECTIVE | 3 | 0 | 0 | 3 | 3      |

**Preamble:** The course offers a systematic approach to discretize continuous systems into finite elements, and obtain approximate solutions to differential equations governing various engineering problems.

**Prerequisite** : Theory of Elasticity and Plasticity

**Course Outcomes** : After the completion of the course the student will be able to

|             |  |
|-------------|--|
| <b>CO 1</b> | Idealize the physical problem into a mathematical model to obtain approximate solutions. <b>(Cognitive Knowledge Level: Apply)</b>           |
| <b>CO 2</b> | Formulate shape functions to solve problems using finite element method <b>(Cognitive Knowledge Level: Apply)</b>                            |
| <b>CO 3</b> | Derive stiffness matrices to solve various structural mechanics and continuum mechanics problems. <b>(Cognitive Knowledge Level:Analyse)</b> |
| <b>CO 4</b> | Achieve proficiency in isoparametric formulation, numerical integration, and their applications. <b>(Cognitive Knowledge Level:Evaluate)</b> |
| <b>CO 5</b> | Develop stiffness matrix for plate bending elements and acquire a knowledge of solution techniques. <b>(Cognitive Knowledge Level:Apply)</b> |

#### Mapping of course outcomes with program outcomes

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
|-------------|------|------|------|------|------|------|
| <b>CO 1</b> | 1    | 1    | 1    | 1    | 2    | 2    |
| <b>CO 2</b> | 1    | 1    | 2    | 2    | 1    | 2    |
| <b>CO 3</b> | 1    | 1    | 2    | 1    | 1    | 2    |
| <b>CO 4</b> | 1    | 1    | 2    | 2    | 2    | 2    |
| <b>CO 5</b> | 1    | 1    | 2    | 2    | 1    | 2    |

#### Assessment Pattern

| Course Name      | Finite Element Method       |                  |                                    |
|------------------|-----------------------------|------------------|------------------------------------|
| Bloom's Category | Continuous Evaluation Tests |                  | End Semester Examination (% marks) |
|                  | Test 1 (% marks)            | Test 2 (% marks) |                                    |
| Remember         |                             |                  |                                    |
| Understand       | 10                          | 10               | 10                                 |
| Apply            | 50                          | 50               | 50                                 |
| Analyse          | 30                          | 30               | 30                                 |
| Evaluate         | 10                          | 10               | 10                                 |
| Create           |                             |                  |                                    |

**Mark distribution**

| Total Marks | CIE Marks | ESE marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 100         | 40        | 60        | 3 Hours      |

|  |   |          |
|--|---|----------|
| <b>Continuous Internal Evaluation Pattern</b>                                  | : |          |
| Seminar*   | : | 10 marks |
| Course based task/Micro Project//Data collection and interpretation/Case study | : | 10 marks |
| Test paper 1 (Module 1 and Module 2)   | : | 10 marks |
| Test paper 2 (Module 3 and Module 4)   | : | 10 marks |

\*Seminar should be conducted in addition to the theory hours. Topics for the seminar should be from recent technologies in the respective course

**End Semester Examination Pattern:** The end semester examination will be conducted by the college. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 4 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 8 marks. Total duration of the examination will be 3 Hrs.

## SYLLABUS

### MODULE 1 (8 hours)

Historical Background – General steps of finite element method – Applications and advantages of finite element method – Computer Programs for finite element method.

Idealization of physical problem- Mathematical modelling of Engineering problems -Concept of Boundary, initial and eigen value problems – Variational methods of approximation-Rayleigh Ritz Method-Weighted residual method – Galerkin's Residual methods - method of least square.

### MODULE 2 (7 hours)

Formulation of finite element problem - Generalized and natural coordinates of FEA-Shape functions-polynomials- Lagrangian and Hermitian interpolation- Strong formulation and weak formulation - Compatibility- C0 and C1 elements-convergence criteria- Conforming and non-conforming elements- Patch test.

### MODULE 3 (8 hours)

Axial deformation of bars under uniformly varying loads- Definition of stiffness matrix- derivation of stiffness matrix for a spring element- derivation of stiffness matrix for a bar element - derivation of stiffness matrix for a beam element (two noded and three noded) - derivation of stiffness matrix for a CST element - derivation of stiffness matrix for a LST element- derivation of bilinear four noded rectangular element stiffness matrix.

### MODULE 4 (7 hours)

Isoparametric formulation – Introduction to Isoparametric formulation of a bar element stiffness matrix – Isoparametric formulation of a plane quadrilateral element (beam) stiffness matrix- Isoparametric formulation of quadratic rectangular (Q8) element- Isoparametric formulation of serendipity element - Newton cotes and Gauss quadrature.

### MODULE 5 (6 hours)

Basic concepts of plate bending- derivation of plate bending element stiffness matrix -Shear locking, reduced and selective reduced integrations; Spurious energy modes – Global assembly of element equations; Storage schemes in FEA – Banded and Skyline storage; Calculation of semi band width – node numbering for optimal bandwidth – Solution schemes in FEA – Frontal solver

**References**

1. Cook R D et al., Concepts and Applications of Finite Element Analysis, John Wiley & Sons, Singapore, fifth edition, 2014.
2. Logan D L, A First Course in Element Method, Thomson, 2007.
3. J.N. Reddy, An Introduction to Finite Element Method, Tata McGraw Hill Publishing Company Ltd, New Delhi, fourth edition 2019.
4. Hutton D V, Fundamentals of Finite Element Analysis, Tata McGraw Hill Education Private Ltd. New Delhi, second edition 2004.
5. Bathe K J, Finite Element Procedures in Engineering Analysis, Prentice Hall, New Delhi, second edition 1996.
6. Zienkiewicz O C and Taylor R W., Finite Element Method, Elsevier ButterworthHeinemann, UK, seventh edition 2024.
7. Y. M. Desai, T. I. Eldho, A. H. Shah, Finite Element Method with Applications in Engineering, Pearson Education India, second edition 2018.

**COURSE CONTENTS AND LECTURE SCHEDULE**

| No  | Topic  | No. of Lecture/<br>Tutorial hours |
|---|--|-----------------------------------|
| <b>Module 1: Introduction to Finite Element Methods</b> |  | <b>8</b>                          |
| 1.1   | Historical Background- General steps of finite element method – Applications and advantages of finite element method | 1                                 |
| 1.2   | Computer Programs for finite element method.   | 2                                 |
| 1.3   | Idealization of physical problem- Mathematical modelling of Engineering problems                                     | 1                                 |
| 1.4   | Concept of Boundary, initial and eigen value problems  | 1                                 |
| 1.5   | Variational methods of approximation-Rayleigh Ritz Method  | 1                                 |
| 1.6   | Weighted residual method   | 1                                 |
| 1.7   | Method of least square methods   | 1                                 |
| <b>Module 2: Shape Functions</b>                        |  | <b>7</b>                          |
| 2.1   | Concept of nodes – elements  | 1                                 |
| 2.2   | Generalized and natural coordinates of FEA   | 1                                 |
| 2.3   | Shape functions- polynomials   | 1                                 |
| 2.4   | Lagrangian and Hermitian interpolation   | 2                                 |
| 2.5   | Compatibility- C0 and C1 elements  | 1                                 |
| 2.6   | Conforming and non-conforming elements   | 1                                 |

|     |   |          |
|-----|---|----------|
|     | <b>Module 3: Displacement (stiffness) method in FEA</b>                                 | <b>8</b> |
| 3.1 | Definition- derivation of stiffness matrix for a spring element                         | 1        |
| 3.2 | Derivation of stiffness matrix for a bar element and equations                          | 2        |
| 3.3 | Derivation of stiffness matrix for a beam element and equations                         | 1        |
| 3.4 | Derivation of stiffness matrix for a CST element and equations                          | 2        |
| 3.5 | derivation of stiffness matrix for a LST element and equations                          | 2        |
|     | <b>Module 4: Isoparametric formulations and numerical integrations</b>                  | <b>7</b> |
| 4.1 | Introduction – Isoparametric formulation of a bar element stiffness matrix              | 2        |
| 4.2 | Isoparametric formulation of a plane quadrilateral element (beam) stiffness matrix      | 2        |
| 4.3 | Newton- cots and Gauss quadrature   | 3        |
|     | <b>Module 5: Plate Bending Elements</b>   | <b>6</b> |
| 5.1 | Basic concepts of plate bending   | 1        |
| 5.2 | Derivation of plate bending element stiffness matrix and equations                      | 1        |
| 5.3 | Shear locking, reduced and selective reduced integrations; Spurious energy modes        | 1        |
| 5.4 | Global assembly of element equations; Storage schemes in FEA Banded and Skyline storage | 1        |
| 5.5 | Calculation of semi-band width-node numbering for optimal bandwidth                     | 1        |
| 5.6 | Solution schemes in FEA – Frontal solver  | 1        |

KNOWLEDGE IS POWER

**Model Question Paper**

**QP CODE:**

Pages: 2

Reg No.: \_\_\_\_\_

Name: \_\_\_\_\_

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM  
SECOND SEMESTER M.TECH DEGREE EXAMINATION, MAY 2025**

*Course Code: M24CE1E204A*

*Course Name: FINITE ELEMENT METHOD*

Max. Marks:60

Duration: 3 hours

**PART A**

*Answer all questions. Each question carries 4 marks.*

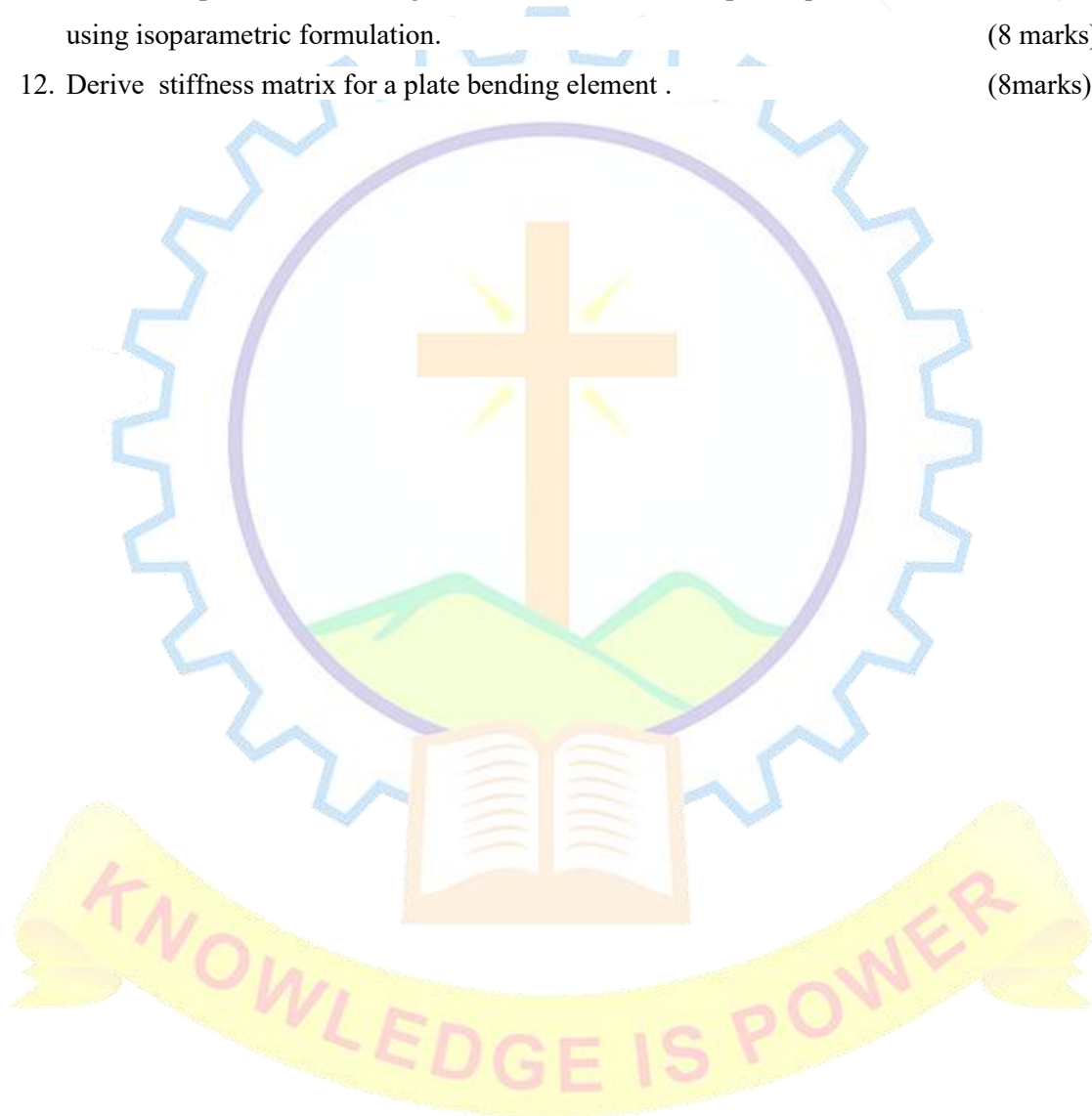
1. Outline the general steps involved in the finite element method for solving engineering problems.
2. Distinguish between conforming and non-conforming elements in finite element analysis.
3. In what manner does the stiffness matrix reflect the behavior of a spring in finite element analysis?
4. Illustrate the concept of isoparametric formulation for a one-dimensional bar element.
5. Some elements exhibit more stiffness than they actually are. What are these problems called? Suggest and discuss remedial measures.

**PART B**

*Answer any five questions. Each question carries 8 marks.*

6. a. Elucidate the significance of idealizing a physical problem in the context of finite element analysis. (4 marks)  
b. Discuss the importance of assumptions and simplifications in mathematical modeling for finite element analysis. (4 marks)
7. Illustrate the concepts of boundary and eigenvalue problems in the domain of finite element analysis with examples. (8 marks)

8. Develop the shape functions for four noded bar element using Normalized coordinates. (8 marks)
9. Derive the stiffness matrix for a linear quadrilateral (LST) element. (8 marks)
10. Illustrate the finite element form of Galerkin's method in one dimension with an example. (8 marks)
11. Extend the process of deriving the stiffness matrix for a plane quadrilateral element (beam) using isoparametric formulation. (8 marks)
12. Derive stiffness matrix for a plate bending element . (8marks)



| CODE        | COURSE NAME                 | CATEGORY | L | T | P | S | CREDIT |
|-------------|-----------------------------|----------|---|---|---|---|--------|
| M24CE2E204B | THEORY OF PLATES AND SHELLS | ELECTIVE | 3 | 0 | 0 | 3 | 3      |

**Preamble:** The course covers fundamental behaviour of the plates and shells with different geometry under various types of loads. The structural responses of various thin-walled structures like plates, shells and folded plates are also discussed.

**Prerequisite:** Theory of elasticity and Plasticity

**Course Outcomes:** After the completion of the course the student will be able to

|      |   |
|------|---|
| CO 1 | Understand the fundamental principles of bending of plates. <b>(Cognitive Knowledge Level: Understand)</b>                                |
| CO 2 | Apply solution techniques in solving plate problems. <b>(Cognitive Knowledge Level: Apply)</b>  |
| CO 3 | Evaluate symmetrical bending of circular plates and use the concept to analyse annular plates. <b>(Cognitive Knowledge Level:analyse)</b> |
| CO 4 | Analyse the shell structures using membrane and bending theory. <b>(Cognitive Knowledge Level: Analyse)</b>                               |
| CO 5 | Apply the principles of folded plate structures. <b>(Cognitive Knowledge Level: Apply)</b>  |

**Mapping of course outcomes with program outcomes:**

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
|------|------|------|------|------|------|------|
| CO 1 | 1    | 1    | 2    | 2    | 1    | 1    |
| CO 2 | 2    | 1    | 1    | 2    | 2    | 1    |
| CO 3 | 1    | 1    | 2    | 2    | 2    | 1    |
| CO 4 | 2    | 1    | 2    | 2    | 2    | 1    |
| CO 5 | 1    | 1    | 2    | 1    | 2    | 1    |

**Assessment Pattern:**

| Course Name      | THEORY OF PLATES AND SHELLS |                  |                                    |
|------------------|-----------------------------|------------------|------------------------------------|
| Bloom's Category | Continuous Evaluation Tests |                  | End Semester Examination (% marks) |
|                  | Test 1 (% marks)            | Test 2 (% marks) |                                    |
| Remember         |                             |                  |                                    |
| Understand       | 30                          | 20               | 30                                 |
| Apply            | 40                          | 40               | 40                                 |
| Analyse          | 30                          | 40               | 30                                 |
| Evaluate         |                             |                  |                                    |
| Create           |                             |                  |                                    |

**Mark distribution:**

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 100         | 40        | 60        | 3 Hours      |

|  |   |          |
|--|---|----------|
| <b>Continuous Internal Evaluation Pattern</b>                                  | : |          |
| Seminar*   | : | 10 marks |
| Course based task/Micro Project//Data collection and interpretation/Case study | : | 10 marks |
| Test paper 1 (Module 1 and Module 2)   | : | 10 marks |
| Test paper 2 (Module 3 and Module 4)   | : | 10 marks |

\*Seminar should be conducted in addition to the theory hours. Topics for the seminar should be from recent technologies in the respective course

**End Semester Examination Pattern:** The end semester examination will be conducted by the college. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 4 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 8 marks. Total duration of the examination will be 3 Hrs.

## SYLLABUS

### MODULE 1 (5 hours)

#### Introduction to Plate Fundamentals and Basic Equations: -

Assumptions in the theory of thin plates-Classification of Plates - Pure bending of Plates - Relations between bending moments and curvature - Particular cases of pure bending of rectangular plates - Cylindrical bending with immovable and simply supported edges

### MODULE 2 (10 hours)

#### Rectangular Plates under Lateral Loads: -

Differential equation of plates – Boundary conditions – Navier solution for simply supported plates subjected to uniformly distributed load and point load – Levy's method solution of plates having two opposite edges simply supported with u.d.l.

### MODULE 3 (7 hours)

#### Laterally Loaded Circular Plates: -

Differential equation of equilibrium – Uniformly loaded circular plates with simply supported and fixed boundary conditions – Annular plate with uniform moment and shear force along the boundaries. Effect of transverse shear deformation - plates of variable thickness.

### MODULE 4 (7 hours)

#### Classical Theory of Shells: -

Structural behaviour of thin shells – Classification of shells – Singly and doubly curved shells with examples – Membrane theory and bending theory of doubly curved shells -equilibrium equations.

### MODULE 5 (7 hours)

#### Folded Plates:

Introduction to folded plates - Classification and Structural Action-Analytical techniques of folded plates. Theory of Bending of Thin Plates under Lateral and In-plane Loads. De-shuttering Scheme for Folded Plates.

### References

1. Timoshenko, S.P., and Krieger, S.W., Theory of Plates and Shells, McGraw Hill, 1987.
2. Ventsel, E., and Krauthammer, T., Thin plates and shells, Theory, Analysis and Applications, Marcel Dekker, Inc, New York, 2001.
2. Szilard, R., Theory and Analysis of Plates – Classical Numerical Methods, Prentice Hall Inc., 1974.
3. Bairagi, N.K., Plate Analysis, Khanna Publishers, New Delhi, 1986.

4. Gould, P.L., Analysis of Shells and Plates, Springer-Verlag, New York, 1988.
5. Timoshenko, S. P., Mujica, I. M., & Doerner, S. L. R. Z. (2007). *Plate and Shell Structures: Theory and Applications*.
6. Crocker, M. J. (2007). *Theory of Plates and Shells: An Introduction*. Wiley.
7. Inman, D. J. (2001). *Plate and Shell Structures: Theory and Applications*.

### COURSE CONTENTS AND LECTURE SCHEDULE

| No              | Topic  | No. of Lecture/<br>Tutorial hours |
|-----------------|--|-----------------------------------|
| <b>MODULE 1</b> |  | <b>5</b>                          |
| 1.1             | Overview of the Theory of Thin Plates: Assumptions and Principles  | 2                                 |
| 1.2             | Analysis of Pure Bending in Plates   | 1                                 |
| 1.3             | Understanding the Relationship between Bending Moments and Curvature   | 1                                 |
| 1.4             | Specific Scenarios in Pure Bending: Rectangular Plates, Cylindrical Bending with Fixed and Simply Supported Edges  | 1                                 |
| <b>MODULE 2</b> |  | <b>10</b>                         |
| 2.1             | Derivation of the Differential Equation for Plates   | 1                                 |
| 2.2             | Establishment of Boundary Conditions   | 1                                 |
| 2.3             | Application of Navier's Solution for Simply Supported Plates under Uniformly Distributed Load and Point Load   | 4                                 |
| 2.4             | Solution using Levy's Method for Plates with Two Opposite Edges Simply Supported and Varied Symmetrical Boundary Conditions on the Other Two Edges with Uniformly Distributed Load | 4                                 |
| <b>MODULE 3</b> |  | <b>7</b>                          |
| 3.1             | Differential equation of equilibrium   | 1                                 |
| 3.2             | Uniformly loaded circular plates with simply supported boundary conditions.  | 1                                 |
| 3.3             | Uniformly loaded circular plates with fixed boundary conditions.   | 1                                 |
| 3.4             | Annular plates with uniform moment and shear force along the boundaries.   | 2                                 |
| 3.5             | Effect of transverse shear deformation on plates of variable thickness.  | 2                                 |
| <b>MODULE 4</b> |  | <b>7</b>                          |
| 4.1             | Structural behavior of thin shells   | 1                                 |
| 4.2             | Classification of shells   | 1                                 |
| 4.3             | Singly and doubly curved shells with examples  | 1                                 |

|     |  |          |
|-----|--|----------|
| 4.4 | Membrane theory and bending theory of doubly curved shells             | 3        |
| 4.5 | Equilibrium equations  | 1        |
|     | <b>MODULE 5</b>  | <b>7</b> |
| 5.1 | Introduction, Classification, Structural action and analysis           | 2        |
| 5.2 | Assumptions in the analysis of folded plates                           | 2        |
| 5.3 | Theory of bending of thin plates with lateral loads and in plane loads | 2        |
| 5.4 | Scheme for de-shuttering.  | 1        |



**Model Question Paper**

**QP CODE:**

Pages: 1

Reg No.: \_\_\_\_\_

Name: \_\_\_\_\_

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**SECOND SEMESTER M.TECH DEGREE EXAMINATION, MAY 2025**

**Course Code: M24CE2E204B**

**Course Name: THEORY OF PLATES AND SHELLS**

Max. Marks:60

Duration: 3 hours

**PART A**

**Answer all questions. Each question carries 4 marks.**

1. Indicate whether the following statement is 'true' 'false' or 'maybe'. Give brief justification for full credit. "Plates are stiffer than beams".
2. Address the theory and underlying concept of the statement, 'If the deflection of the plate is very modest, the thickness to span ratio of the plate is less than 1/20'.
3. Analyze a circular plate of radius 'a' simply supported throughout along its outer edge and subjected to point load P at its center.
4. What functions do bending theory and membrane theory have in shell structures?
5. Sketch the various shapes of folded plate roofs used in practice.

**PART B**

**Answer any five questions. Each question carries 8 marks.**

6. Analyse the rectangular plate under pure bending for  $M_x = M_y = M$ .
7. Prove that maximum and minimum slopes are orthogonal in case of pure bending of plates.
8. Calculate the deflection produced in a simply supported rectangular plate loaded with sinusoidal load of the form  $q(x, y) = q_0 \sin \frac{\pi x}{a} \sin \frac{\pi y}{b}$ , where a and b are the dimensions of the plate.
9. Derive the differential equation for the deflection of a circular plate loaded symmetrically about an axis perpendicular to the plate through its centre.
10. Calculate the bending moment at the support and at the centre for a circular plate with clamped edges under external pressure 'p'.
11. Determine the membrane forces in a structure with a single curved shell.
12. Which kind of structure is an elliptical paraboloid? Describe the structural action.

| CODE        | COURSE NAME  | CATEGORY | L | T | P | S | CREDIT |
|-------------|--|----------|---|---|---|---|--------|
| M24CE1E204C | FORENSIC ENGINEERING<br>IN CIVIL ENGINEERING<br>STRUCTURES | ELECTIVE | 3 | 0 | 0 | 3 | 3      |

**Preamble:** The course covers the different aspects of assessing the integrity of structures. Through a blend of theoretical knowledge and practical insights, students will learn to assess structural integrity, diagnose performance problems, and implement effective solutions.

**Prerequisite** : Nil

**Course Outcomes** : After the completion of the course the student will be able to

|             |  |
|-------------|--|
| <b>CO 1</b> | Develop a thorough understanding and identification of the various causes of structural failures ( <b>Cognitive Knowledge Level: Analyse</b> )   |
| <b>CO 2</b> | Diagnose distress within structural elements utilizing a range of techniques. ( <b>Cognitive Knowledge Level: Apply</b> )                        |
| <b>CO 3</b> | Evaluate various environmental challenges and natural hazards affecting structural integrity ( <b>Cognitive Knowledge Level: Analyse</b> )       |
| <b>CO 4</b> | Use modern techniques of retrofitting to enhance the resilience and longevity of structures( <b>Cognitive Knowledge Level: Analyse</b> )         |
| <b>CO 5</b> | Gain practical insights into real-world instances of structural failure analysis and remediation. ( <b>Cognitive Knowledge Level: Evaluate</b> ) |

#### Mapping of course outcomes with program outcomes

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
|-------------|------|------|------|------|------|------|
| <b>CO 1</b> | 1    | 1    | 1    | 2    | 1    | 1    |
| <b>CO 2</b> | 2    | 1    | 2    | 2    | 1    | 1    |
| <b>CO 3</b> | 2    | 1    | 2    | 2    | 1    | 1    |
| <b>CO 4</b> | 1    | 1    | 2    | 2    | 1    | 1    |
| <b>CO 5</b> | 1    | 1    | 2    | 2    | 1    | 1    |

**Assessment Pattern**

| Course Name      | FORENSIC ENGINEERING IN CIVIL ENGINEERING STRUCTURES |                  |                                    |
|------------------|--|------------------|------------------------------------|
| Bloom's Category | Continuous Evaluation Tests                          |                  | End Semester Examination (% Marks) |
|                  | Test 1 (% Marks)                                     | Test 2 (% Marks) |                                    |
| Remember         |  |                  |                                    |
| Understand       | 20   | 20               | 20                                 |
| Apply            | 30   | 30               | 30                                 |
| Analyse          | 40   | 40               | 40                                 |
| Evaluate         | 10   | 10               | 10                                 |
| Create           |  |                  |                                    |

**Mark distribution**

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 100         | 40        | 60        | 3 Hours      |

|  |   |          |
|--|---|----------|
| <b>Continuous Internal Evaluation Pattern</b>                                  | : |          |
| Seminar*   | : | 10 marks |
| Course based task/Micro Project//Data collection and interpretation/Case study | : | 10 marks |
| Test paper 1 (Module 1 and Module 2)   | : | 10 marks |
| Test paper 2 (Module 3 and Module 4)   | : | 10 marks |

\*Seminar should be conducted in addition to the theory hours. Topics for the seminar should be from recent technologies in the respective course

**End Semester Examination Pattern:** The end semester examination will be conducted by the college. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 4 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 8 marks. Total duration of the examination will be 3 Hrs.

## SYLLABUS

### MODULE 1 (7 hours)

Review of construction theory and principles, understanding performance problems and their implications, Responsibility and accountability in structural failures, Case studies illustrating lessons learned from failures, Causes of distress in structural members: design and material deficiencies, overloading

### MODULE 2 (7 hours)

Introduction to non-destructive testing (NDT) methods, Ultrasonic pulse velocity method, rebound hammer method, ASTM classifications for distress assessment, Case studies analyzing distress in single and multistorey buildings, Prediction of structural weakness using fiber optic methods

### MODULE 3 (7 hours)

Impact of corrosive, chemical, and marine environments on structures, Pollution and carbonation issues affecting durability, Damage assessment due to earthquakes and floods, Strengthening strategies for buildings as per BIS 1893 and 4326 provisions, Durability considerations for RCC structures

### MODULE 4 (8 hours)

Introduction to modern retrofitting techniques, Structural first aid and post-disaster rehabilitation approaches, Guniting, jacketing, and use of chemicals in repair, Application of polymers, Ferro cement, and fiber concretes, Rust eliminators and polymer coating for rebar protection, Foamed concrete and mortar repair for cracks, Shoring, underpinning, and pre-stressing for strengthening

### MODULE 5 (7 hours)

Analysis of building failures, including heritage and high-rise buildings, Case studies focusing on water tanks, bridges, and other structures, Examination of investigative techniques and forensic engineering principles, Lessons learned and best practices in structural failure analysis

### References

1. Robert Ratay, "Forensic Structural Engineering Handbook second edition 2021"
2. V. Ramachandran, "Failure Analysis of Engineering Structures: Methodology and Case Histories"(2005).
3. Robert Ratay, "Investigation of Structural Failures: A Guide for Engineers" first edition 2009.
4. Christiane Maierhofer, "Non-Destructive Evaluation of Reinforced Concrete Structures: Non-Destructive Testing Methods" first edition 2010.

5. Malcolm Holland, "Practical Guide to Diagnosing Structural Movement in Buildings" first edition 2012.
6. Roberto Barros, "NDT Techniques for the Diagnosis of Concrete Structures"(2016)
7. N.J. Delatte, "Beyond Failure: Forensic Case Studies for Civil Engineers", ASCE, 2009

### COURSE CONTENTS AND LECTURE SCHEDULE

| No  | Topic   | No. of Lecture/<br>Tutorial hours |
|-----|---|-----------------------------------|
|     | <b>Module 1 Structural Failure Analysis</b>   | <b>7</b>                          |
| 1.1 | Review of construction theory and principles  | 1                                 |
| 1.2 | Understanding performance problems and their implications                               | 2                                 |
| 1.3 | Responsibility and accountability in structural failures                                | 1                                 |
| 1.4 | Case studies illustrating lessons learned from failures                                 | 1                                 |
| 1.5 | Causes of distress in structural members: design and material deficiencies, overloading | 2                                 |
|     | <b>Module 2 Distress Diagnosis and Assessment</b>                                       | <b>7</b>                          |
| 2.1 | Visual inspection techniques for identifying distress                                   | 1                                 |
| 2.2 | Introduction to non-destructive testing (NDT) methods                                   | 1                                 |
| 2.3 | Ultrasonic pulse velocity method, rebound hammer method                                 | 2                                 |
| 2.4 | ASTM classifications for distress assessment  | 1                                 |
| 2.5 | Case studies analyzing distress in single and multistorey buildings                     | 1                                 |
| 2.6 | Prediction of structural weakness using fiber optic methods                             | 1                                 |
|     | <b>Module 3 Environmental Challenges and Natural Hazards</b>                            | <b>7</b>                          |
| 3.1 | Impact of corrosive, chemical, and marine environments on structures                    | 2                                 |
| 3.2 | Pollution and carbonation issues affecting durability                                   | 1                                 |
| 3.3 | Damage assessment due to earthquakes and floods   | 1                                 |
| 3.4 | Strengthening strategies for buildings as per BIS 1893 and 4326 provisions              | 2                                 |
| 3.5 | Durability considerations for RCC structures  | 1                                 |
|     | <b>Module 4 Retrofitting and Rehabilitation Techniques</b>                              | <b>8</b>                          |
| 4.1 | Introduction to modern retrofitting techniques  | 1                                 |
| 4.2 | Structural first aid and post-disaster rehabilitation approaches                        | 1                                 |
| 4.3 | Guniting, jacketing, and use of chemicals in repair                                     | 1                                 |
| 4.4 | Application of polymers, Ferro cement, and fiber concretes                              | 1                                 |
| 4.5 | Rust eliminators and polymer coating for rebar protection                               | 1                                 |
| 4.6 | Foamed concrete and mortar repair for cracks  | 1                                 |

|     |   |          |
|-----|---|----------|
| 4.7 | Shoring, underpinning, and pre-stressing for strengthening                  | 2        |
|     | <b>Module 5 Case Studies in Structural Failures</b>                         | <b>7</b> |
| 5.1 | Analysis of building failures, including heritage and high-rise buildings   | 2        |
| 5.2 | Case studies focusing on water tanks, bridges, and other structures         | 2        |
| 5.3 | Examination of investigative techniques and forensic engineering principles | 2        |
| 5.4 | Lessons learned and best practices in structural failure analysis           | 1        |



**Model Question Paper**

**QP CODE:**

Pages: 2

Reg No.: \_\_\_\_\_

Name: \_\_\_\_\_

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM  
SECOND SEMESTER M.TECH DEGREE EXAMINATION, MAY 2025**

*Course Code: M24CE1E204C*

*Course Name: FORENSIC ENGINEERING IN CIVIL ENGINEERING STRUCTURES*

**PART A**

*Answer all questions. Each question carries 4 marks.*

1. Examine the responsibilities and accountabilities of engineers and construction managers in preventing structural failures.
2. Identify a method to the quality of concrete in a structure.
3. Outline the key considerations in damage assessment for structures affected by earthquakes and floods.
4. Discuss the use of polymer coatings in the protection of rebar.
5. Examine the forensic engineering principles applied in the examination of failed structures.

**PART B**

*Answer any five questions. Each question carries 8 marks.*

6. (a) Explain the basic principles of construction theory. How do these principles guide the design and building processes? (4 marks)  
(b) Identify and explain the common design and material deficiencies that cause distress in structural members. (4 marks)
7. (a) Discuss the ASTM classifications for distress assessment in concrete structures. How are these classifications used in practice? (4 marks)  
(b) Describe the principle and applications of the ultrasonic pulse velocity method in non-destructive testing. (4 marks)
8. (a) Discuss the impact of corrosive, chemical, and marine environments on the durability of structures. (4 marks)  
(b) Explain the importance of durability considerations in the design and maintenance of

RCC structures.

(4 marks)

9. (a) Provide an overview of modern retrofitting techniques used in the construction industry.

(4 marks)

(b) What is structural first aid, and how is it applied in post-disaster rehabilitation? (4 marks)

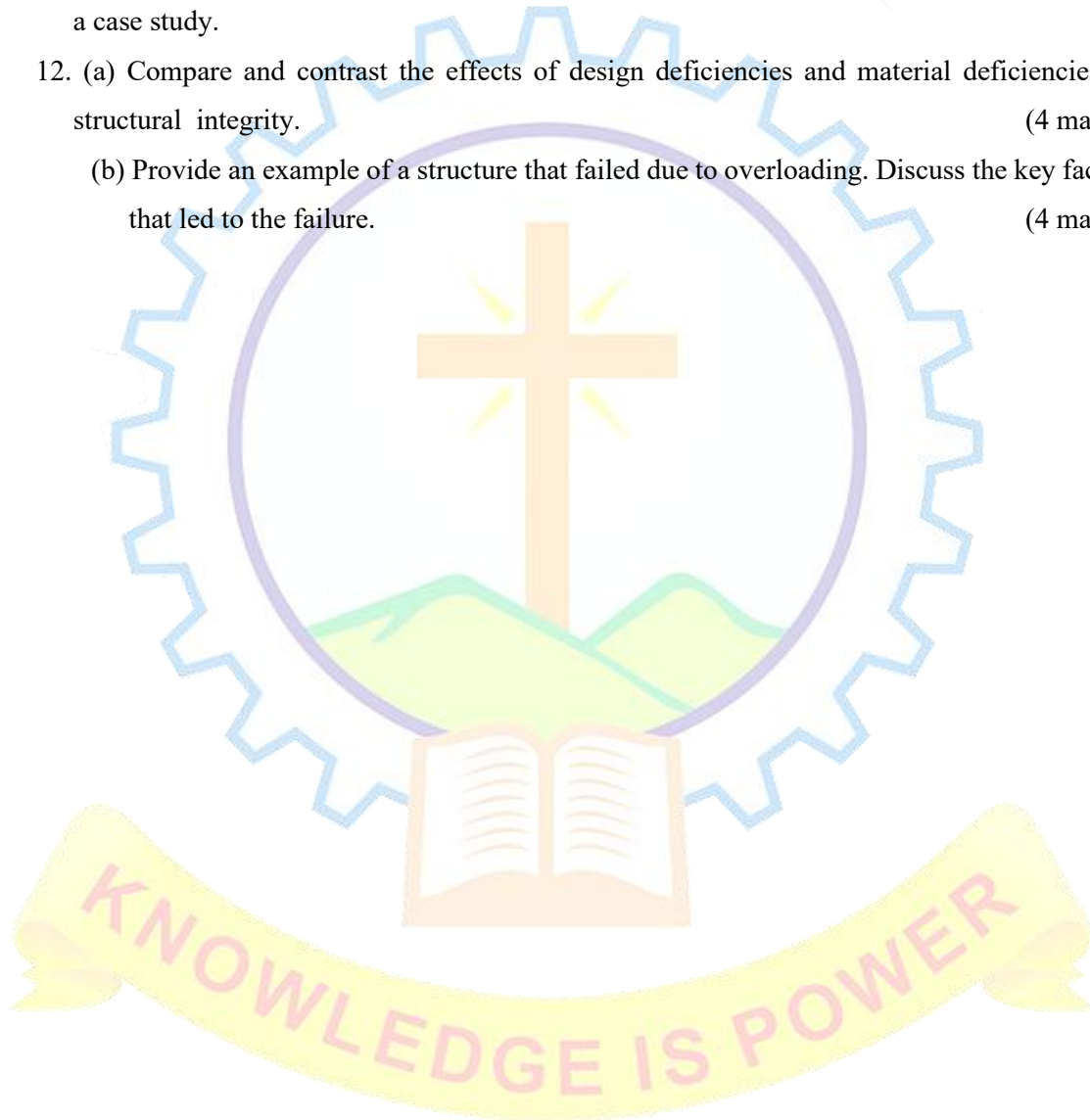
10. Analyze a case study of a building failure, focusing on either a heritage or a high-rise building.

What were the key factors leading to the failure?

11. Illustrate how ASTM standards guide the evaluation of distressed concrete structures through a case study.

12. (a) Compare and contrast the effects of design deficiencies and material deficiencies on structural integrity. (4 marks)

(b) Provide an example of a structure that failed due to overloading. Discuss the key factors that led to the failure. (4 marks)



| CODE        | COURSE NAME                             | CATEGORY | L | T | P | S | CREDIT |
|-------------|---|----------|---|---|---|---|--------|
| M24CE2E204D | PREFABRICATION AND MODULAR CONSTRUCTION | ELECTIVE | 3 | 0 | 0 | 3 | 3      |

**Preamble:** The course covers the manufacturing of prefabricated elements, quality control, design principles, load-bearing behavior, seismic considerations, structural connections, transportation, assembly and the integration of building services. Through an in-depth analysis of various applications and case studies, students gain insights into the practical implementation of these construction methods in residential, commercial and specialized structures.

**Prerequisite** : Basic knowledge of structural analysis and design of concrete structures.

**Course Outcomes** : After the completion of the course the student will be able to

|      |  |
|------|--|
| CO 1 | Understand current trends and challenges in prefabrication and modular construction. <b>(Cognitive Knowledge Level: Understand)</b>  |
| CO 2 | Analyze the design principles and load-bearing behavior of prefabricated concrete elements, including considerations for handling, erection and seismic loads. <b>(Cognitive Knowledge Level: Analyse)</b>         |
| CO 3 | Identify the types of structural connections in prefabricated systems and understand their design details. <b>(Cognitive Knowledge Level: Apply)</b>   |
| CO 4 | Plan and execute the logistics, transportation, site preparation and assembly of prefabricated elements and modular units, including the building services and finishes. <b>(Cognitive Knowledge Level: Apply)</b> |
| CO 5 | Analyse the applications of prefabrication and modular construction in various types of structures through case studies. <b>(Cognitive Knowledge Level: Analyse)</b>   |

#### Mapping of course outcomes with program outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
|------|------|------|------|------|------|------|
| CO 1 | 1    | 1    | 2    | 2    | 1    | 2    |
| CO 2 | 2    | 1    | 2    | 2    |      | 2    |
| CO 3 | 1    | 1    | 2    | 2    |      |      |
| CO 4 | 1    | 1    | 2    | 2    |      | 2    |
| CO 5 | 2    | 1    | 2    | 2    | 1    | 2    |

**Assessment Pattern**

| Course Name      | Precast and Modular Construction |            |                              |
|------------------|----------------------------------|------------|------------------------------|
| Bloom's Category | Continuous Evaluation Tests      |            | End Semester Examination (%) |
|                  | Test 1 (%)                       | Test 2 (%) |                              |
| Remember         |                                  |            |                              |
| Understand       | 20                               | 20         | 20                           |
| Apply            | 40                               | 40         | 40                           |
| Analyse          | 40                               | 40         | 40                           |
| Evaluate         |                                  |            |                              |
| Create           |                                  |            |                              |

**Mark distribution**

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 100         | 40        | 60        | 3 Hours      |

|   |   |          |
|---|---|----------|
| <b>Continuous Internal Evaluation</b>                                   | : |          |
| Seminar   | : | 10 marks |
| Course based task/Seminar/Data collection and interpretation/Case study | : | 10marks  |
| Test paper 1 (Module 1 and Module 2)                                    | : | 10 marks |
| Test paper 2 (Module 3 and Module 4)                                    | : | 10 marks |

**End Semester Examination**

The examination will be conducted by the College with the question paper provided by the Industry. The examination will be for 3 Hrs and will contain 7 questions, with a minimum one question from each module of which the students should answer any five. Each question can carry 12 marks. The valuation of the answer scripts shall be done by the expert in the Industry handling the course.

## SYLLABUS

### MODULE 1 (6 hours)

Overview of prefabrication and modular construction, Historical development and current trends, Advantages and challenges of construction using prefabricated elements, Comparison with cast-in-place construction, Manufacturing of prefabricated Elements, Quality control in manufacturing, Types of prefabricated concrete elements.

### MODULE 2 (8 hours)

Design principles for prefabricated concrete elements, Load-bearing behavior of prefabricated elements, handling and erection stresses, Behavior of prefabricated structures under seismic loads.

### MODULE 3 (9 hours)

Types of structural connections in prefabricated systems. Connection details and joint design for prefabricated and modular structures.

### MODULE 4 (6 hours)

Transportation, Assembly and Installation - Logistics and transportation of prefabricated elements and modular units, Site preparation and foundation systems, Assembly and erection techniques for prefabricated and modular structures, Integration of building services and finishes.

### MODULE 5 (7 hours)

Applications and Case Studies - Applications of construction using prefabricated elements in various types of structures, Applications of modular construction in residential, commercial and special structures, Case studies of successful prefabricated and modular construction projects, Future trends and innovations in prefabrication and modular construction.

### References

1. Koncz T. Manual of Precast Concrete Construction. Bauverlag, GMBH, 1976.
2. CBRI. Building Materials and Components. India, 1990.
3. Structural Precast Concrete Handbook, Building and Construction Authority, 2001.
4. Ryan E. Smith, Prefab Architecture: A Guide to Modular Design and Construction, John Wiley and Sons, Inc., 2010.
5. Ulrich Knaack, Sharon Chung-Klatte and Reinhard Hasselbach, Prefabricated Systems – Principles of Construction, Birkhäuser, 2012.
6. Structural design manual, Precast concrete connection details, Society for the studies in the use of precast concrete, Netherland Betor Verlag, 1978.

7. Gerostiza C.Z., Hendrikson C. and Rehat D.R., Knowledge based process planning for construction and manufacturing, Academic Press Inc., 1994

**COURSE CONTENTS AND LECTURE SCHEDULE**

| No              | Topic   | No. of Lecture/<br>Tutorial hours |
|-----------------|---|-----------------------------------|
| <b>Module 1</b> |   | <b>6</b>                          |
| 1.1             | Overview of prefabrication and modular construction, Historical development and current trends                      | 2                                 |
| 1.2             | Advantages and challenges of construction using prefabricated elements, Comparison with cast-in-place construction  | 2                                 |
| 1.3             | Manufacturing of prefabricated Elements, Quality control in manufacturing, Types of prefabricated concrete elements | 2                                 |
| <b>Module 2</b> |   | <b>8</b>                          |
| 2.1             | Design principles for prefabricated concrete elements   | 2                                 |
| 2.2             | Load-bearing behavior of prefabricated elements   | 2                                 |
| 2.3             | Handing and erection stresses   | 2                                 |
| 2.4             | Behavior of prefabricated structures under seismic loads  | 2                                 |
| <b>Module 3</b> |   | <b>9</b>                          |
| 3.1             | Types of structural connections in prefabricated systems  | 3                                 |
| 3.2             | Connection details for prefabricated and modular structures   | 3                                 |
| 3.3             | Joint design for prefabricated and modular structures   | 3                                 |
| <b>Module 4</b> |   | <b>6</b>                          |
| 4.1             | Logistics and transportation of prefabricated elements and modular units  | 2                                 |
| 4.2             | Site preparation and foundation systems   | 1                                 |
| 4.3             | Assembly and erection techniques for prefabricated and modular structures   | 2                                 |
| 4.4             | Integration of building services and finishes   | 1                                 |
| <b>Module 5</b> |   | <b>7</b>                          |
| 5.1             | Applications of construction using prefabricated elements in various types of structures                            | 2                                 |
| 5.2             | Applications of modular construction in residential, commercial and special structures                              | 2                                 |
| 5.3             | Case studies of successful prefabricated and modular construction projects  | 2                                 |
| 5.4             | Future trends and innovations in prefabrication and modular construction  | 1                                 |

**Model Question Paper**

**QP CODE:**

Pages: 1

Reg No.: \_\_\_\_\_

Name: \_\_\_\_\_

**MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM  
SECOND SEMESTER M.TECH DEGREE EXAMINATION, MAY 2025**

**Course Code: M24CE2E204D**

**Course Name: PREFABRICATION AND MODULAR CONSTRUCTION**

Max. Marks:60

Duration: 3 hours

**PART A**

***Answer all questions. Each question carries 4 marks.***

1. List out the challenges of construction using prefabricated elements.
2. Analyse the handling and erection stresses in prefabricated elements.
3. Identify the considerations for a satisfactory connection design.
4. Analyse the transportation of prefabricated elements and modular units.
5. Identify the future trends and innovations in prefabrication and modular construction.

**PART B**

***Answer any five questions. Each question carries 8 marks.***

6. Analyse the various operations involved in manufacturing of prefabricated elements.
7. Examine the behaviour and design of panel construction with suitable sketches.
8. Identify the types of beam to column connections in prefabricated systems.
9. Compare the foundation systems for prefabricated structures.
10. Elaborate the design considerations of prefabricated concrete beams and columns.
11. Briefly explain the assembly principles that are important to consider for a logistical prefabrication.
12. Evaluate the applications of modular construction in residential and commercial structures.

| CODE       | COURSE NAME              | CATEGORY | L | T | P | S | CREDIT |
|------------|--------------------------|----------|---|---|---|---|--------|
| M24CE1L207 | STRUCTURAL DESIGN STUDIO | LAB      | 0 | 0 | 3 | 3 | 2      |

**Preamble:** The course provides an ability to interpret the response of structural elements/whole structure using software packages such as ETABS, STAAD, ANSYS, ABAQUS. The course develops a firm foundation for research and practice in Structural Engineering. All design and detailing shall be done as per the latest IRC, IS and other relevant Codes of Practice.

**Prerequisite** : Civil Engineering Software Lab

**Course Outcomes** : After the completion of the course the student will be able to

|      |   |
|------|---|
| CO 1 | Analyze and design Reinforced Concrete Structures using ETABS/STAAD. <b>(Cognitive Knowledge Level: Analyze)</b>                            |
| CO 2 | Analyze and design steel Structures using ETABS/STAAD. <b>(Cognitive Knowledge Level: Analyze)</b>  |
| CO 3 | Develop structural detailing and design documents. <b>(Cognitive Knowledge Level: Apply)</b>  |
| CO 4 | Model and conduct static analysis of structural elements/ whole structures using ANSYS/ABAQUS. <b>(Cognitive Knowledge Level: Analyze)</b>  |
| CO 5 | Model and conduct dynamic analysis of structural elements/ whole structures using ANSYS/ABAQUS. <b>(Cognitive Knowledge Level: Analyze)</b> |

**Mapping of course outcomes with program outcomes:**

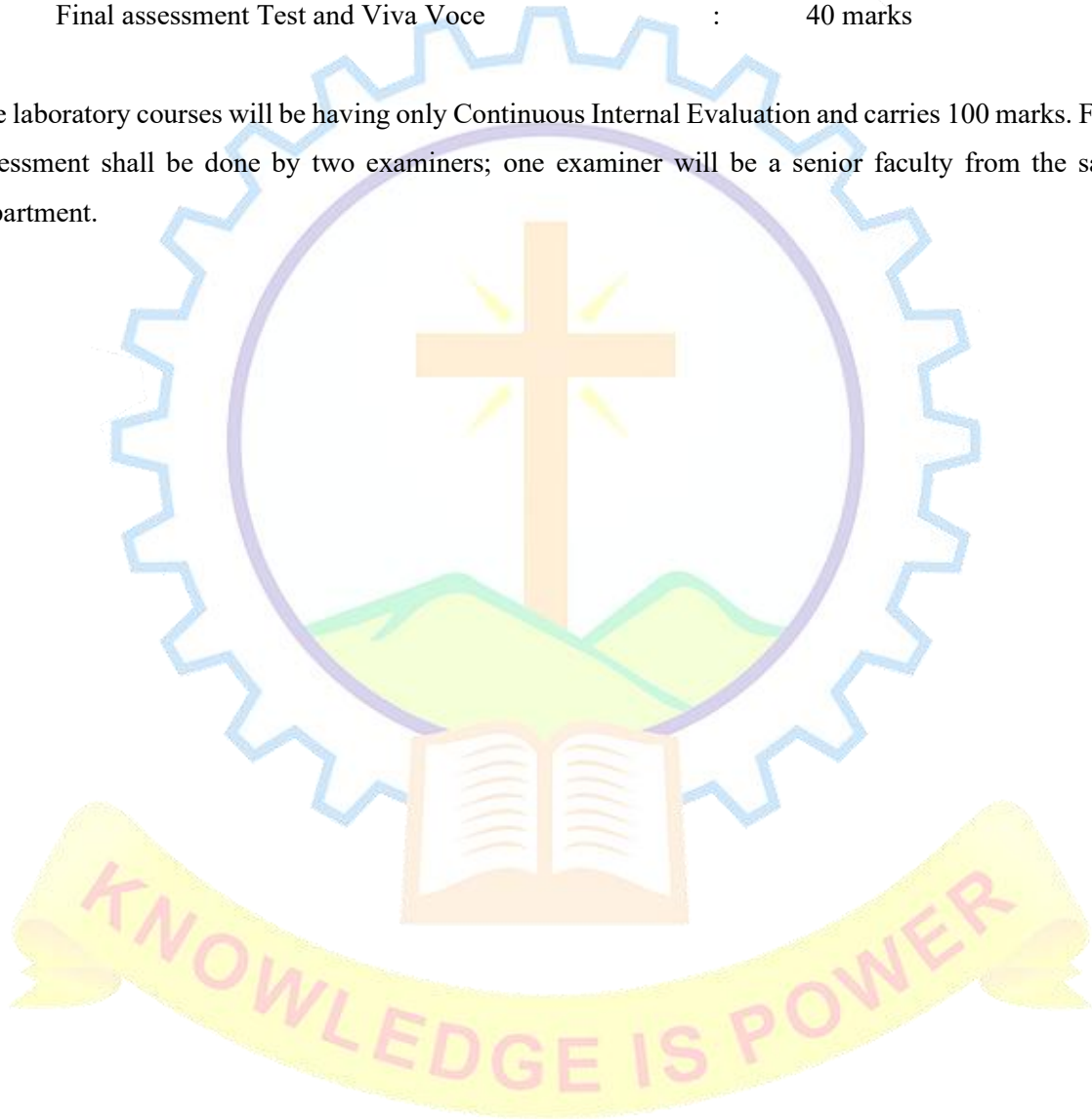
|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
|------|------|------|------|------|------|------|
| CO 1 | 1    | 1    | 2    | 2    | 2    | 2    |
| CO 2 | 1    | 1    | 2    | 2    | 2    | 2    |
| CO 3 | 2    | 1    | 1    | 2    | 1    | 1    |
| CO 4 | 1    | 1    | 2    | 2    | 2    | 2    |
| CO 5 | 1    | 1    | 2    | 3    | 2    | 2    |

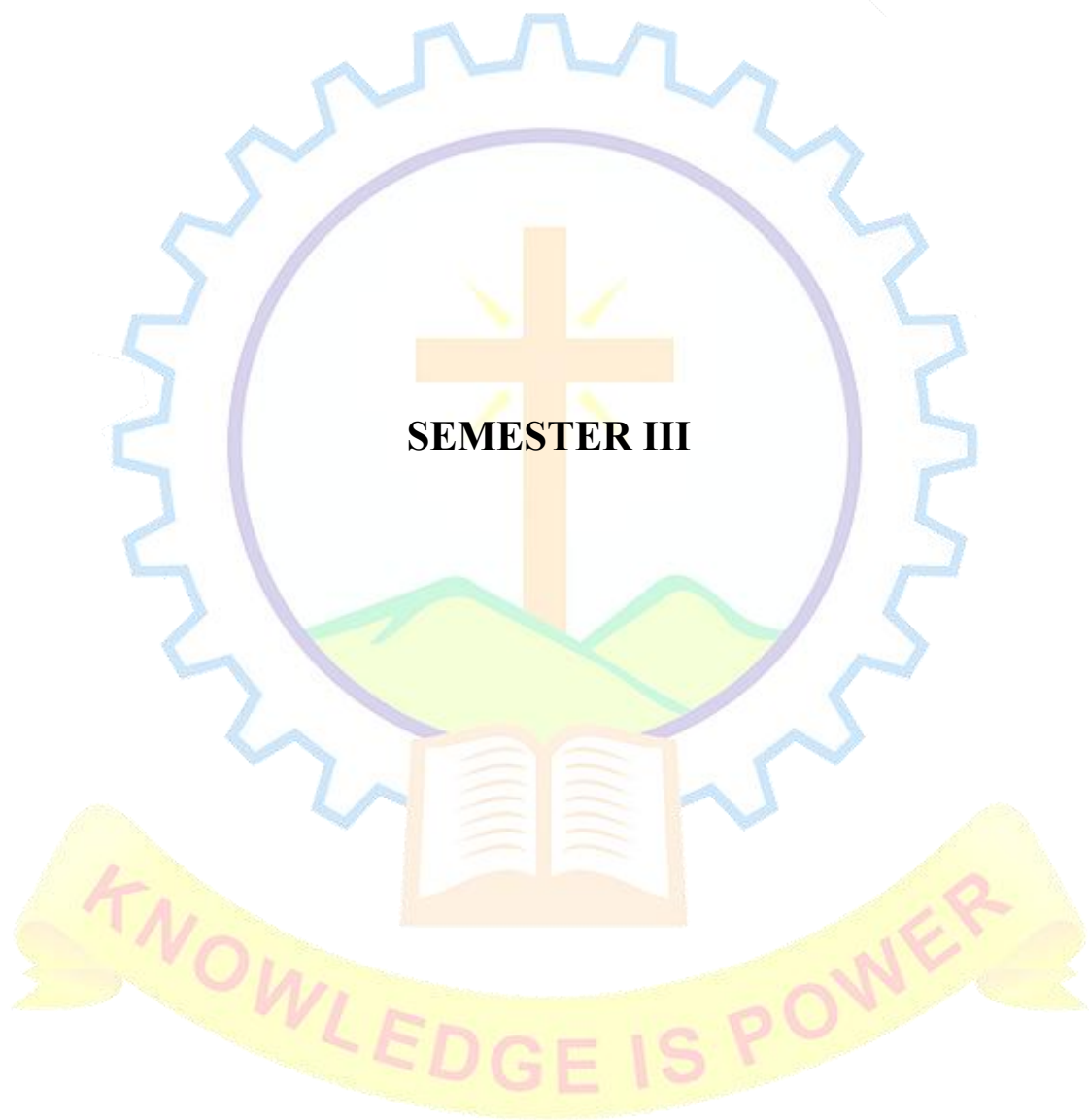
**Mark distribution:**

| Total Marks | CIE Marks | ESE Marks |
|-------------|-----------|-----------|
| 100         | 60        | 40        |

|   |   |          |
|---|---|----------|
| <b>Continuous Internal Evaluation Pattern</b> | : |          |
| Lab work and Viva-voce                        | : | 60 marks |
| Final assessment Test and Viva Voce           | : | 40 marks |

The laboratory courses will be having only Continuous Internal Evaluation and carries 100 marks. Final assessment shall be done by two examiners; one examiner will be a senior faculty from the same department.





| CODE                                     | COURSE NAME | CATEGORY | L | T | P | S | CREDIT |
|--|-------------|----------|---|---|---|---|--------|
| M24CE2M301/<br>M24CE2M305/<br>M24CE2M306 | MOOC        | MOOC     | 0 | 0 | 0 | 0 | 2      |

A MOOC course of a minimum 8-week duration must be successfully completed before the end of the fourth semester (starting from Semester 1). The MOOC course shall be considered valid only if it is conducted by AICTE, NPTEL, SWAYAM, or NITTTR. The course must have a minimum duration of 8 weeks and should include syllabus content equivalent to at least 40 hours of teaching. Additionally, it must have a proctored/offline end-semester examination. Students may complete the MOOC course at their convenience but must do so before the end of the fourth semester. The Board of Studies (BoS) will provide a list of approved MOOC courses, provided that at least 70% of the course content aligns with the student's area or stream of study. However, a MOOC course will not be considered if more than 50% of its content overlaps with a core/elective course in the respective discipline or with an open elective. A credit of 2 will be awarded to students who successfully complete the MOOC course as per the evaluation criteria of the respective agency conducting the course.

#### LIST OF APPROVED MOOC COURSE

1. Maintenance and Repair of Concrete Structures

Duration: 12 weeks

Provider: NPTEL

Course Content: This course focuses on identifying damage mechanisms in concrete structures, such as reinforcement and cement matrix deterioration, and explores the use of non-destructive testing methods along with techniques for structural strengthening and stabilization.

Relevance: The students will be able to suggest evaluation and repair/retrofitting methods for extending the service life of concrete structures.

2. Retrofitting and Rehabilitation of Civil Infrastructure

Duration: 12 weeks

Provider: NPTEL

Course Content: This course explores repair, retrofitting, and rehabilitation techniques for masonry and concrete structures, covering deterioration causes, evaluation, and strengthening methods.

Relevance: It provides students with essential knowledge in challenging issues for efficient retrofitting and rehabilitation to extend the durability of existing structure in a sustainable manner.

3. Development and Applications of Special Concretes

Duration: 8 weeks

Provider: NPTEL

Course Content: This course explores the development of special concretes , construction methods and the use of concrete in diverse environments.

Relevance: It equips the students with better knowledge on concrete materials, construction methods and construction environment

4. Energy Efficiency Acoustics and Daylighting in Building

Duration: 12 weeks

Provider: NPTEL

Course Content: This course exposes the students to the concepts of functional design of building for thermal aspects and energy efficiency; especially in tropical climates i.e. in Indian context.

Relevance: The student will be capable of performing fenestration design for natural ventilation and daylighting & design of space for external and internal noise control.

5. Vibration of Continuous Systems

Duration: 12 weeks

Provider: NPTEL Swayam

Course Content: This course emphasizes continuous modeling of structures to accurately capture their dynamic behavior of the structures or machine components. Relevance: It will equip the students to formulate and solve vibration problems of the continuous systems by exact method as well as by numerical techniques.

6. Earthquake Geology: A tool for Seismic Hazard Assessment

Duration: 12 weeks

Provider: NPTEL Swayam

Course Content: This course focuses on seismically active faults to assess past earthquakes and understand fault behavior, especially in regions lacking historic records.

Relevance: It aims to equip the students with knowledge essential for seismic hazard assessment and future earthquake prediction.

7. Rock Mechanics and Tunneling

Duration: 12 weeks

Provider: NPTEL Swayam

Course Content: This course provides a foundational understanding of load transfer and stability in geotechnical structures built on or in rock, essential for civil and mining engineers.

Relevance: It equip the students with knowledge of applications of tunnelling in underground transport systems.

8. Elastic Stability of Structures Duration: 12 weeks

Provider: NPTEL

Course Content: This course covers the principles of structural stability, focusing on how small changes in load can lead to catastrophic instability and collapse.

Relevance: It is highly relevant for students, providing skills to analyze various structural members and systems with the application of stability theory in design guidelines and international standards.

9. Natural Hazards Duration: 8 weeks

Provider: NPTEL Swayam

Course Content: This course explores the mechanisms, origins, and impacts of natural disasters like earthquakes, floods, and tsunamis, focusing on different environments such as coastal and hilly terrains.

Relevance: It equips students with hazard mitigation approaches and assessment techniques to minimize disaster impacts.

10. Characterization of Construction Materials

Duration: 12 weeks

Provider: NPTEL

Course Content: The objective of the course is to introduce the characterization of construction materials and their behaviour, with a view of developing their understanding of the mechanisms that govern the performance of these materials.

Relevance: The students will get better understanding on physics of the characterization techniques and their application to cement science.

11. Earthquake Resistant Design of Foundations

Duration: 8 weeks

Provider: NPTEL

Course Content: This course covers various types of foundations, soil investigations, and seismic design considerations for both shallow and deep foundations.

Relevance: It equips students with the skills to design foundations that can withstand lateral loads and prevent failure during earthquakes.

12. Strategies For Sustainable Design

Duration: 12 weeks

Provider: NPTEL Swayam

Course Content: This course covers sustainability principles, climate change mitigation, and real-world applications through case studies, field visits, and assignments.

Relevance: The students can explore environmental performance, building technologies, and key standards like NBC India and GRIHA, with a focus on UN SDGs and assessment methods.

13. Introduction to Accounting and Finance for Civil Engineers

Duration: 8 weeks

Provider: NPTEL

Course Content: This course addresses the growing need for civil engineers to understand basic accounting and finance amidst evolving contracting models and reduced government financial involvement.

Relevance: It offers a foundational understanding of accounting and finance.

#### 14. Advanced Foundation Engineering

Duration: 12 weeks

Provider: NPTEL

Course Content: This course covers advanced foundation design topics such as shallow foundations on slopes, layered soils, and eccentric/inclined loading, as well as pile behavior under uplift and lateral loads.

Relevance: It enables students to design foundation for complex conditions.

#### 15. Soil Structure Interaction

Duration: 12 weeks

Provider: NPTEL

Course Content: This course explores soil-structure interaction models for shallow foundations and piles under various loading conditions, including beams and plates on elastic foundations solved using Finite Difference Method.

Relevance: It equips students with essential knowledge of soil-structure interaction models for various loading and subgrade conditions.

#### 16. Predictive Analytics - Regression and Classification

Duration: 12 weeks

Provider: NPTEL Swayam

Course Content: This course offers a foundational understanding of statistical predictive models, focusing on their construction and implementation for solving prediction problems.

Relevance: It provides students with a comprehensive understanding of statistical predictive models, emphasizing their development and practical application.

#### 17. Measure Theoretic Probability 1

Duration: 8 weeks

Provider: NPTEL Swayam

Course outline: This course builds on basic probability distributions and random variables, focusing on the mathematical formulation of probability using measure theory.

Relevance: It provides students with essential knowledge of probability spaces, integration theory, convergence theorems which are relevant for advanced studies in the field.

#### 18. Theory and Practice of Non Destructive Testing

Duration: 8 weeks

Provider: NPTEL

Course outline: This course covers the fundamental science and principles behind non-

destructive testing methods, focusing on their role in quality control, flaw detection, and structural health monitoring.

Relevance: It is highly relevant for students, fostering applications in overall quality control and structural health monitoring

#### 19. Bridge Engineering

Duration: 12 weeks

Provider: NPTEL

Course Content: This course provides knowledge of principles of engineering mechanics, load transfer mechanisms, analysis methodologies, design principles, damage mechanics, failure mechanisms, construction, inspection, maintenance, repair and retrofit strategies in the realm of bridge engineering.

Relevance: The students will be able to equip themselves with fundamental concepts of analysis and design of bridges, understand field based construction, inspection, maintenance, repair and rehabilitation techniques of bridges and comprehend the emerging global trends in the domain of bridge engineering.

#### 20. Admixtures and Special Concretes

Duration: 12 weeks

Provider: NPTEL Swayam

Course Content: This course explores the mechanisms of chemical and mineral admixtures and their impact on concrete performance, covering the formulation and properties of special concretes used in modern construction.

Relevance: It is highly relevant for students, equipping them with the skills to apply their knowledge of the properties of special concretes increasingly used in modern construction.

#### 21. Construction methods and equipment management

Duration: 8 weeks

Provider: NPTEL Swayam

Course Content: This course covers key guidelines for selecting the right equipment, estimating its cost and productivity, and determining optimal replacement time in construction industry.

Relevance: The students will be able to equip themselves with understanding of equipment capabilities for successful project planning and cost estimation in construction.



| CODE        | COURSE NAME                                  | CATEGORY | L | T | P | S | CREDIT |
|-------------|--|----------|---|---|---|---|--------|
| M24CE1E302A | MAINTENANCE AND REHABILITATION OF STRUCTURES | ELECTIVE | 3 | 0 | 0 | 3 | 3      |

Preamble: This course provides a comprehensive understanding of the durability and repair of concrete structures. It focuses on the causes of deterioration, assessment techniques, and repair strategies. Students will learn about corrosion, reinforcement, and deterioration mechanisms, as well as condition assessment, surface repair, and structural strengthening techniques.

**Prerequisite:** Nil

**Course Outcomes:** After completion of the course the student will be able to

|      |   |
|------|---|
| CO 1 | Explain corrosion mechanisms and effects on embedded metal and reinforcement in concrete structures. <b>(Cognitive Knowledge Level: Understand)</b>                                       |
| CO 2 | Analyze deterioration mechanisms to predict and mitigate damage in concrete structures. <b>(Cognitive Knowledge Level: Apply)</b>   |
| CO 3 | Describe condition assessment methods for concrete structures, including visual inspections, on-site testing, and laboratory testing. <b>(Cognitive Knowledge Level: Apply)</b>           |
| CO 4 | Apply surface repair methods and materials to restore and protect concrete infrastructures. <b>(Cognitive Knowledge Level: Apply)</b>   |
| CO 5 | Apply structural strengthening and stabilization techniques to design and implement effective repair solutions for damaged concrete structures. <b>(Cognitive Knowledge Level: Apply)</b> |

**Mapping of course outcomes with program outcomes**

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
|------|------|------|------|------|------|------|
| CO 1 | 2    |      | 2    | 2    | 2    |      |
| CO 2 | 3    | 2    |      | 2    |      | 2    |
| CO 3 | 2    |      | 2    |      | 2    | 1    |
| CO 4 | 2    |      |      | 2    | 2    | 2    |
| CO 5 |      |      | 2    | 2    | 2    |      |

**Assessment Pattern**

| Course Name      | Maintenance and Rehabilitation of structures |                |                                  |
|------------------|--|----------------|----------------------------------|
| Bloom's Category | Continuous Assessment Tests                  |                | End Semester Examination (Marks) |
|                  | Test 1 (Marks)                               | Test 2 (Marks) |                                  |
| Remember         |  |                |                                  |
| Understand       | 40   | 30             | 20                               |
| Apply            | 30   | 40             | 40                               |
| Analyse          | 30   | 30             | 40                               |
| Evaluate         |  |                |                                  |
| Create           |  |                |                                  |

**Mark distribution**

| Total Marks | CIA Marks | ESE marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 100         | 40        | 60        | 3 Hours      |

**Continuous Internal Evaluation Pattern**

|                                      |   |          |
|--------------------------------------|---|----------|
| Micro project/Course based project   | : | 10 marks |
| Course based task/Seminar/Quiz       | : | 10 marks |
| Test paper 1 (Module 1 and Module 2) | : | 10 marks |
| Test paper 2 (Module 3 and Module 4) | : | 10 marks |

**End Semester Examination Pattern:** The end semester examination will be conducted by the college. There will be two parts; Part A and Part B. Part A contains 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 4 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 8 marks. The total duration of the examination will be 3 Hr

## SYLLABUS

### MODULE 1 (7 hours)

Significance and fundamentals of corrosion, Corrosion of embedded metal, Carbonation-induced and chloride-induced corrosion, Types of reinforcement, Assessment - Quality of TMT / QST Steel Rebars, Metallic and non-metallic coated rebars, Corrosion in prestressed concrete.

### MODULE 2 (7 hours)

Deterioration of cementitious systems- Introduction, sulphate attack, biofouling and acid attack, - frost attack, freeze-thaw and alkali-silica reaction, Shrinkage and Creep based deterioration, Fire attack, abrasion and erosion.

### MODULE 3 (7 hours)

Condition assessment of concrete structures: Exposure conditions, visual inspection, on-site Concrete testing, Testing of concrete in laboratory, mechanical and corrosion testing of rebars.

### MODULE 4 (7 hours)

Strategies and materials for surface repair, Surface preparation and protective treatment, Coating on concrete infrastructures, Types of Waterproofing, Techniques for Waterproofing concrete structures.

### MODULE 5 (8 hours)

Structural Strengthening & Stabilization- Load effects and Introduction to Structural Strengthening & Stabilization - Beams and Slabs, Columns & Walls, Structural strengthening (Joints and connections), Injection Grouts for concrete repair, Structural repair of prestressed concrete systems, Case studies on structural repair, Root cause analysis -Adopting precise methodology, Cathodic Protection in Concrete Structures - Service life estimation

### Reference

1. Denison Campbell, Allen and Harold Roper, Concrete Structures, Materials, Maintenance and Repair, Longman Scientific and Technical UK, 1991.
2. M.S. Shetty, Concrete Technology – Theory and Practice, S. Chand and Company, New Delhi, 1992.
3. R.T. Allen and S.C. Edwards, Repair of Concrete Structures, Blakie and Sons, UK, 1987.
4. R. D. Woodson, Concrete Structures- Protection, Repair and Rehabilitation, Butterworth-Heinemann, UK, 2009.
5. P. S. Gahlot, S. Sharma, Building Repair and Maintenance Management, CBS publishers, New

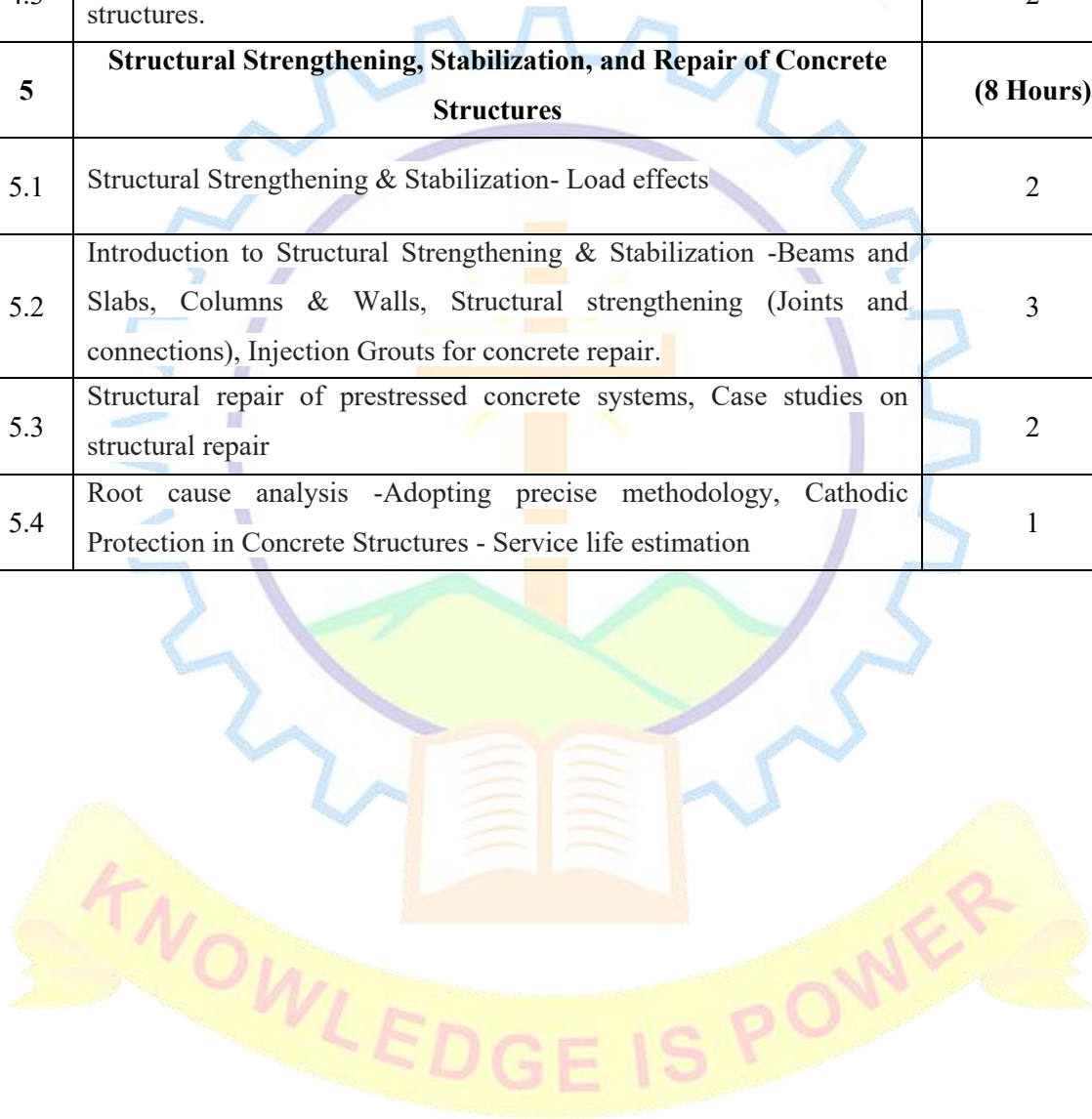
Delhi, 2013

6. Forensic Structural Engineering Handbook, Second Edition, Robert T. Ratay
7. Structural Renovation of Buildings: Methods, Details, and Design Examples, Second Edition - Alexander Newman, P.E., MBA, F. ASCE.

### COURSE CONTENTS AND LECTURE SCHEDULE

| No.      | Topic   | No. of Lecture/<br>Tutorial hours |
|----------|---|-----------------------------------|
| <b>1</b> | <b>Corrosion of Reinforcement in Concrete Structures</b>  | <b>(7 Hours)</b>                  |
| 1.1      | Significance and fundamentals of corrosion, Corrosion of embedded metal   | 2                                 |
| 1.2      | Carbonation-induced and chloride-induced corrosion, Types of reinforcement  | 2                                 |
| 1.3      | Assessment - Quality of TMT / QST Steel Rebars, Metallic and non-metallic coated rebars, Corrosion in prestressed concrete. | 3                                 |
| <b>2</b> | <b>Deterioration Mechanisms in Cementitious Systems</b>   | <b>(7 Hours)</b>                  |
| 2.1      | Deterioration of cementitious systems- Introduction, sulphate attack, biofouling and acid attack                            | 2                                 |
| 2.2      | Frost attack, freeze-thaw and alkali-silica reaction  | 2                                 |
| 2.3      | Shrinkage and Creep based deterioration   | 2                                 |
| 2.4      | Fire attack, abrasion and erosion.  | 1                                 |
| <b>3</b> | <b>Condition Assessment and Testing of Concrete Structures</b>  | <b>(7 Hours)</b>                  |
| 3.1      | Condition assessment of concrete structures: Exposure conditions, visual inspection   | 2                                 |
| 3.2      | On-site Concrete testing, Testing of concrete in laboratory   | 3                                 |
| 3.3      | Mechanical and corrosion testing of rebars.   | 2                                 |

|          |  |                  |
|----------|--|------------------|
| <b>4</b> | <b>Surface Repair and Waterproofing of Concrete Structures</b>   | <b>(7 Hours)</b> |
| 4.1      | Strategies and materials for surface repair,   | 2                |
| 4.2      | Surface preparation and protective treatment, Coating on concrete infrastructures  | 3                |
| 4.3      | Types of Waterproofing, Techniques for Waterproofing concrete structures.  | 2                |
| <b>5</b> | <b>Structural Strengthening, Stabilization, and Repair of Concrete Structures</b>  | <b>(8 Hours)</b> |
| 5.1      | Structural Strengthening & Stabilization- Load effects   | 2                |
| 5.2      | Introduction to Structural Strengthening & Stabilization -Beams and Slabs, Columns & Walls, Structural strengthening (Joints and connections), Injection Grouts for concrete repair. | 3                |
| 5.3      | Structural repair of prestressed concrete systems, Case studies on structural repair   | 2                |
| 5.4      | Root cause analysis -Adopting precise methodology, Cathodic Protection in Concrete Structures - Service life estimation  | 1                |



**Model Question Paper**

**QPCODE:**

Pages:2

Reg No.: \_\_\_\_\_

Name: \_\_\_\_\_

**MAR ATHANASIOUS COLLEGE OF ENGINEERING  
(AUTONOMOUS), KOTHAMANGALAM  
THIRD SEMESTER M. TECH DEGREE EXAMINATION, DECEMBER  
2025**

**CourseCode: M24CE1E302A**

**CourseName: MAINTENANCE AND REHABILITATION OF STRUCTURES**

Max. Marks: 60

Duration: 3 Hours

**PART A**

***Answer all questions; each question carries 4 marks***

1. Describe corrosion in prestressed concrete and its potential consequences.
2. Discuss how fire damage affects cementitious systems.
3. Identify the role of visual inspection in assessing concrete structure conditions.
4. List common materials used for surface repair of concrete structures, including their properties and uses.
5. Explain the use of injection grouts in concrete repair, including their properties and applications.

**PART B**

***Answer any five questions; each question carries 8 marks***

6. Compare carbonation-induced and chloride-induced corrosion in reinforced concrete.
7. Discuss the alkali-silica reaction (ASR) in cementitious systems, including prevention methods.
8. Outline corrosion testing methods for rebars and their importance in predicting structure life.
9. Justify the importance of waterproofing in concrete structures and factors influencing system selection.

10. Explain cathodic protection principles and applications in concrete structures, including factors influencing effectiveness.
11. Discuss metallic and non-metallic coatings for preventing rebar corrosion, including types, applications, and benefits.
12. Describe surface preparation and protective treatments for concrete structures, including purposes, advantages, and disadvantages.



| CODE        | COURSE NAME          | CATEGORY | L | T | P | S | CREDIT |
|-------------|----------------------|----------|---|---|---|---|--------|
| M24CE1E302B | STRUCTURAL STABILITY | Elective | 3 | 0 | 0 | 3 | 3      |

**Preamble:** This course provides an in-depth understanding of stability principles, criteria, and analytical methods for analyzing elastic instability in columns, beam-columns, frames, plates, and shells. The course integrates classical theories with modern computational techniques, including finite element methods, to address practical stability challenges in engineering structures.

**Prerequisite:** Theory of Elasticity and Plasticity

**Course Outcomes:** After the completion of the course the student will be able to

|      |  |
|------|--|
| CO 1 | Identify the importance of stability analysis in structural design and conduct stability analysis for columns. <b>(Cognitive Knowledge Level: Apply)</b> |
| CO 2 | Apply stability analysis to evaluate the behavior of beam-columns under various loading conditions. <b>(Cognitive Knowledge Level: Analyze)</b>          |
| CO 3 | Perform Stability analysis of Frames with various boundary and loading conditions. <b>(Cognitive Knowledge Level: Apply)</b>                             |
| CO 4 | Analyze the behavior of structural elements such as plates and shells by applying classical theories. <b>(Cognitive Knowledge Level: Analyze)</b>        |
| CO 5 | Conduct stability analysis of plated structure under various loading conditions. <b>(Cognitive Knowledge Level: Apply)</b>                               |

**Mapping of course outcomes with program outcomes**

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
|------|------|------|------|------|------|------|
| CO 1 | 1    |      | 1    | 2    | 1    | 1    |
| CO 2 | 1    |      | 1    | 2    | 1    | 1    |
| CO 3 | 1    |      | 1    | 1    | 1    | 1    |
| CO 4 | 1    |      | 1    | 1    | 1    | 1    |
| CO 5 | 1    |      | 2    | 2    | 1    | 1    |

**Assessment Pattern**

| Course name      | Structural Stability        |                 |                                   |
|------------------|-----------------------------|-----------------|-----------------------------------|
| Bloom's Category | Continuous Assessment Tests |                 | End Semester Examination (%Marks) |
|                  | Test 1 (%Marks)             | Test 2 (%Marks) |                                   |
| Remember         |                             |                 |                                   |
| Understand       | 30                          | 30              | 30                                |
| Apply            | 40                          | 40              | 40                                |
| Analyse          | 30                          | 30              | 30                                |
| Evaluate         |                             |                 |                                   |
| Create           |                             |                 |                                   |

**Mark distribution**

| Total Marks | CIA Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 100         | 40        | 60        | 3 Hours      |

|  |   |          |
|--|---|----------|
| <b>Continuous Internal Evaluation Pattern</b>                                  | : |          |
| Seminar*   | : | 10 marks |
| Course based task/Micro Project//Data collection and interpretation/Case study | : | 10 marks |
| Test paper 1 (Module 1 and Module 2)   | : | 10 marks |
| Test paper 2 (Module 3 and Module 4)   | : | 10 marks |

\*Seminar should be conducted in addition to the theory hours. Topics for the seminar should be from recent technologies in the respective course

**End Semester Examination Pattern:** The end semester examination will be conducted by the college. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 4 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 8 marks. Total duration of the examination will be 3 Hrs.

## SYLLABUS

### MODULE 1 (6 hours)

Concept of stability, instability and bifurcation, different forms of structural instability, analytical approaches of stability analysis. Fourth order Elastica – large deflection of column buckling –elastic instability of columns–Euler’s theory–assumptions– limitations. Equilibrium approach.

### MODULE 2 (6 hours)

**Compression Members:** Stability problem as an Eigen value problem–various modes of failure for various end conditions– both ends hinged–both ends fixed–one end fixed other end free– one end fixed other end hinged–Energy approach–Rayleigh Ritz– Galarkin’s method.

### MODULE 3 (7 hours)

**Beam Columns Element** – Beam column equation–solution of differential equation for various lateral loads–uniformly distributed load and concentrated loads

**Frames**-Energy method – solutions for various end conditions– bottom fixed– bottom hinged – horizontal compression members, buckling of frames.

### MODULE 4 (6 hours)

**Plates:** Introduction- Classification of plates- Thin plates and thick plates – Assumptions in the theory of thin plates- Differential equation for cylindrical bending of rectangular plates

**Shells:** Classical theory of Shells – Structural behaviour of thin shells – Classification of shells – Singly and doubly curved shells with examples

### MODULE 5 (10 hours)

**Stability of plates:** Inplane and lateral loads– Boundary conditions–Critical buckling pressure– Introduction to torsional buckling and lateral buckling.

Finite element application to stability analysis– Finite element stability analysis–element stiffness matrix - Derivation of element stiffness matrix for a structural element.

### References

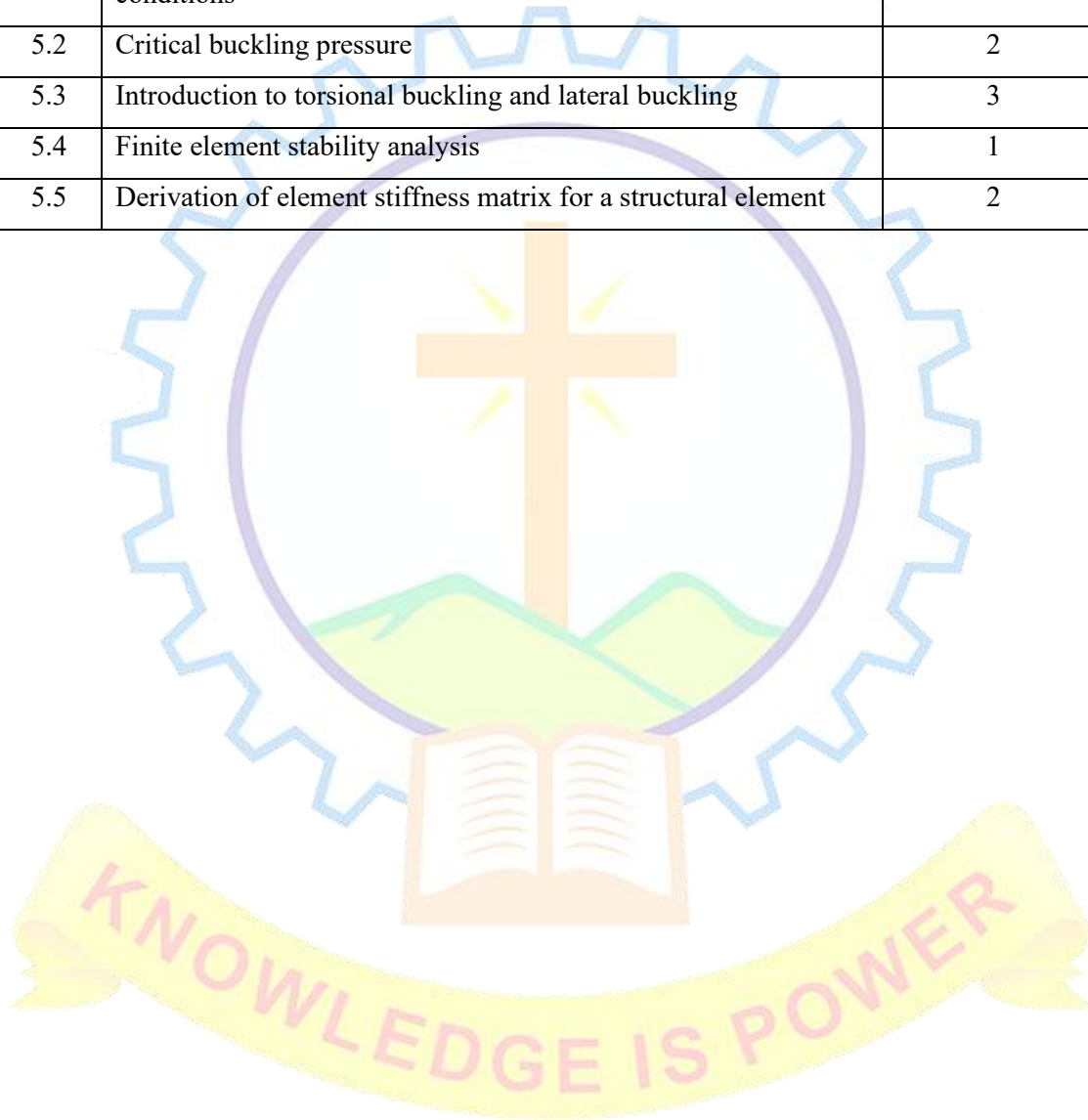
1. Chajes, A., “Principles of Structural Stability Theory”, Prentice Hall, 1974.
2. Iyengar, N.G.R., "Elastic Stability of Structural Elements", Macmillan India Ltd., Newdelhi, 2007.
3. Ziegler H, “Principles of structural stability”, Blarsdell, Wallham, Mass, 1963.

4. Thompson J M, G W Hunt, "General stability of elastic stability", Wiley, New York.
5. Timoshenko, Gere, "Theory of elastic stability", Mc Graw Hill, New York.
6. Don O Brush, B O Almorh, "Buckling of Bars, plates and shells", Mc Graw Hill, 1975.
7. Cox H L, "The buckling of plates and shells", Macmillan, New York, 1963.
8. AshwiniKukar, "Stability of Structures ", Allied Publishers LTD, New Delhi, 1998.
9. Murali L. Gambir, "Stability Analysis and Design of Structures", Springer Verlag, Berlin, 2004.
10. Brush, D.O., and Almorh, B.O., Buckling of bars, plates and shells, McGraw Hill, 1975.

### COURSE CONTENTS AND LECTURE SCHEDULE

| No              | Topic  | No. of Lecture/<br>Tutorial hours |
|-----------------|--|-----------------------------------|
| <b>Module 1</b> |  |                                   |
| 1.1             | Concept of stability, instability and bifurcation, different forms of structural instability, analytical approaches of stability analysis          | 1                                 |
| 1.2             | Fourth order Elastica – large deflection of column buckling  | 2                                 |
| 1.3             | Equilibrium approach   | 1                                 |
| 1.4             | Instability of columns–Euler’s theory–assumptions– limitations   | 2                                 |
| <b>Module 2</b> |  |                                   |
| 2.1             | Stability problem as an Eigen value problem  | 1                                 |
| 2.2             | Various modes of failure for various end conditions– both ends hinged–both ends fixed–one end fixed other end free– one end fixed other end hinged | 3                                 |
| 2.3             | Energy method- Rayleigh Ritz, Galerkin methods   | 2                                 |
| <b>Module 3</b> |  |                                   |
| 3.1             | Introduction to Beam-columns element   | 1                                 |
| 3.2             | Differential equation for concentrated lateral loads - distributed loads   | 3                                 |
| 3.3             | Buckling of frames: Solutions for various end conditions   | 2                                 |
| 3.4             | Horizontal compression members   | 1                                 |
| <b>Module 4</b> |  |                                   |
| 4.1             | Introduction to plate - classification of plates   | 1                                 |
| 4.2             | Assumptions in the theory of thin plates   | 1                                 |
| 4.3             | Differential equation for cylindrical bending of rectangular   | 2                                 |

|                 |  |   |
|-----------------|--|---|
|                 | plates   |   |
| 4.4             | Classical theory of Shells – Structural behaviour of thin shells         | 1 |
| 4.5             | Classification of shells – Singly and doubly curved shells with examples | 1 |
| <b>Module 5</b> |  |   |
| 5.1             | Stability of plates: Inplane and lateral loads– boundary conditions      | 2 |
| 5.2             | Critical buckling pressure   | 2 |
| 5.3             | Introduction to torsional buckling and lateral buckling                  | 3 |
| 5.4             | Finite element stability analysis  | 1 |
| 5.5             | Derivation of element stiffness matrix for a structural element          | 2 |



**Model Question Paper**

**QP CODE:**

Pages: 2

Reg No.: \_\_\_\_\_

Name: \_\_\_\_\_

**MAR ATHANASIUS COLLEGE OF ENGINEERING  
(AUTONOMOUS), KOTHAMANGALAM  
THIRD SEMESTER M.TECH DEGREE EXAMINATION, DECEMBER 2025**

**Course Code: M24CE1E302B**

**Course Name: STRUCTURAL STABILITY**

Max. Marks: 60

Duration: 3 hours

**PART A**

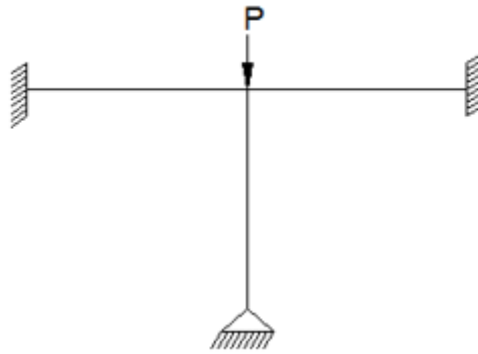
**Answer all questions. Each question carries 4 marks.**

1. Briefly explain the analytical approaches of stability analysis.
2. Evaluate the critical load of a cantilever column by Rayleigh-Ritz method.
3. Explain the different energy methods to evaluate the elastic buckling of columns. List the merits of energy method.
4. Derive the fourth order differential equation for laterally loaded thin rectangular plate.
5. Explain the boundary conditions of a plate.

**PART B**

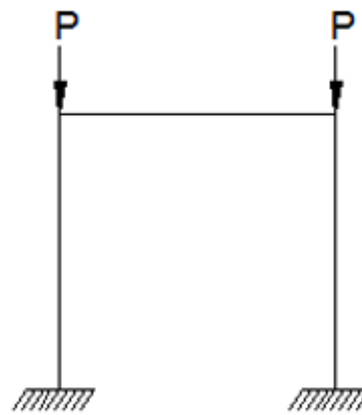
**Answer any five questions. Each question carries 8 marks.**

6. Using equilibrium approach determine the critical load of a column fixed at one end and hinged at the other end.
7. Explain elastica and using large deflection theory derive the expression for critical load of a simply supported column.
8. Derive the expression for maximum deflection and maximum bending moment of a beam column with a concentrated lateral load at the centre.
9. Compute the critical load of the frame shown in Fig. 1 by energy method. All members have the same 'EI' and 'I'.



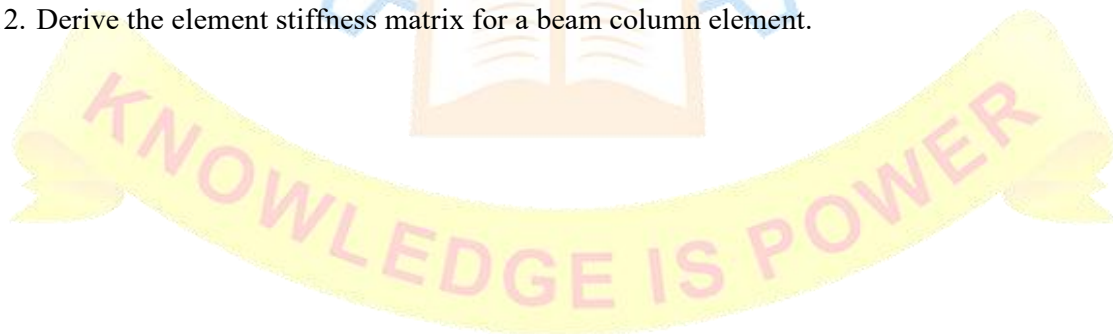
**Fig.1**

10. Determine the critical load of the portal frame with sway shown in Fig. 2 using equilibrium approach. All members have the same 'EI' and 'l'.



**Fig. 2**

11. Define force resultant and derive the expressions for force resultant.  
12. Derive the element stiffness matrix for a beam column element.



| CODE        | COURSE NAME                                       | CATEGORY | L | T | P | S | CREDIT |
|-------------|---|----------|---|---|---|---|--------|
| M24CE1E302C | ARTIFICIAL INTELLIGENCE IN STRUCTURAL ENGINEERING | ELECTIVE | 3 | 0 | 0 | 3 | 3      |

**Preamble** : This course is designed to provide students with a comprehensive understanding of AI techniques and their applications in structural analysis, design, planning, and monitoring. Through a combination of theoretical knowledge and practical case studies, students will gain the skills necessary to leverage AI tools effectively in their professional practice.

**Prerequisite** : Basic Knowledge of Structural Engineering, Construction Management and Python programming

**Course Outcomes** : After the completion of the course the student will be able to

|             |  |
|-------------|--|
| <b>CO 1</b> | Understand AI, machine learning, and deep learning concepts and their applications in structural engineering, including current trends, tools, best practices, and challenges. <b>(Cognitive knowledge level: Apply)</b> |
| <b>CO 2</b> | Apply AI techniques to extract models, predict structural behavior, and analyze visuals for structural analysis, design, and rehabilitation. <b>(Cognitive knowledge level: Apply)</b>                                   |
| <b>CO 3</b> | Apply AI techniques in construction planning, scheduling, project management, and BIM for efficient project execution and control. <b>(Cognitive knowledge level: Apply)</b>   |
| <b>CO 4</b> | Utilize AI techniques for structural health monitoring, sensor data analysis, and damage detection in structures. <b>(Cognitive knowledge level: Apply)</b>  |
| <b>CO 5</b> | Implement AI solutions in structural engineering through case studies on materials, processes, and practical applications. <b>(Cognitive knowledge level: Apply)</b>   |

#### Mapping of course outcomes with program outcomes

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
|-------------|------|------|------|------|------|------|
| <b>CO 1</b> | 1    | 2    | 1    | 1    | 2    | 1    |
| <b>CO 2</b> | 2    | 2    | 1    | 2    | 2    | 1    |
| <b>CO 3</b> | 2    | 2    | 1    | 2    | 2    | 1    |
| <b>CO 4</b> | 2    | 2    | 1    | 2    | 2    | 1    |
| <b>CO 5</b> | 2    | 2    | 1    | 2    | 2    | 1    |

#### Assessment Pattern

| Course name      | Artificial Intelligence in Structural Engineering |                |                                  |
|------------------|---|----------------|----------------------------------|
| Bloom's Category | Continuous Assessment Tests                       |                | End Semester Examination (Marks) |
|                  | Test 1 (Marks)                                    | Test 2 (Marks) |                                  |
| Remember         |   |                |                                  |
| Understand       | 20  | 20             | 20                               |
| Apply            | 80  | 80             | 80                               |
| Analyse          |   |                |                                  |
| Evaluate         |   |                |                                  |
| Create           |   |                |                                  |

**Mark distribution**

| Total Marks | CIA Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 100         | 40        | 60        | 3 Hours      |

|  |   |          |
|--|---|----------|
| <b>Continuous Internal Evaluation Pattern</b>                                  | : |          |
| Seminar*   | : | 10 marks |
| Course based task/Micro Project//Data collection and interpretation/Case study | : | 10 marks |
| Test paper 1 (Module 1 and Module 2)   | : | 10 marks |
| Test paper 2 (Module 3 and Module 4)   | : | 10 marks |

\*Seminar should be conducted in addition to the theory hours. Topics for the seminar should be from recent technologies in the respective course.

**End Semester Examination Pattern:** The end semester examination will be conducted by the college. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 4 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 8 marks. Total duration of the examination will be 3 Hrs.

## SYLLABUS

### MODULE 1 (6 hours)

**Introduction to AI and its applications in structural engineering:** Overview of machine learning, deep learning, AI techniques, Introduction to AI tools in structural engineering- TensorFlow, PyTorch - Trends and Best Practices.

### MODULE 2 (8 hours)

**Techniques for structural analysis and design:** Extraction of models based on data retrieval- Prediction of structural behavior- mathematical representations of physical phenomena - Examination of visuals from images and videos. AI tools in Structural Analysis, Design, Material Selection, Retrofitting and Rehabilitation

### MODULE 3 (8 hours)

**Construction planning, scheduling, and project management:** Overview of construction project life cycle, Trends in implementation of AI technologies in construction planning and schedule, AI models in project management- data collection, model selection and training, Applications in Project Monitoring and Control, Cost Estimation and Budgeting and Quality Management, Introduction to AI-integrated BIM practices in the construction sector.

### MODULE 4 (7 hours)

**Structural health monitoring and damage detection:** Data-driven structural health monitoring and damage detection, Sensor data processing and analysis using AI techniques, Damage detection and prognosis using AI models, Case studies of AI applications in structural health monitoring.

### MODULE 5 (7 hours)

**Case Studies and Practical Applications:** Perspectives on the Impact of Artificial Intelligence on Materials and Processes, Implementation and Deployment of AI Solutions, Case studies of AI in Structural Engineering.

### References

1. S. Russel and P. Norvig. Artificial Intelligence: A Modern Approach (Third Edition), Prentice Hall, 2009
2. George Klir, U. St. Clair and B. Yuan, Fuzzy Set Theory: Foundations and Applications, Prentice Hall, 1997

3. Pengzhen Lu, Shengyong Chen, Yujun Zheng, 2012, Artificial Intelligence in Civil Engineering, Computational Intelligence in Civil and Hydraulic Engineering. <https://doi.org/10.1155/2012/145974>
4. Tapeh, A.T.G., Naser, M.Z. Artificial Intelligence, Machine Learning, and Deep Learning in Structural Engineering: A Scientometrics Review of Trends and Best Practices. *Arch Computat Methods Eng* 30, 115–159 (2023). <https://doi.org/10.1007/s11831-022-09793-w>
5. Prasad B. K. R., Eskandari H., and Reddy B. V. V., Prediction of compressive strength of SCC and HPC with high volume fly ash using ANN, *Construction and Building Materials*. (2009) 23, no. 1, 117–128, 2-s2.0-54049113941, <https://doi.org/10.1016/j.conbuildmat.2008.01.014>.
6. N. Liu, B. G. Kang and Y. Zheng, "Current trend in planning and scheduling of construction project using artificial intelligence," IET Doctoral Forum on Biomedical Engineering, Healthcare, Robotics and Artificial Intelligence 2018 (BRAIN 2018), Ningbo, China, 2018, pp. 1-6, doi: 10.1049/cp.2018.1731.
7. Rane, Nitin, Integrating Building Information Modelling (BIM) and Artificial Intelligence (AI) for Smart Construction Schedule, Cost, Quality, and Safety Management: Challenges and Opportunities (September 16, 2023). Available at SSRN: <https://ssrn.com/abstract=4616055> or <http://dx.doi.org/10.2139/ssrn.4616055>
8. Senouci A. and Al-Derham H. R., Genetic algorithm-based multi-objective model for scheduling of linear construction projects, *Advances in Engineering Software*. (2008) 39, no. 12, 1023–1028, 2-s2.0-49249121672, <https://doi.org/10.1016/j.advengsoft.2007.08.002>.
9. Kaveh A. and Talatahari S., An improved ant colony optimization for constrained engineering design problems, *Engineering Computations* (Swansea, Wales). (2010) 27, no. 1, 155–182, 2-s2.0-75949130675, <https://doi.org/10.1108/02644401011008577>.
10. Liu J., Li H., and He C., Predicting the compressive strength of concrete using rebound method and artificial neural network, *ICIC Express Letters*. (2011) 5, no. 4, 1115–1120, 2-s2. <https://doi.org/0-79952372926>.
11. Xu Y, Qian W, Li N, Li H. Typical advances of artificial intelligence in civil engineering. *Advances in Structural Engineering*. 2022;25(16):3405-3424. <https://doi.org/10.1177/13694332221127340>
12. Ghiasi, Ramin; Ghasemi, Mohammad Reza; Noori, Mohammad . (2018). Comparative studies of metamodeling and AI-Based techniques in damage detection of structures. *Advances in Engineering Software*, S0965997817301412–. <https://doi.org/10.1016/j.advengsoft.2018.02>
13. Dimiduk, D.M., Holm, E.A. & Niezgod, S.R. Perspectives on the Impact of Machine Learning, Deep Learning, and Artificial Intelligence on Materials, Processes, and Structures Engineering. *Integr Mater Manuf Innov* 7, 157–172 (2018). <https://doi.org/10.1007/s40192-018-0117-8>

**COURSE CONTENTS AND LECTURE SCHEDULE**

| No                       | Topic   | No. of Lecture/<br>Tutorial hours |
|--------------------------|---|-----------------------------------|
| <b>Module 1(6 hours)</b> |   |                                   |
| 1.1                      | Introduction to AI and its applications in structural engineering   | 2                                 |
| 1.2                      | Overview of machine learning, deep learning, and AI techniques  | 2                                 |
| 1.3                      | Introduction to AI tools in structural engineering- Trends and Best Practices.  | 2                                 |
| <b>Module 2(8 hours)</b> |   |                                   |
| 2.1                      | Extraction of models based on data retrieval  | 2                                 |
| 2.2                      | Prediction of structural behavior- mathematical representations of physical phenomena   | 3                                 |
| 2.3                      | Examination of visuals from images and videos. AI tools in Structural Analysis, Design, Material Selection, Retrofitting and Rehabilitation.  | 3                                 |
| <b>Module 3(8 hours)</b> |   |                                   |
| 3.1                      | Overview of construction project life cycle, Trends in implementation of AI technologies in construction planning and schedule.   | 3                                 |
| 3.2                      | AI models in project management- data collection, model selection and training. Applications in Project Monitoring and Control, Cost Estimation and Budgeting and Quality Management. | 3                                 |
| 3.3                      | Introduction to AI-integrated BIM practices in the construction sector.   | 2                                 |
| <b>Module 4(7 hours)</b> |   |                                   |
| 4.1                      | Data-driven structural health monitoring and damage detection, Sensor data processing and analysis using AI techniques.   | 3                                 |
| 4.2                      | Damage detection and prognosis using AI models  | 2                                 |
| 4.3                      | Case studies of AI applications in structural health monitoring.  | 2                                 |
| <b>Module 5(7 hours)</b> |   |                                   |
| 5.1                      | Perspectives on the Impact of Artificial Intelligence on Material selection and Construction processes  | 3                                 |
| 5.2                      | Implementation and Deployment of AI Solutions   | 2                                 |
| 5.3                      | Case studies of AI in Structural Engineering.   | 2                                 |

**Model Question Paper**

**QP CODE:**

Pages:2

Reg No.: \_\_\_\_\_

Name: \_\_\_\_\_

**MAR ATHANASIOUS COLLEGE OF ENGINEERING  
(AUTONOMOUS), KOTHAMANGALAM**

**THIRD SEMESTER M.TECH DEGREE EXAMINATION, DECEMBER 2024**

**Course Code: M24CE1E302C**

**Course Name: ARTIFICIAL INTELLIGENCE IN STRUCTURAL ENGINEERING**

Max. Marks:60

Duration: 3 hours

**PART A**

***Answer all questions. Each question carries 4 marks.***

1. In what ways can Artificial Intelligence be applied to real-world problems on structural engineering?
2. How can AI techniques be applied to predict the behaviour of a structural element?
3. Enumerate the ways AI is being used for project monitoring and control.
4. Elucidate the differences in prediction accuracy and training time between ANN and ELM in damage detection.
5. Explain how AI tools are utilized to enhance material selection and streamline construction processes to achieve better project results.

**PART B**

***Answer any five questions. Each question carries 8 marks.***

6. How do machine learning and AI differ in their application within structural engineering?
7. Discuss the best practices for implementing AI in structural engineering?
8. Examine how does AI improve decision-making in rehabilitation and retrofitting by combining structural models with sensor or visual data?
9. Describe the effectiveness of AI algorithms in integrating data-driven models with engineering judgment for structural safety assessments.
10. Illustrate how AI-BIM integration helps you to make better decisions in project management?
11. AI techniques aid in damage localization and severity estimation. Do you agree with this statement? Justify your answer with suitable case studies.

12. As a structural engineer, explain how Artificial Intelligence is influencing materials selection and construction processes.



| CODE        | COURSE NAME                | CATEGORY | L | T | P | S | CREDIT |
|-------------|----------------------------|----------|---|---|---|---|--------|
| M24CE2E302D | SOIL STRUCTURE INTERACTION | ELECTIVE | 3 | 0 | 0 | 3 | 3      |

**Preamble:** This course provides students with the fundamental principles of soil mechanics and structural engineering, emphasizing the interaction between soil and structures. Students will acquire knowledge on bearing capacity and settlement estimations, stress distribution, bore log analysis, earth pressure and contact pressure distribution and design of various foundations and retaining structures.

**Prerequisite** : Geotechnical Engineering and Design of concrete structures.

**Course Outcomes:** After the completion of the course the student will be able to

|             |  |
|-------------|--|
| <b>CO 1</b> | Apply the fundamentals of bearing capacity theories, settlement analysis and SPT test to analyze bore log data. (Cognitive Knowledge Level- Apply)   |
| <b>CO 2</b> | Gain understanding of soil-structure interaction principles, stress distribution and contact pressure distribution beneath rigid and flexible footings. (Cognitive Knowledge Level- Understand)    |
| <b>CO 3</b> | Explore earth pressure theories, active and passive pressures, and their application to retaining walls, diaphragm walls, sheet piles, and braced excavations. (Cognitive Knowledge Level-Analyze) |
| <b>CO 4</b> | Analyze and design various types of shallow foundations. (Cognitive Knowledge Level- Analyze)  |
| <b>CO 5</b> | Analyze laterally loaded piles, pile group behavior, uplift capacity and non-linear load-deflection responses. (Cognitive Knowledge Level- Analyze)  |

**Mapping of course outcomes with program outcomes**

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
|-------------|------|------|------|------|------|------|
| <b>CO 1</b> | 3    | 2    | 2    | 2    | 2    | 2    |
| <b>CO 2</b> | 1    |      | 1    | 1    |      |      |
| <b>CO 3</b> | 2    | 2    | 2    | 1    | 1    |      |
| <b>CO 4</b> | 3    | 1    | 2    | 1    | 1    |      |
| <b>CO 5</b> | 3    | 2    | 2    | 1    | 1    | 1    |

**Assessment Pattern**

| Course name      | SOIL STRUCTURE INTERACTION  |                  |                                  |
|------------------|-----------------------------|------------------|----------------------------------|
| Bloom's Category | Continuous Assessment Tests |                  | End Semester Examination (Marks) |
|                  | Test 1 (% Marks)            | Test 2 (% Marks) |                                  |
| Remember         |                             |                  |                                  |
| Understand       | 50                          |                  | 20                               |
| Apply            | 50                          | 30               | 20                               |
| Analyse          |                             | 70               | 60                               |
| Evaluate         |                             |                  |                                  |
| Create           |                             |                  |                                  |

**Mark distribution**

| Total Marks | CIA Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 100         | 40        | 60        | 3 Hours      |

|  |   |          |
|--|---|----------|
| <b>Continuous Internal Evaluation Pattern</b>                                  | : |          |
| Seminar*   | : | 10 marks |
| Course based task/Micro Project//Data collection and interpretation/Case study | : | 10 marks |
| Test paper 1 (Module 1 and Module 2)   | : | 10 marks |
| Test paper 2 (Module 3 and Module 4)   | : | 10 marks |

\*Seminar should be conducted in addition to the theory hours. Topics for the seminar should be from recent technologies in the respective course

**End Semester Examination Pattern:** The end semester examination will be conducted by the college. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 4 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 8 marks. Total duration of the examination will be 3 Hrs.

## SYLLABUS

### MODULE 1 (7 hours)

Review of soil mechanics: Bearing capacity analysis by Terzaghi's theory, Skempton, Meyerhof and IS code method. Types of settlement for soil – immediate or elastic settlement, primary consolidation settlement, secondary compression settlement. Settlement calculation for granular and clayey soils based on IS code method. Soil parameters from field sounding tests. Standard penetration test – bore log data analysis based on SPT results.

### MODULE 2 (7 hours)

Stress distribution - Boussinesq and Westergard's solution.

Introduction to soil-structure interaction – significance of SSI. Contact pressure distribution beneath rigid and flexible footings-cohesive and non-cohesive soils, concept of modulus of subgrade reaction, pressure bulb. Static and Dynamic loading effects-static & dynamic SSI (concept only).

### MODULE 3 (7 hours)

Concepts of earth pressure theories – Rankine's and Coulomb's theories. Active and passive earth pressure. Earth pressure distribution on retaining walls and diaphragm walls. Earth pressures on sheet piles, braced excavations. Design of retaining wall - cantilever and counterfort retaining wall, diaphragm wall and sheet pile.

### MODULE 4 (8 hours)

Structural design of shallow foundations – combined footing – rectangular and trapezoidal, strip footing. Rigid beam method and Winkler's model analysis of raft foundations.

### MODULE 5 (7 hours)

Pile foundation- Laterally loaded piles. Reese and Matlock's generalized solution. Displacement of pile group under lateral load by Interaction Factor Approach, Pile integrity test. Non-linear load-deflection response. Uplift capacity of piles and anchors. Applications of soil structure interaction.

### Reference

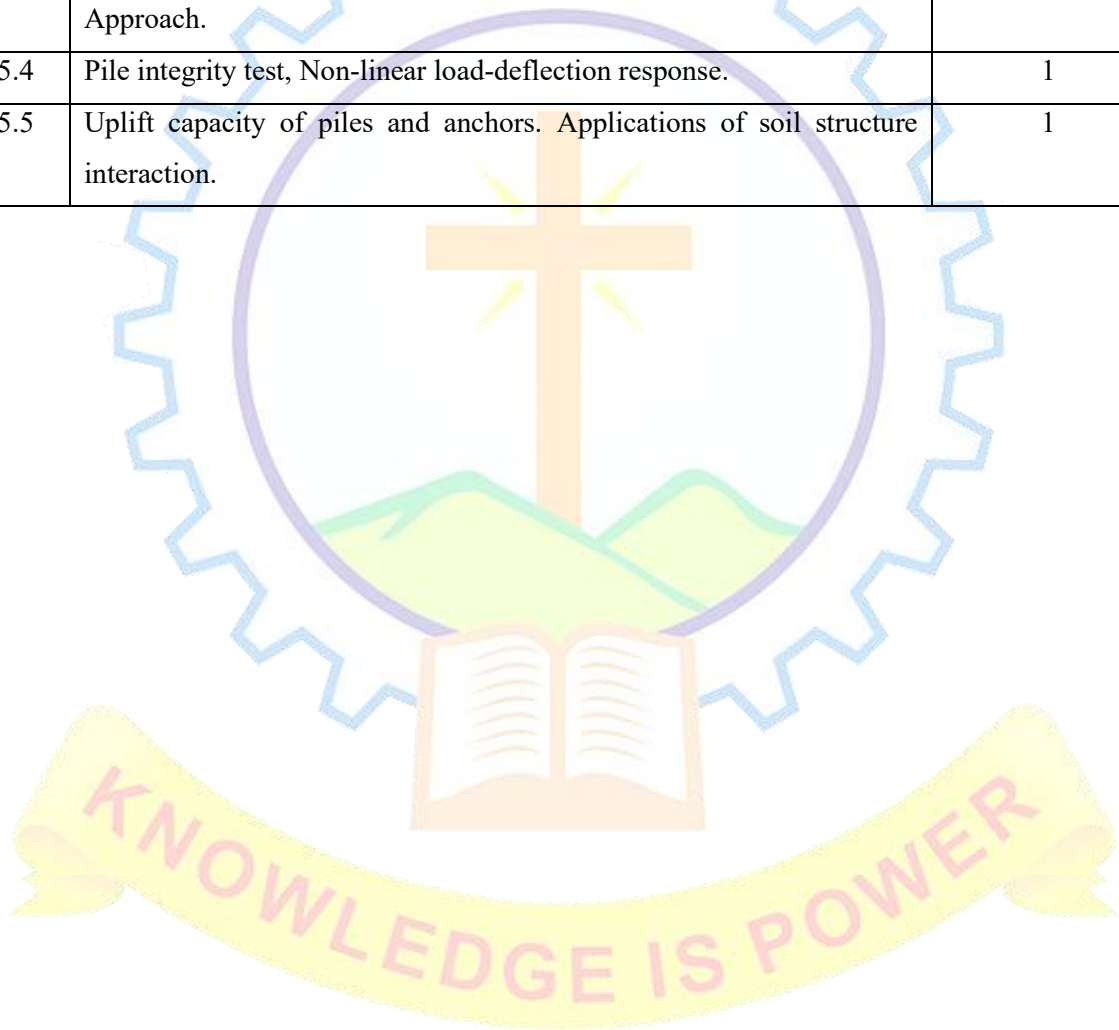
1. Wolf, J.P. (1985). *Soil-Structure Interaction*. Prentice-Hall.
2. Varghese, P.C. (2005). *Foundation Engineering*. Prentice-Hall of India.
3. Arora, K.R. (2009). *Soil Mechanics and Foundation Engineering*. Standard Publishers Distributors.
4. Bowles, J.E., "Foundation analysis and design", McGraw Hill 1996.

5. Tomlinson, M. J., “Foundation Design and construction”, English language book society and pitman, London.
6. Reese, L.C., & Van Impe, W.F. (2001). *Single Piles and Pile Groups Under Lateral Loading*. CRC Press.
7. Das, B.M. (2011). *Principles of Foundation Engineering*. Cengage Learning.

### COURSE CONTENTS AND LECTURE SCHEDULE

| No              | Topic   | No. of Lecture/<br>Tutorial hours |
|-----------------|---|-----------------------------------|
| <b>Module 1</b> |   |                                   |
| 1.1             | Review of soil mechanics: Bearing capacity analysis by Terzaghi’s theory, Skempton, Meyerhof and IS code method.  | 1                                 |
| 1.2             | Types of settlement for soil – immediate or elastic settlement, primary consolidation settlement, secondary compression settlement.                         | 1                                 |
| 1.3             | Settlement calculation for granular and clayey soils based on IS code method.   | 2                                 |
| 1.4             | Soil parameters from field sounding tests.  | 1                                 |
| 1.5             | Standard penetration test – bore log data analysis based on SPT results.  | 2                                 |
| <b>Module 2</b> |   |                                   |
| 2.1             | Stress distribution - Boussinesq and Westergard’s solution.   | 2                                 |
| 2.2             | Introduction to soil-structure interaction – significance of SSI.   | 1                                 |
| 2.3             | Contact pressure distribution beneath rigid and flexible footings- cohesive and non-cohesive soils, concept of modulus of subgrade reaction, pressure bulb. | 2                                 |
| 2.4             | Static and Dynamic loading effects-static & dynamic SSI (concept only).   | 2                                 |
| <b>Module 3</b> |   |                                   |
| 3.1             | Concepts of earth pressure theories – Rankine’s and Coulomb’s theories.   | 1                                 |
| 3.2             | Active and passive earth pressure. Earth pressure distribution on retaining walls and diaphragm walls.  | 2                                 |
| 3.3             | Earth pressures on sheet piles, braced excavations  | 2                                 |
| 3.4             | Design of retaining wall - cantilever and counterfort retaining wall, diaphragm wall and sheet pile.  | 2                                 |

| <b>Module 4</b> |   |   |
|-----------------|---|---|
| 4.1             | Structural design of shallow foundations.   | 2 |
| 4.2             | Combined footing – rectangular and trapezoidal.                                   | 2 |
| 4.3             | Structural design of strip footing.   | 2 |
| 4.4             | Rigid beam method and Winkler’s model analysis of raft foundations.               | 2 |
| <b>Module 5</b> |   |   |
| 5.1             | Pile foundation- Laterally loaded piles.  | 2 |
| 5.2             | Reese and Matlock’s generalized solution  | 1 |
| 5.3             | Displacement of pile group under lateral load by Interaction Factor Approach.     | 2 |
| 5.4             | Pile integrity test, Non-linear load-deflection response.                         | 1 |
| 5.5             | Uplift capacity of piles and anchors. Applications of soil structure interaction. | 1 |



**Model Question Paper**

**QP CODE:**

Pages: 2

Reg No.: \_\_\_\_\_

Name: \_\_\_\_\_

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM  
THIRD SEMESTER M.TECH DEGREE EXAMINATION, DECEMBER 2025**

**Course Code: M24CE2E302D**

**Course Name: SOIL STRUCTURE INTERACTION**

Max. Marks:60

Duration: 3 hours

**PART A**

**Answer all questions. Each question carries 4 marks.**

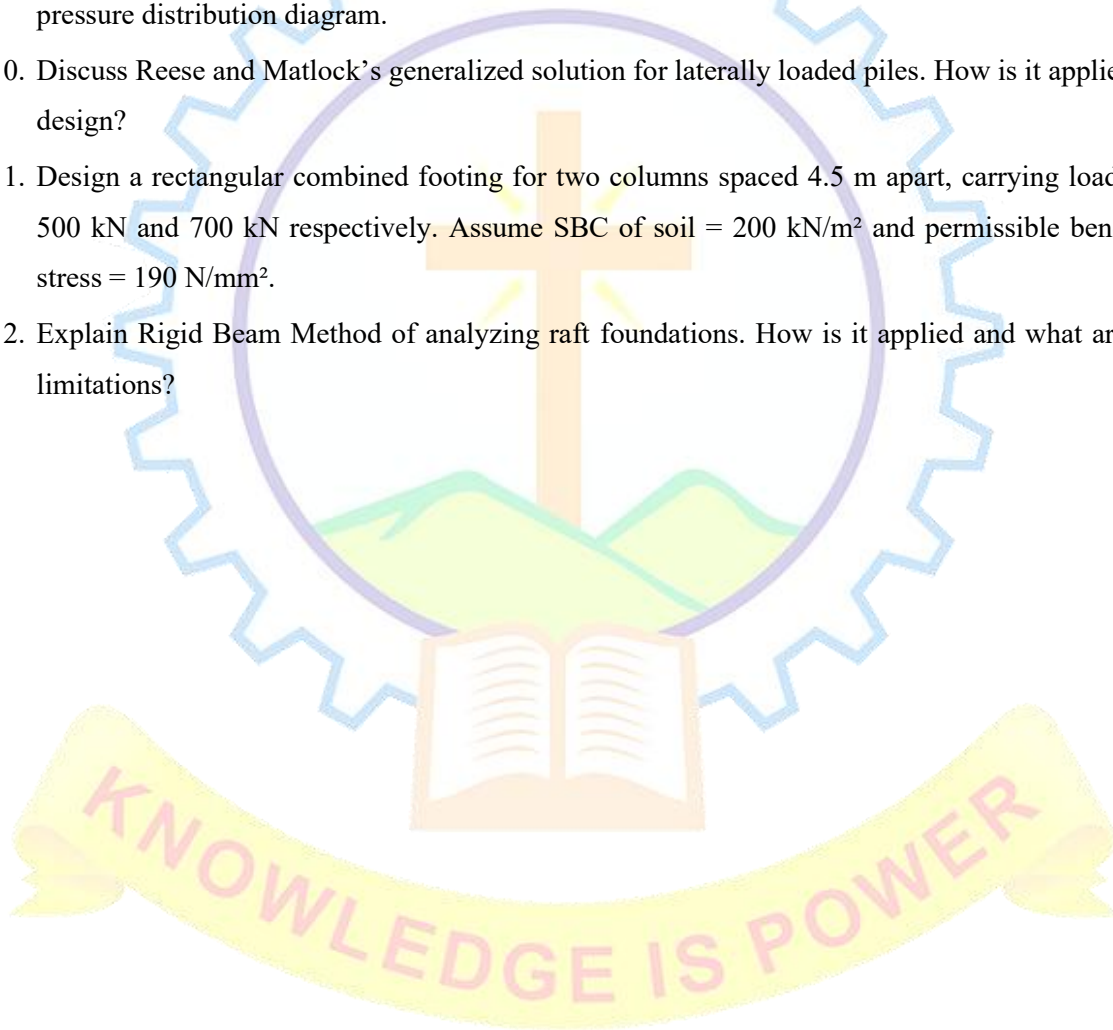
1. Write short notes on the correction of Standard Penetration Test (SPT) N-values.
2. How does contact pressure differ beneath rigid and flexible footings? Explain with suitable figures.
3. Differentiate between active and passive earth pressure with neat sketches.
4. Explain the conditions under which a strip footing is preferred over isolated footings.
5. What is a Pile Integrity Test? Explain its significance in assessing pile quality.

**PART B**

**Answer any five questions. Each question carries 8 marks.**

6. a) Determine the immediate settlement of a flexible rectangular footing ( $6\text{ m} \times 3\text{ m}$ ) resting on granular soil with:  $q=150\text{ kPa}$ ;  $\mu=0.3$ ,  $E=25,000\text{ kN/m}^2$ ; Influence factor  $I=0.88$ .  
b) From borehole data, the corrected N-values at 3 m, 6 m, and 9 m depths are 12, 18, and 22 respectively. Estimate the allowable bearing capacity of soil using IS code method for a square footing placed at 1.5 m depth. Use IS code recommendation for granular soils. Assume suitable width of footing.
7. a) What is soil-structure interaction (SSI)? Explain its significance in design of foundations subjected to dynamic loads like earthquakes or machine vibrations.  
b) A point load of  $Q=100\text{ kN}$  is applied at the surface of a semi-infinite elastic mass. Calculate the vertical stress at a depth of 2 m and radial distance  $r = 1\text{ m}$  using Boussinesq's equation.

8. Design a counterfort retaining wall to retain 6 m high backfill (level backfill). The soil properties are:  $\gamma=19 \text{ kN/m}^3$ ;  $\phi=32^\circ$ . The spacing of counterforts is 3 m. Use M25 concrete and Fe500 steel. Calculate and design: Thickness of stem, toe slab, and heel slab; Reinforcement for stem and base slab; Size and reinforcement of counterforts and Earth pressure distribution and resultant force.
9. A cantilever sheet pile wall is driven into sandy soil to retain a 4 m deep excavation. The soil has:  $\gamma =18 \text{ kN/m}^3$ ,  $\phi =35^\circ$ . Assume that there is no water table, active and passive pressures follow Rankine's theory and Factor of safety for passive pressure = 1.5. Determine the Required embedment depth of the sheet pile, maximum moment in the pile, point of zero shear and sketch pressure distribution diagram.
10. Discuss Reese and Matlock's generalized solution for laterally loaded piles. How is it applied in design?
11. Design a rectangular combined footing for two columns spaced 4.5 m apart, carrying loads of 500 kN and 700 kN respectively. Assume SBC of soil = 200 kN/m<sup>2</sup> and permissible bending stress = 190 N/mm<sup>2</sup>.
12. Explain Rigid Beam Method of analyzing raft foundations. How is it applied and what are its limitations?



### INTERNSHIP

| Slot | Course Code | Course               | Marks |    | L-T-P-S | Hours | Credit |
|------|-------------|----------------------|-------|----|---------|-------|--------|
|      |             |                      |       |    |         |       |        |
| K    | M24CE2I303  | <b>**Internship</b>  | 50    | 50 | --      | -     | 3      |
| K    | M24CE2I307  | <b>## Internship</b> | 50    | 50 | --      | --    | 4      |

\*\*Internship- mandatory internship of 6 to 8 weeks

## Internship - mandatory internship of more than 16 weeks

Internships are educational and career development opportunities, providing practical experience in a field or discipline. They are structured, short-term, supervised placements often focused around particular tasks or projects with defined timescales. An internship may be compensated or non-compensated by the organization providing the internship. The internship has to be meaningful and mutually beneficial to the intern and the organization. It is important that the objectives and the activities of the internship program are clearly defined and understood. The internship offers the students an opportunity to gain hands-on industrial or organizational exposure; to integrate the knowledge and skills acquired through the coursework; interact with professionals and other interns; and to improve their presentation, writing, and communication skills. Internship often acts as a gateway for final placement for many students.

A student shall opt for carrying out the Internship at an Industry/Research Organization or at another institute of higher learning and repute (Academia). The organization for Internship shall be selected/decided by the students on their own with prior approval from the faculty advisor/respective PG Programme Coordinator/Guide/Supervisor. Every student shall be assigned an internship Supervisor/Guide at the beginning of the Internship. The training shall be related to their specialization after the second semester for a minimum duration of six to eight weeks. On completion of the course, the student is expected to be able to develop skills in facing and solving the problems experiencing in the related field.

#### Objectives

- ✓ Exposure to the industrial environment, which cannot be simulated in the classroom and hence creating competent professionals for the industry.
- ✓ Provide possible opportunities to learn understand and sharpen the real time technical / managerial skills required at the job.
- ✓ Exposure to the current technological developments relevant to the subject area of training.
- ✓ Create conducive conditions with quest for knowledge and its applicability on the job.
- ✓ Understand the social, environmental, economic and administrative considerations that

influence the working environment.

- ✓ Expose students to the engineer's responsibilities and ethics.

## **Benefits of Internship**

### **Benefits to Students**

- ✓ An opportunity to get hired by the Industry/ organization.
- ✓ Practical experience in an organizational setting & Industry environment.
- ✓ Excellent opportunity to see how the theoretical aspects learned in classes are integrated into the practical world. On-floor experience provides much more professional experience which is often worth more than classroom teaching.
- ✓ Helps them decide if the industry and the profession is the best career option to pursue.
- ✓ Opportunity to learn new skills and supplement knowledge.
- ✓ Opportunity to practice communication and teamwork skills.
- ✓ Opportunity to learn strategies like time management, multi-tasking etc in an industrial setup.
- ✓ Makes a valuable addition to their resume.
- ✓ Enhances their candidacy for higher education/placement.
- ✓ Creating network and social circle and developing relationships with industry people.
- ✓ Provides opportunity to evaluate the organization before committing to a full time position.

### **Benefits to the Institute**

- ✓ Build industry academia relations.
- ✓ Makes the placement process easier.
- ✓ Improve institutional credibility & branding.
- ✓ Helps in retention of the students.
- ✓ Curriculum revision can be made based on feedback from Industry/students.
- ✓ Improvement in teaching learning process.

### **Benefits to the Industry**

- ✓ Availability of ready to contribute candidates for employment.
- ✓ Year round source of highly motivated pre-professionals.
- ✓ Students bring new perspectives to problem solving.
- ✓ Visibility of the organization is increased on campus.
- ✓ Quality candidate's availability for temporary or seasonal positions and projects.
- ✓ Freedom for industrial staff to pursue more creative projects.
- ✓ Availability of flexible, cost-effective workforce not requiring a long term employer commitment.
- ✓ Proven, cost-effective way to recruit and evaluate potential employees.

- ✓ Enhancement of employer's image in the community by contributing to the educational enterprise.

### **Types of Internships**

- ✓ Industry Internship with/without Stipend
- ✓ Govt / PSU Internship (BARC/Railway/ISRO etc)
- ✓ Internship with prominent education/research Institutes
- ✓ Internship with Incubation centres /Start-ups

### **Guidelines**

- ✓ All the students need to go for internship for minimum duration of 6 to 8 weeks.
- ✓ Students can take mini projects, assignments, case studies by discussing it with concerned authority from industry and can work on it during internship.
- ✓ All students should compulsorily follow the rules and regulations as laid by industry.
- ✓ Every student should take prior permissions from concerned industrial authority if they want to use any drawings, photographs or any other document from industry.
- ✓ Student should follow all ethical practices and SOP of industry.
- ✓ Students have to take necessary health and safety precautions as laid by the industry.
- ✓ Student should contact his /her Guide/Supervisor from college on weekly basis to communicate the progress.
- ✓ Each student has to maintain a diary/log book
- ✓ After completion of internship, students are required to submit
- ✓ Report of work done
- ✓ Internship certificate copy
- ✓ Feedback from employer / internship mentor
- ✓ Stipend proof (in case of paid internship).

**Total Marks 100:** The marks awarded for the Internship will be on the basis of (i) Evaluation done by the Industry (ii) Students diary (iii) Internship Report and (iv) Comprehensive Viva Voce.

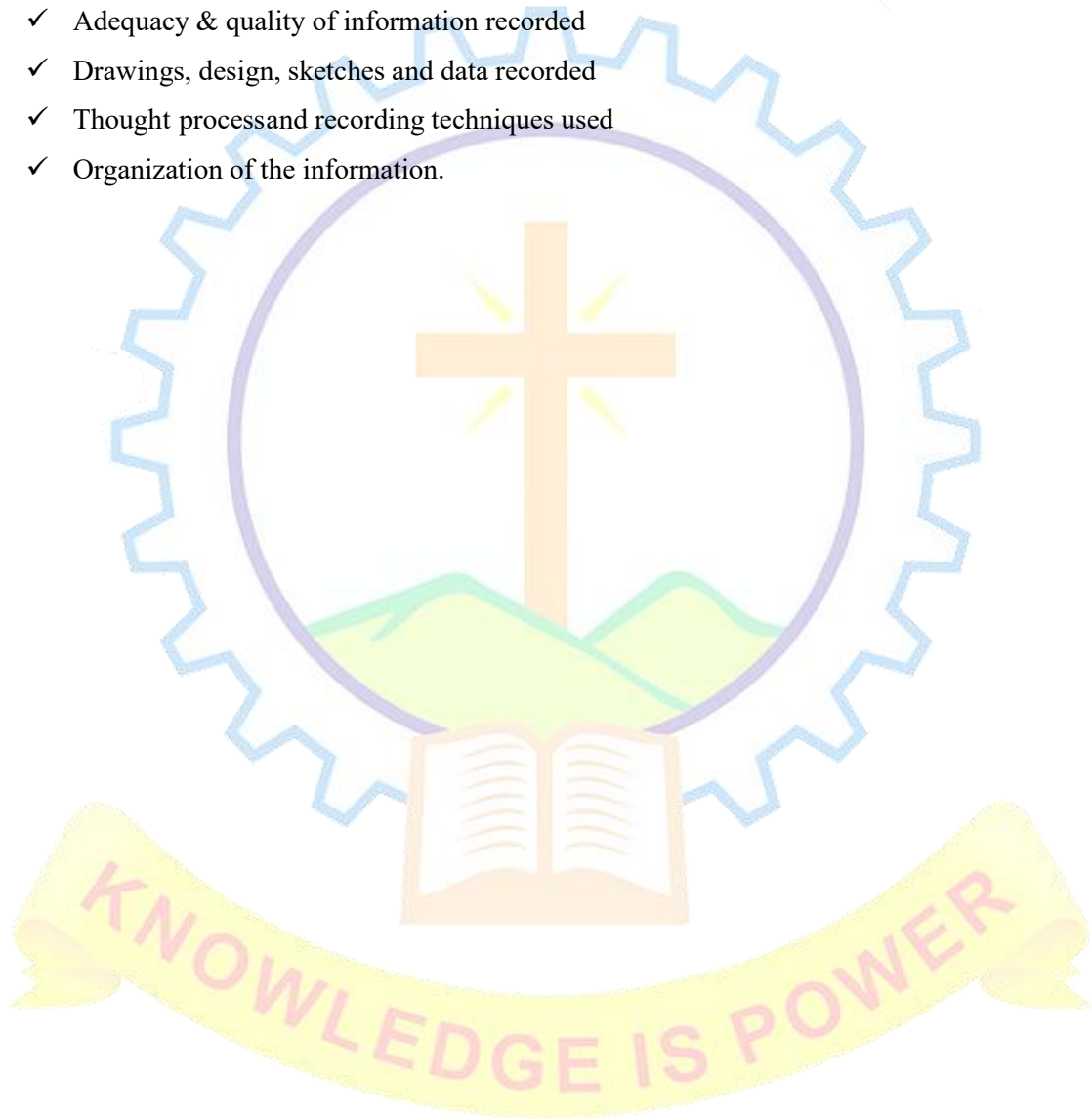
### **Continuous Internal Evaluation: 50 marks**

|                                 |   |          |
|---------------------------------|---|----------|
| Student's diary                 | - | 25 Marks |
| Evaluation done by the Industry | - | 25 Marks |

**Student's Diary/ Daily Log:** The main purpose of writing daily diary is to cultivate the habit of documenting and to encourage the students to search for details. It develops the students' thought process and reasoning abilities. The students should record in the daily training diary the day to day account of

the observations, impressions, information gathered and suggestions given, if any. It should contain the sketches & drawings related to the observations made by the students. The daily training diary should be signed after every day by the supervisor/ in charge of the section where the student has been working. The diary should also be shown to the Faculty Mentor visiting the industry from time to time and got ratified on the day of his visit. Student's diary will be evaluated on the basis of the following criteria:

- ✓ Regularity in maintenance of the diary
- ✓ Adequacy & quality of information recorded
- ✓ Drawings, design, sketches and data recorded
- ✓ Thought process and recording techniques used
- ✓ Organization of the information.



**The format of student's diary**

Name of the Organization/Section:

Name and Address of the Section Head:

Name and Address of the Supervisor:

Name and address of the student:

Internship Duration: From ..... To .....

Brief description about the nature of internship:

|     |  |
|-----|--|
| Day | Brief write up about the Activities carried out: Such as design, sketches, result observed, issues identified, data recorded, etc. |
|-----|--|

|   |  |
|---|--|
| 1 |  |
| 2 |  |
| 3 |  |

*Signature of Industry Supervisor*

*Signature of Section Head/HR Manager Office Seal*

**Attendance Sheet**

Name of the Organization/Section:

Name and Address of the Section Head:

Name and Address of the Supervisor:

Name and address of the student:

Internship Duration: From ..... To .....

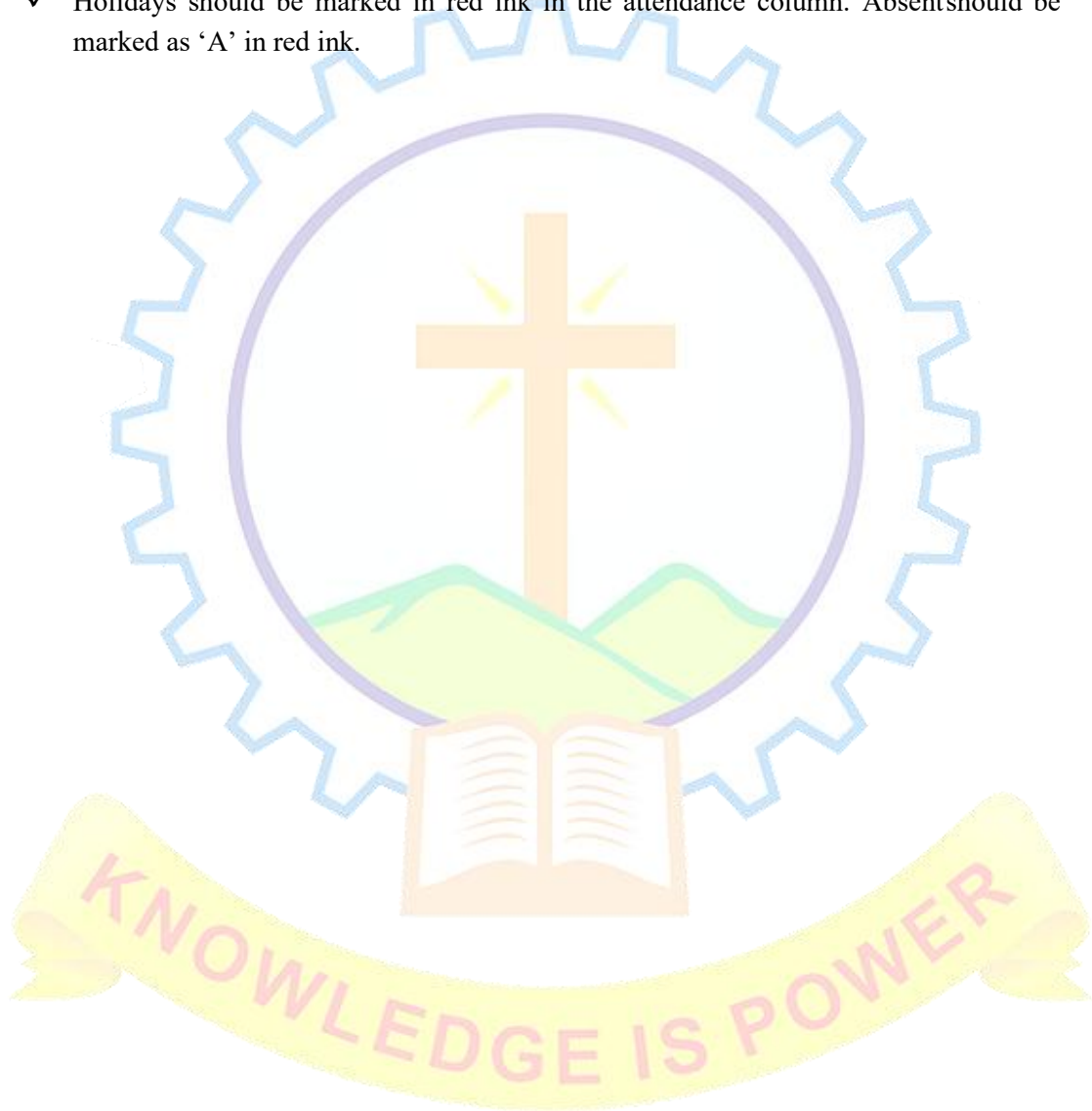
| Month & Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | ... |
|--------------|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|-----|
|              |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |     |
| Month & Year |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |     |
| Month & Year |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |     |

*Signature of Industry Supervisor*

*Signature of Section Head/HR Manager  
Office Seal*

**Note:**

- ✓ Student's Diary shall be submitted by the students along with attendance record and an evaluation sheet duly signed and stamped by the industry to the Institute immediately after the completion of the training.
- ✓ Attendance Sheet should remain affixed in daily training diary. Do not remove or tear it off.
- ✓ Student shall sign in the attendance column. Do not mark 'P'.
- ✓ Holidays should be marked in red ink in the attendance column. Absent should be marked as 'A' in red ink.



**Evaluation done by the Industry (Marks 25)**

**Format for Supervisor Evaluation of Intern**

Student Name : \_\_\_\_\_ Date: \_\_\_\_\_

Supervisor Name : \_\_\_\_\_ Designation: \_\_\_\_\_

Company/Organization : \_\_\_\_\_

Internship Address: \_\_\_\_\_

Dates of Internship: From \_\_\_\_\_ To \_\_\_\_\_

*Please evaluate intern by indicating the frequency with which you observed following parameters:*

| <b>Parameters Marks</b>                  | Needs improvement<br>(0 – 0.25 mark) | Satisfactory<br>(0.25 – 0.50 mark) | Good<br>(0.75 mark) | Excellent<br>(1 mark) |
|--|--------------------------------------|------------------------------------|---------------------|-----------------------|
| Behavior                                 |                                      |                                    |                     |                       |
| Performs in a dependable Manner          |                                      |                                    |                     |                       |
| Cooperates with coworkers and supervisor |                                      |                                    |                     |                       |
| Shows interest in work                   |                                      |                                    |                     |                       |
| Learns quickly                           |                                      |                                    |                     |                       |
| Shows initiative                         |                                      |                                    |                     |                       |
| Produces high quality work               |                                      |                                    |                     |                       |
| Accepts responsibility                   |                                      |                                    |                     |                       |
| Accepts criticism                        |                                      |                                    |                     |                       |
| Demonstrates organizational skills       |                                      |                                    |                     |                       |
| Uses technical knowledge and expertise   |                                      |                                    |                     |                       |
| Shows good judgment                      |                                      |                                    |                     |                       |
| Demonstrates creativity/originality      |                                      |                                    |                     |                       |
| Analyzes problems effectively            |                                      |                                    |                     |                       |
| Is self-reliant                          |                                      |                                    |                     |                       |
| Communicates well                        |                                      |                                    |                     |                       |
| Writes effectively                       |                                      |                                    |                     |                       |
| Has a professional attitude              |                                      |                                    |                     |                       |
| Gives a professional appearance          |                                      |                                    |                     |                       |
| Is punctual                              |                                      |                                    |                     |                       |
| Uses time effectively                    |                                      |                                    |                     |                       |

Overall performance of student: Intern (Tick one):

Needs improvement (0 - 0.50 mark) / Satisfactory (0.50 – 1.0 mark) / Good (1.5 mark) / Excellent (2.0 mark) Additional comments, if any (2 marks) :

*Signature of Industry Supervisor*

*Signature of Section Head/HR Manager*

*Office Seal*

**End Semester Evaluation (External Evaluation): 50 Marks**

|                   |   |          |
|-------------------|---|----------|
| Internship Report | - | 25 Marks |
| Viva Voce         | - | 25 Marks |

**Internship Report:** After completion of the internship, the student should prepare a comprehensive report to indicate what he has observed and learnt in the training period and should be submitted to the faculty Supervisor. The student may contact Industrial Supervisor/ Faculty Mentor for assigning special topics and problems and should prepare the final report on the assigned topics. Daily diary will also help to a great extent in writing the industrial report since much of the information has already been incorporated by the student into the daily diary. The training report should be signed by the Internship Supervisor, Programme Coordinator and Faculty Mentor.

The Internship report (25 Marks) will be evaluated on the basis of following criteria:

- ✓ Originality
- ✓ Adequacy and purposeful write-up
- ✓ Organization, format, drawings, sketches, style, language etc.
- ✓ Variety and relevance of learning experience
- ✓ Practical applications, relationships with basic theory and concepts taught in the course

**Viva Voce (25 Marks)** will be done by a committee comprising Faculty Supervisor, PG Programme Coordinator and an external expert (from Industry or research/academic Institute). This committee will be evaluating the internship report also.

**DISSERTATION PHASE 1**

| TRACK I  |             |                         |       |     |           |       |        |
|----------|-------------|-------------------------|-------|-----|-----------|-------|--------|
| Slot     | Course Code | Course                  | Marks |     | L-T-P-S   | Hours | Credit |
|          |             |                         | CIE   | ESE |           |       |        |
| P        | M24CE2P304  | Dissertation Phase 1    | 100   | --  | 0-0-16-16 | 16    | 11     |
| TRACK II |             |                         |       |     |           |       |        |
| P        | M24CE2P308  | ###Dissertation Phase 1 | 100   | --  | --        | --    | 11     |

**TRACK 1 / TRACK 2**

In second year, the students can choose either of the two tracks: TRACK 1 or TRACK 2. Track 1 is conventional M.Tech programme in which the dissertation Phase 1 is conducted in college. Track 2 is M.Tech programme designed for students who undergone long term internship (not less than 16 weeks) in industry. An aspirant in track 2 needs to do the dissertation in the industry. The candidates should also be good with performing in-depth research and colluding the conclusions of research led by them. Such students are expected to have the following skills: Technical Skills, Research Skills, Communication Skills, Critical Thinking Skills, and Problem-Solving Skills.

**The eligibility for Track 2:**

- Shall have qualified in the GATE or have a SGPA above 8.0 during the first semester, and
- Qualify an interview during the end of second semester by an expert committee constituted by the College.

**Objectives**

The objectives of Phase 1 of an M.Tech dissertation typically focus on laying a strong foundation for the research work to be conducted in subsequent phases. While specific objectives can vary depending on the institution, discipline, and project, the following are common goals for Phase 1:

1. **Topic Identification and Selection:** To identify a relevant, feasible, and innovative research topic aligned with the student's area of interest and the field's current trends or challenges.
2. **Literature Review:** To conduct a preliminary review of existing research and literature to understand the state of the art, identify gaps, and establish the context for the proposed work.
3. **Problem Definition:** To clearly define the research problem or question that the dissertation aims to address, ensuring it is specific, measurable, and researchable.
4. **Objective Formulation:** To establish clear and achievable objectives for the overall dissertation, outlining what the research intends to accomplish.
5. **Feasibility Assessment:** To evaluate the practicality of the proposed research in terms of available resources, time constraints, and technical requirements.
6. **Methodology Outline:** To develop a preliminary plan for the research methodology, including the tools, techniques, or approaches that will be used to investigate the problem.

7. **Synopsis Preparation:** To prepare and submit a concise synopsis or proposal summarizing the research topic, objectives, significance, and planned approach for approval by the academic supervisor or committee.
8. **Background Knowledge Building:** To deepen the student's understanding of the chosen domain and related concepts, ensuring a solid theoretical foundation for the research.

These objectives are designed to set the stage for Phase 2 and beyond, where the focus typically shifts to implementation, experimentation, and analysis. Phase 1 is critical for ensuring that the research is well-planned and directed toward a meaningful contribution to the field.

### Course Outcome

After completing dissertation phase 1 student should be able to

- Demonstrate **Research Topic Selection Skills:** Students will be able to identify and select a research topic that is innovative, relevant, and feasible within the scope of their M.Tech program.
- Conduct **Effective Literature Analysis:** Students will develop the ability to critically review and synthesize existing literature to identify research gaps and establish the context for their study.
- Define a **Clear Research Problem:** Students will acquire the skill to articulate a well-defined research problem or question, ensuring it is specific, measurable, and aligned with their dissertation goals.
- Formulate **Research Objectives and Methodology:** Students will be able to formulate clear research objectives and outline a preliminary methodology, demonstrating an understanding of the tools and approaches required for their study.
- Prepare a **Comprehensive Research Proposal:** Students will gain the capability to create a structured synopsis or proposal, effectively communicating the significance, objectives, and planned approach of their research for evaluation.

| Course Outcome (CO)                              | Mapped Program Outcome (PO)   | Justification  |
|--|---|--|
| CO1: Demonstrate Research Topic Selection Skills | PO1: Ability to independently carry out research/investigation and development work | Selecting a research topic requires independent exploration and judgment, aligning with research skills. |
|  | PO3: Demonstrate mastery over the specialization area                               | Topic selection reflects an understanding of advanced concepts beyond undergraduate level.               |
| CO2: Conduct Effective Literature Analysis       | PO1: Ability to independently carry out research/investigation and development work | Literature analysis is a core research skill, requiring independent critical thinking.                   |

| Course Outcome (CO)                                | Mapped Program Outcome (PO)  | Justification  |
|--|--|--|
|  | PO3: Demonstrate mastery over the specialization area                                    | Analyzing literature demonstrates depth of knowledge in the chosen field.                        |
| CO3: Define a Clear Research Problem               | PO1: Ability to independently carry out research/investigation and development work      | Defining a research problem is a fundamental step in independent research.                       |
|  | PO4: Apply stream knowledge to design or develop solutions for real-world problems       | A well-defined problem often addresses real-world challenges using specialized knowledge.        |
| CO4: Formulate Research Objectives and Methodology | PO1: Ability to independently carry out research/investigation and development work      | Formulating objectives and methodology showcases independence in planning research.              |
|  | PO5: Identify, select, and apply appropriate techniques, resources, and tools            | Outlining methodology involves selecting suitable techniques and tools for the research.         |
| CO5: Prepare a Comprehensive Research Proposal     | PO2: Ability to communicate effectively, write and present technical reports             | Writing a proposal requires clear communication and presentation skills for technical audiences. |
|  | PO6: Engage in life-long learning with consideration of sustainability, societal aspects | A proposal often reflects awareness of broader impacts, fostering                                |

### Continuous Internal Evaluation

The evaluation committee comprises

1. Project coordinator
2. A senior faculty
3. Project supervisor

| Course Outcome (CO)                                | Marks Allocated | Justification  |
|--|-----------------|--|
| CO1: Demonstrate Research Topic Selection Skills   | 15              | Topic selection is foundational but less intensive than later stages; it requires creativity and initial research. |
| CO2: Conduct Effective Literature Analysis         | 25              | Literature review is critical, time-intensive, and requires critical thinking to identify gaps.                    |
| CO3: Define a Clear Research Problem               | 20              | Defining the problem is a pivotal step, requiring clarity and alignment with research goals.                       |
| CO4: Formulate Research Objectives and Methodology | 25              | Formulating objectives and methodology demands detailed planning and technical understanding.                      |
| CO5: Prepare a Comprehensive Research Proposal     | 15              | Proposal preparation integrates all prior work into a concise document, focusing on communication.                 |
| <b>Total</b>                                       | <b>100</b>      |  |

### Detailed Breakdown and Rationale:

1. **CO1: Demonstrate Research Topic Selection Skills (15 marks)**

- ✓ This involves identifying a feasible and innovative topic. It's an essential starting point but less complex than subsequent analytical tasks.
- ✓ Assessment: Relevance, originality, and feasibility of the topic.

2. **CO2: Conduct Effective Literature Analysis (25 marks)**

- ✓ A thorough literature review is a cornerstone of Phase 1, requiring significant effort to survey existing work, analyze gaps, and establish context.
- ✓ Assessment: Depth, breadth, and critical evaluation of sources.

3. **CO3: Define a Clear Research Problem (20 marks)**

- ✓ Defining a specific, measurable research problem is crucial and builds on the literature review. It's moderately weighted as it sets the direction for the dissertation.
- ✓ Assessment: Clarity, specificity, and significance of the problem statement.

4. **CO4: Formulate Research Objectives and Methodology (25 marks)**

- ✓ This requires outlining clear objectives and a preliminary methodology, which involves technical knowledge and planning. It's a high-effort task, justifying equal weight to the literature review.
- ✓ Assessment: Achievability of objectives and appropriateness of the methodology.

5. **CO5: Prepare a Comprehensive Research Proposal (15 marks)**

- ✓ The proposal synthesizes all prior work into a structured document. While important for communication, it's less intensive than analysis or planning, hence a slightly lower weight.
- ✓ Assessment: Structure, clarity, and completeness of the proposal.

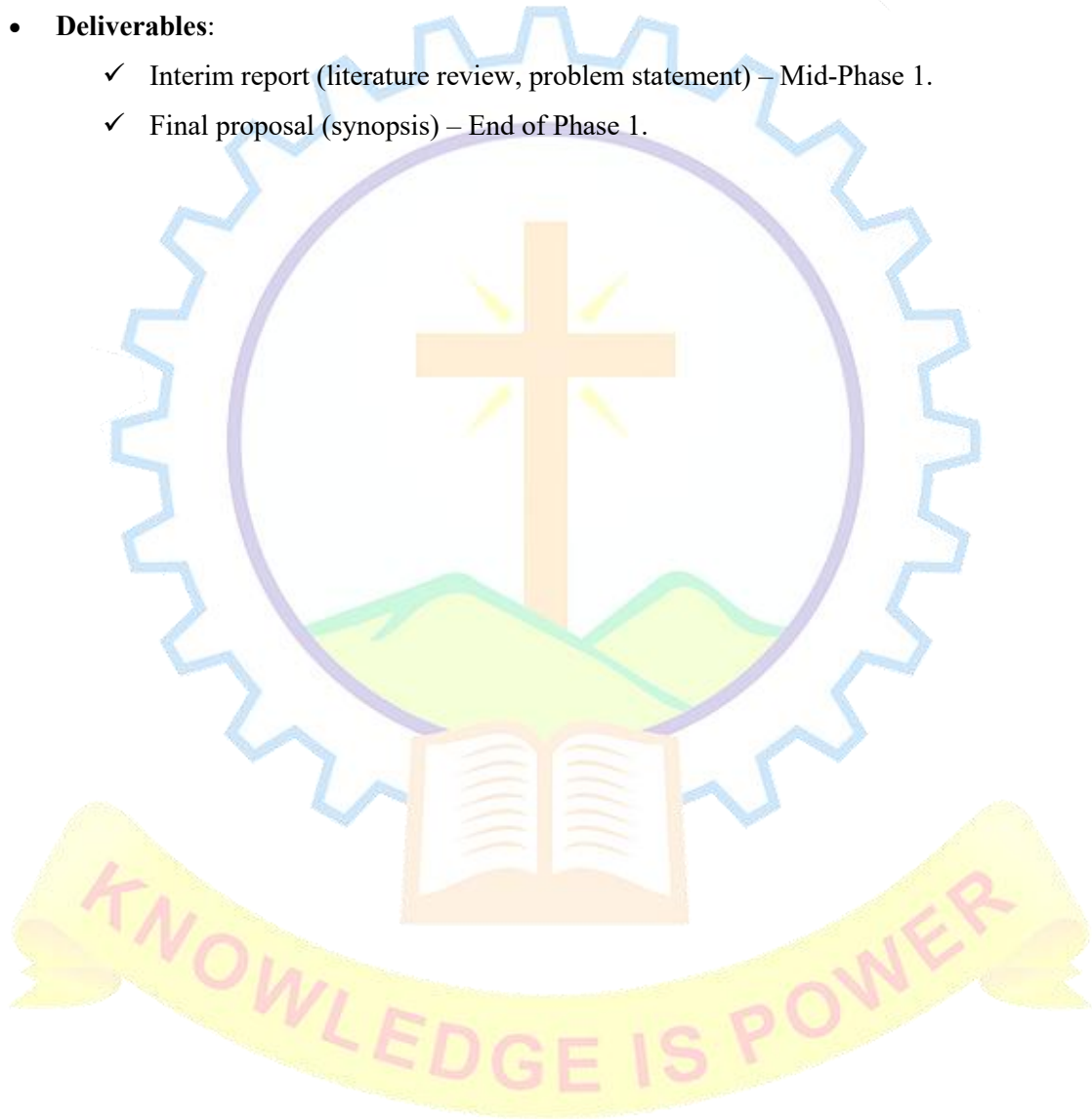
### Scheme for Track 2: M.Tech Dissertation Phase 1 (Industry-Based)

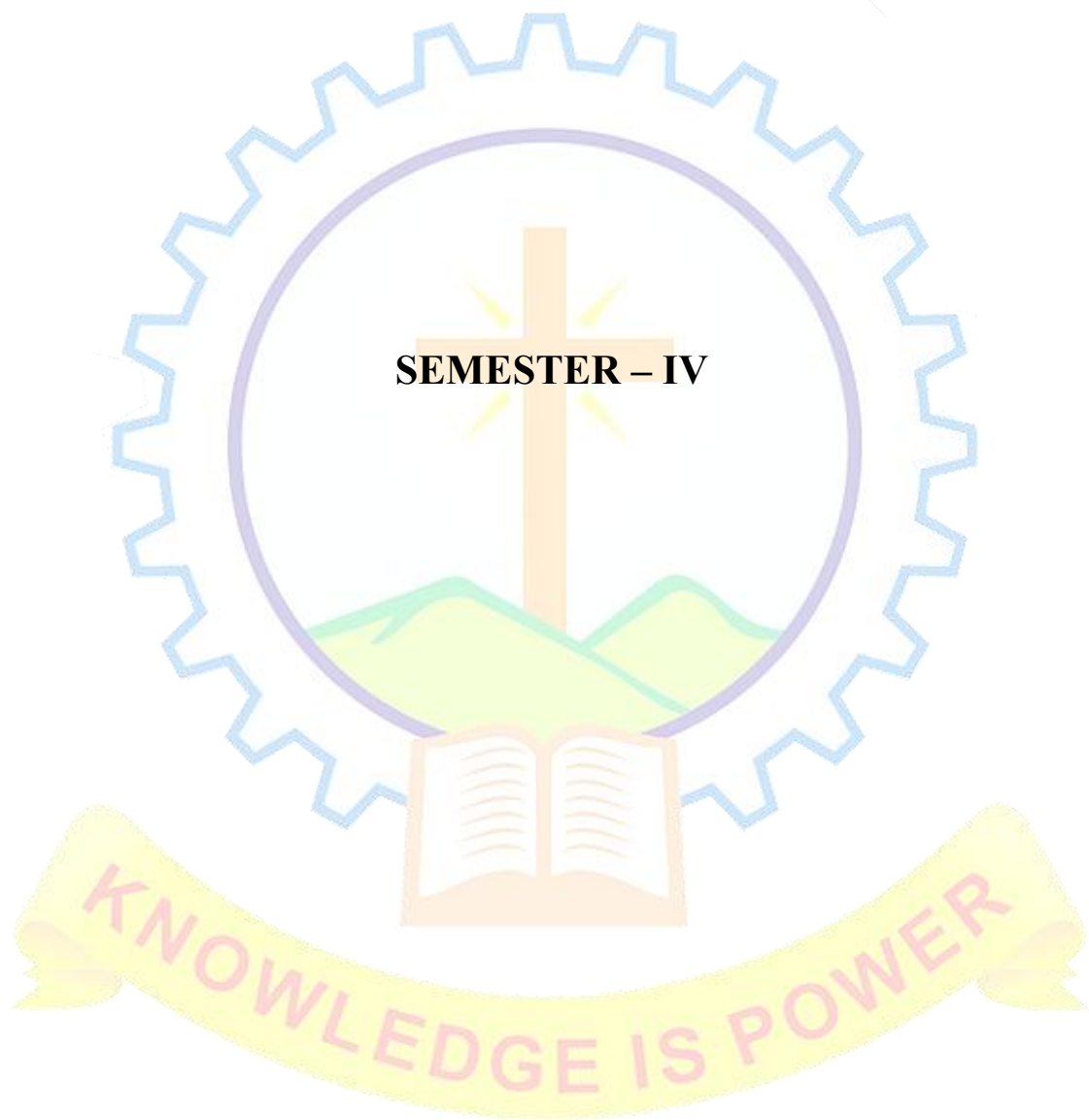
#### Overview

- **Target Students:** Those who have completed a long-term internship ( $\geq 16$  weeks) and aim to conduct their dissertation in industry.
- **Focus:** In-depth research, industry-relevant problem-solving, and collaboration with industrial mentors.
- **Total Marks:** 100 (for Phase 1).
- **Eligibility:**
  - ✓ Qualified in GATE **OR** SGPA  $> 8.0$  in the first semester.
  - ✓ Successful qualification in an interview by an expert committee at the end of the second semester.

### Evaluation Process

- **Industry Mentor Involvement:** The industry mentor (from the internship or dissertation site) provides feedback and assesses feasibility (e.g., 30% weightage).
- **Academic Supervisor:** Ensures academic rigor and alignment with M.Tech standards (e.g., 50% weightage).
- **Expert Committee Review:** Evaluates the final proposal for originality and industry relevance (e.g., 20% weightage, possibly tied to synopsis approval).
- **Deliverables:**
  - ✓ Interim report (literature review, problem statement) – Mid-Phase 1.
  - ✓ Final proposal (synopsis) – End of Phase 1.





**DISSERTATION PHASE 2**

| TRACK 1 |             |                        |       |     |           |       |        |
|---------|-------------|------------------------|-------|-----|-----------|-------|--------|
| Slot    | Course Code | Course                 | Marks |     | L-T-P-S   | Hours | Credit |
|         |             |                        | CIE   | ESE |           |       |        |
| P       | M24CE2P401  | Dissertation Phase 2   | 100   | 100 | 0-0-27-24 | 27    | 18     |
| Total   |             |                        | 100   | 100 |           | 27    | 18     |
| TRACK 2 |             |                        |       |     |           |       |        |
| P       | M24CE2P402  | ##Dissertation Phase 2 | 100   | 100 |           |       | 18     |

##Dissertation Phase 2- Should be done in Industry

**Dissertation Phase 2: Overview**

- **Duration:** Typically the final semester (e.g., fourth semester of M.Tech).
- **Focus:** Implementation, experimentation, analysis, and conclusion of the research initiated in Phase 1.
- **Common Objectives** (adapted for each track):
  1. Execute the proposed methodology.
  2. Analyze results and draw meaningful conclusions.
  3. Demonstrate technical proficiency and problem-solving.
  4. Document and present findings effectively.

**Scheme for Track 1: Dissertation Phase 2 (College-Based)****Course Outcomes (COs) for Track 1**

1. **CO1:** Implement the research methodology proposed in Phase 1 using appropriate tools and techniques (Technical Skills, Problem-Solving Skills).
2. **CO2:** Conduct experiments or simulations to generate data or validate the approach (Research Skills, Critical Thinking Skills).
3. **CO3:** Analyze results and interpret findings to address the research problem (Critical Thinking Skills, Research Skills).
4. **CO4:** Compile a detailed dissertation report documenting the research process and outcomes (Communication Skills).
5. **CO5:** Present and defend the research work effectively to an academic audience (Communication Skills, Technical Skills).

**Evaluation Scheme**

1. **Continuous Internal Evaluation (CIE) – 100 Marks**
  - ✓ Assessed by the project coordinator throughout the semester.
  - ✓ Focus: Progress, effort, and intermediate deliverables.

| Component                           | Marks      | CO Assessed | Justification  |
|-------------------------------------|------------|-------------|--|
| Methodology Implementation Progress | 25         | CO1         | Monitors execution of the proposed plan in a college lab or simulation setup.    |
| Experimental/Simulation Work        | 25         | CO2         | Assesses data collection or validation efforts in a controlled academic setting. |
| Interim Result Analysis             | 20         | CO3         | Evaluates preliminary analysis and critical thinking during the semester.        |
| Draft Report Submission             | 20         | CO4         | Checks documentation quality and adherence to academic standards.                |
| Regular Interaction/Presentation    | 10         | CO5         | Assesses communication and ability to discuss progress with the supervisor.      |
| <b>Total</b>                        | <b>100</b> |             |  |

## 2. End Semester Evaluation (ESE) – 100 Marks

- ✓ Assessed by a panel (Project coordinator+ supervisor + external examiner) at the semester's end.
- ✓ Focus: Final output, rigor, and presentation.

| Component                         | Marks      | CO Assessed | Justification  |
|-----------------------------------|------------|-------------|--|
| Final Methodology Implementation  | 20         | CO1         | Evaluates completeness and technical accuracy of the implemented solution.   |
| Quality of Results/Data           | 25         | CO2         | Assesses the robustness and validity of experimental or simulation outcomes. |
| Depth of Analysis and Conclusions | 25         | CO3         | Examines the interpretation and significance of findings.                    |
| Final Dissertation Report         | 20         | CO4         | Judges the quality, structure, and clarity of the written report.            |
| Viva Voce/Presentation            | 10         | CO5         | Tests ability to defend work and communicate findings to an academic panel.  |
| <b>Total</b>                      | <b>100</b> |             |  |

## Scheme for Track 2: Dissertation Phase 2 (Industry-Based)

### Course Outcomes (COs) for Track 2

1. **CO1:** Implement the industry-oriented methodology proposed in Phase 1 using industry tools/resources (Technical Skills, Problem-Solving Skills).
2. **CO2:** Perform industry-relevant experiments, validations, or prototypes (Research Skills, Critical Thinking Skills).
3. **CO3:** Analyze results and draw conclusions applicable to the industry problem (Critical Thinking Skills, Research Skills).
4. **CO4:** Compile a dissertation report integrating academic and industry perspectives (Communication Skills).

5. **CO5:** Present findings effectively to both academic and industry stakeholders (Communication Skills, Technical Skills).

### Evaluation Scheme

#### 1. Continuous Internal Evaluation (CIE) – 100 Marks

- ✓ Assessed jointly by the Project coordinator, supervisor and industry mentor during the semester.
- ✓ Focus: Industry collaboration, progress, and practical application.

| Component                           | Marks      | CO Assessed | Justification   |
|-------------------------------------|------------|-------------|---|
| Methodology Implementation Progress | 25         | CO1         | Tracks execution of the plan in an industry environment using real-world tools.   |
| Industry Validation/Prototype Work  | 25         | CO2         | Evaluates practical outputs (e.g., prototypes, tests) relevant to industry needs. |
| Interim Result Analysis             | 20         | CO3         | Assesses industry-applicable insights derived during the process.                 |
| Draft Report Submission             | 20         | CO4         | Ensures documentation meets both academic and industry standards.                 |
| Industry Feedback/Interaction       | 10         | CO5         | Gauges communication with industry mentor and progress updates.                   |
| <b>Total</b>                        | <b>100</b> |             |   |

#### 2. End Semester Evaluation (ESE) – 100 Marks

- ✓ Assessed by a panel (Project coordinator, supervisor, industry mentor, external examiner).
- ✓ Focus: Final deliverables, industry relevance, and dual-audience presentation.

| Component                              | Marks      | CO Assessed | Justification   |
|--|------------|-------------|---|
| Final Methodology Implementation       | 20         | CO1         | Evaluates the technical success of the industry-implemented solution.         |
| Quality of Industry Outputs/Results    | 25         | CO2         | Assesses the practical utility and quality of industry-specific deliverables. |
| Depth of Analysis and Industry Impact  | 25         | CO3         | Examines conclusions and their relevance to industry challenges.              |
| Final Dissertation Report              | 20         | CO4         | Judges the report's ability to address academic rigor and industry needs.     |
| Viva Voce/Presentation (Dual Audience) | 10         | CO5         | Tests communication to both academic and industry evaluators.                 |
| <b>Total</b>                           | <b>100</b> |             |   |