MAR ATHANASIUS COLLEGE OF ENGINEERING

(Government Aided & Autonomous)

Kothamangalam 686 666

Affiliated to APJ Abdul Kalam Technological University

Thiruvananthapuram

Master of Technology (M. Tech.)

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 ATHANASIUS 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 program

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	M24CE2E104A	Programme Elective 1	40	60	3-0-0-3	3	3
E	M24CE2E105A	Programme Elective 2	40	60	3-0-0-3	3	3
S	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	--	0-0-17	16	11
	TOTAL		190	110		23	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 16 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	M24CE1P401	Dissertation Phase II	100	100	0-0-27-24	27	18
	TOTAL		100	100		27	18
TRACK 2							
P	M24CE1P402	##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).

Continuous Internal Evaluation	**:**	**40 marks**
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		
End Semester Examination	**:**	**60marks**

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).

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

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. 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:

Parameters Marks	Needs improvement (0 – 0.25 mark)	Satisfactory (0.25 – 0.50 mark)	Good (0.75 mark)	Excellent (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 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
End Semester Examination	**:**	**60 marks**

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 under-performing, 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 there 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.

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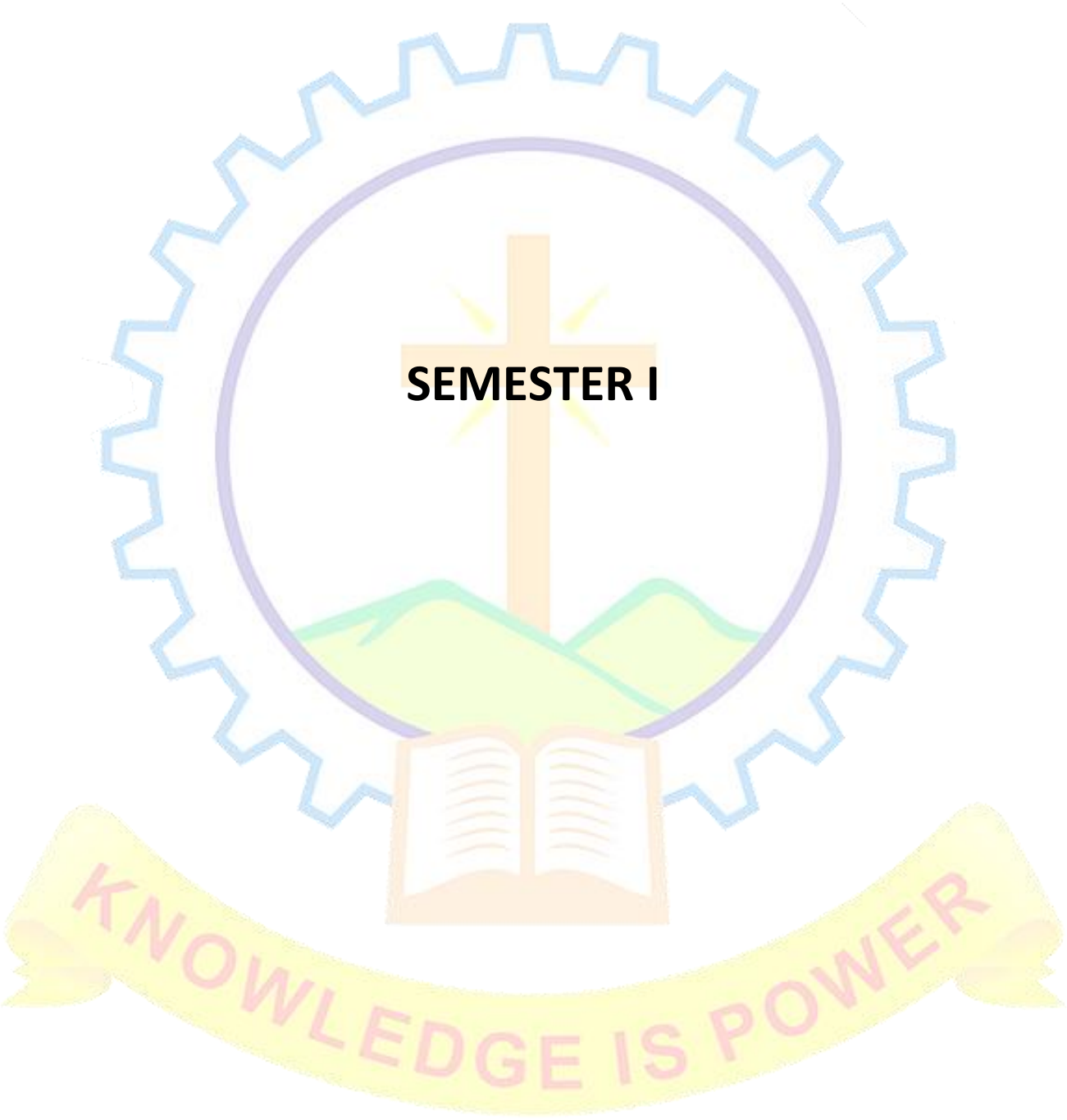

SEMESTER I

BRANCH : Civil Engineering

SPECIALIZATION : Computer Aided Structural Engineering

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. **(Cognitive knowledge level: Apply)**
CO 2	Apply solution technique in structural engineering problems. **(Cognitive knowledge level: Analyse)**
CO 3	Evaluate numerical solutions for ordinary differential equations and their application in structural engineering. **(Cognitive knowledge level: Analyse)**
CO 4	Comprehend various optimization algorithms and tools to tackle problem-solving tasks. **(Cognitive knowledge level: Evaluate)**
CO 5	Develop problem formulations and apply appropriate techniques to solve them. **(Cognitive knowledge level: Evaluate)**

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 Internal 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

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 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/ Tutorial hours
	Module 1	**11**
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
	Module 2	**11**
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	2

	flexural rigidity with different loading cases (Concentrated, uniformly distributed and uniformly varying).	
2.4	Slope and deflection of Overhanging beams having uniform and varying flexural rigidity with different loading cases (Concentrated, Uniformly distributed and uniformly varying).	2
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
	Module 3	**11**
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
	Module 4	**6**
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
	Module 5	**6**
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 ATHANASIUS 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

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

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

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

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

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

7. A simply supported beam of length L, supports a uniformly distributed load of intensity wkN/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 wkN/m over the whole length as shown in Fig. 1. Using 4 subintervals, estimate the deflection at pivotal points using 4^{th} order differential equations.

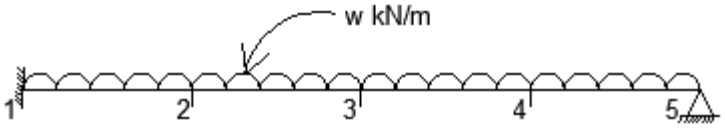

Fig. 1

9. A simply supported beam of length "L" span supports a uniformly distributed w kN/m over the mid $1/3^{rd}$ 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 rigidify. 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 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).

    a) Convert this into a two variable unconstrained optimization problem in *l* and *b.*

    b) Choose a suitable optimization technique to determine the optimal dimensions of the box. Take initial assumption as *l*=*b*=0.5m
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. **(Cognitive knowledge level: Understand)**
CO2	Apply concepts of elasticity in plane stress and plane strain conditions to solve problems in engineering contexts **(Cognitive knowledge level: Apply)**
CO3	Acquire a comprehensive understanding of axisymmetric problems, enabling them to analyze and evaluate complex engineering problems. **(Cognitive knowledge level: Evaluate)**
CO4	Apply the concepts of torsion in different structural configurations. **(Cognitive knowledge level: Apply)**
CO5	Apply theoretical concepts to solve practical engineering problems related to material behaviour and failure prediction. **(Cognitive knowledge level: Apply)**

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 Internal 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	3Hours

Continuous Internal Evaluation Pattern

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), θ (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- Yeilding 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
	Module 1	**8**
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
	Module 2	**10**
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

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
	Module 3	**9**
3.1	Introduction-Definition and significance of axisymetric 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
	Module 4	**9**
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
	Module 5	**9**
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

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Reg. No.:_____

Name:_____

MAR ATHANASIUS 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.

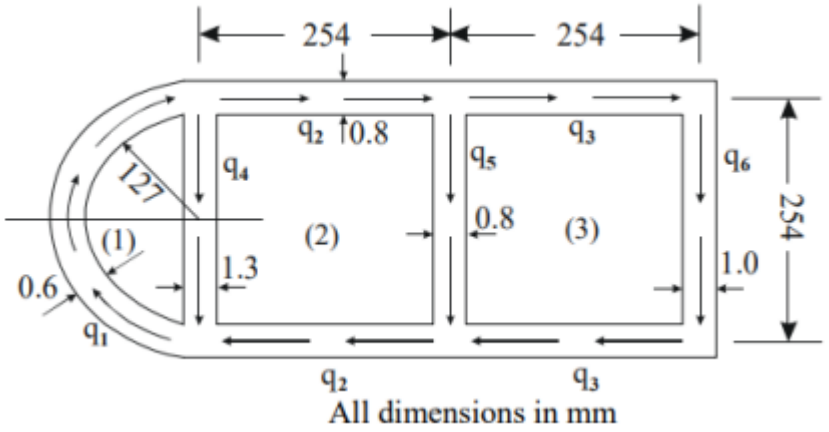

Fig:1

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.

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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. **(Cognitive Knowledge Level-Understand)**
CO2	Develop comprehensive skills in structural analysis using stiffness and direct stiffness methods. (**Cognitive Knowledge Level-Apply)**
CO3	Analyse the rigid and pin-jointed beams, frames and trusses using the flexibility method. (**Cognitive Knowledge Level-Analyse)**
CO4	Analyze the effects of axial force on the flexural stiffness of braced and unbraced beam-columns under axial compression. (**Cognitive Knowledge Level-Analyze)**
CO5	Evaluate the prismatic beam-columns using slope deflection method and stability functions. (**Cognitive Knowledge Level-Evaluate)**

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 Internal Evaluation Tests		End Semester Examination (%Marks)
	Test 1 (% Marks)	Test 2 (% Marks)	
Remember			
Understand	20		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

Continuous Internal Evaluation Pattern

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 StructuralAnalysis", Narosa Publishing House, 2009.
2. Devdas Menon,"StructuralAnalysis", 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/ Tutorial hours
	Module 1	**7**
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
	Module 2	**10**
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
	Module 3	**9**
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
	Module 4	**9**
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
	Module 5	**10**
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 ATHANASIUS 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.

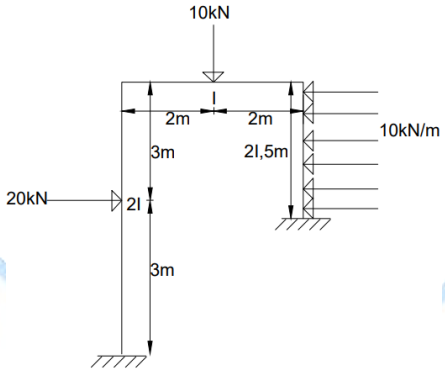
PART B

Answer any five questions. Each question carries 8 marks.

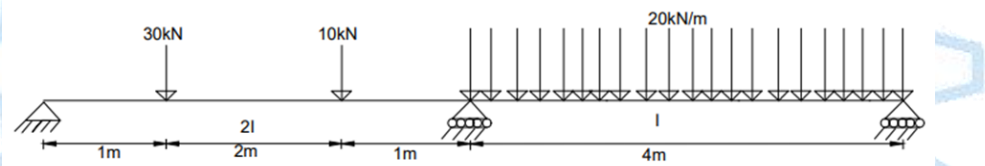
6. a. Elaborate how the member stiffness matrix concept is utilized in the analysis of complex structural systems. (4 Marks)

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

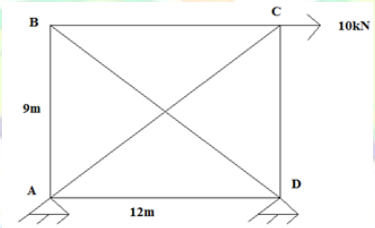
7. Analyze the structure using the element stiffness approach.



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**(Cognitive Knowledge Level: Apply)**
CO 2	Design suitable methodological approach that suits the research and formulate methods for data collection **(Cognitive Knowledge Level: Apply)**
CO 3	Analyse data and interpret results implementing statistical methods **(Cognitive Knowledge Level: Analyse)**
CO 4	Prepare well-structured technical presentations and technical reports **(Cognitive Knowledge Level: Apply)**
CO 5	Adopt methodologies for ethical and effective publication of research outcomes and to acquire intellectual property rights **(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	1	1
CO 2	1	1	2	1	1	1
CO 3	2	1	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 Internal 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, 46th 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/ Tutorial hours
	Module 1	**4**
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
	Module 2	**5**
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
	Module 3	**5**
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
3.4	Parametric and Nonparametric tests, Correlation and regression- Simple regression	2
	Module 4	**5**
4.1	Research Communication: Philosophy, Research Outlets -	1
4.2	Reporting and presenting research - Written and oral communications	1
4.3	Scientific Writing: Paper title, abstract and keywords,	2

	Introduction, Literature Review, Methods, Results, Findings, Discussion, Implication, Conclusion, Limitation, Future Studies, References, Bibliography, Annexure, Appendix, Tables and Figures, Citation, Reference styles	
4.4	Introduction to tools for document preparation	1
	Module 5	**5**
5.1	Relative importance of various forms of publication: Journal, Conference, Technical note	1
5.2	Reviewing process: Stages in the realization of a paper – Submission, Revision, Acceptance	1
5.3	Research metrics: Journal level, Article level and Author level	1
5.4	Research Ethics: Scientific misconduct, Plagiarism, Falsification, Tools for Plagiarism check.	1
5.5	Intellectual property rights : Copyright - Patents - Industrial Design - Trademarks - Geographical Design	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: **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
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

CO 1	Develop different grades of high-performance concrete mixes. **(Cognitive knowledge level: Apply)**
CO 2	Identify the failure mechanisms of RC structural members in flexure. **(Cognitive knowledge level: Apply)**
CO 3	Evaluate the material characteristics of existing structures using NDT methods. **(Cognitive knowledge level: Evaluate)**
CO4	To identify the corrosion in a reinforced concrete system. **(Cognitive knowledge level: Apply)**
CO 5	Evaluate the durability characteristics of the concrete. **(Cognitive knowledge level: Evaluate)**

Mapping of course outcomes with program outcomes

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

Mark distribution

Total Marks	CIE Marks	ESE Marks
100	60	40

Continuous Internal Evaluation Pattern

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, rebound hammer, and rebar locator
6	Corrosion measurements using half-cell potentiometer
7	Study of Autogenous and Drying shrinkage
8	Mix design for fiber-reinforced concrete and determination of fracture toughness.
9	Sorptivity test and water permeability test on concrete

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.

PROGRAMME ELECTIVE I

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. **(Cognitive knowledge level: Apply)**
CO 2	Analyze and design prestressed concrete structural members and sections subjected to flexure and shear **(Cognitive knowledge level: Analyze)**
CO 3	Analyze and design statically indeterminate prestressed concrete beams adopting suitable cable profiles. **(Cognitive knowledge level: Analyze)**
CO 4	Analyze composite prestressed concrete structural members and sections subjected to flexure and shear. **(Cognitive knowledge level: Analyze)**
CO 5	Apply the concept of prestressing in various members **(Cognitive knowledge level: Apply)**

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 Internal 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

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 (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/ Tutorial hours
	Module 1	**8**
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
	Module 2	**8**
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
	Module 3	**7**
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
	Module 4	**7**
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
	Module 5	**6**
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^3.
7. A beam 10m span having 200mm wide and 300mm deep is post tensioned with parabolic cable having an area of 320mm^2 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=2.1×10^5 MPa, E_c=3.5×10^4MPa 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}=5N/mm^2. f_{ck}=40N/mm^2 and cover to the tension reinforcement is 50mm. if the characteristic tensile strength of steel in stirrups is 250N/mm^2. 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.

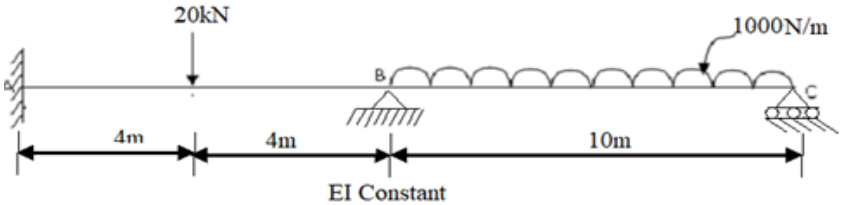


Figure 1

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 30kN/mm^2. If the differential shrinkage is 100x10^{-6} units, estimate the shrinkage stresses developed in the precast and cast in situ units.

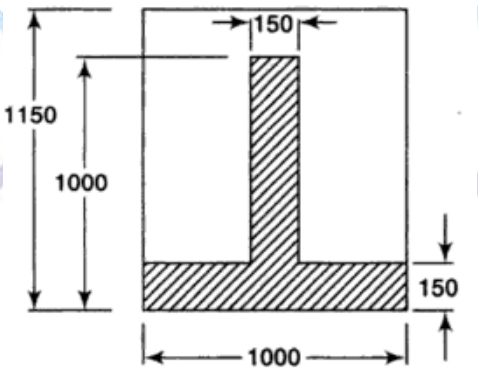


Figure 2

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 50N/mm^2. A prestressing force of 1055kN is applied by a single tendon symmetrically placed over a mild steel anchor of size 150mm x 200mm. Permissible bending stress for the bearing plate is 165 N/mm^2. There is no eccentricity of the tendon at the ends. Use Fe250 grade steel for reinforcement.

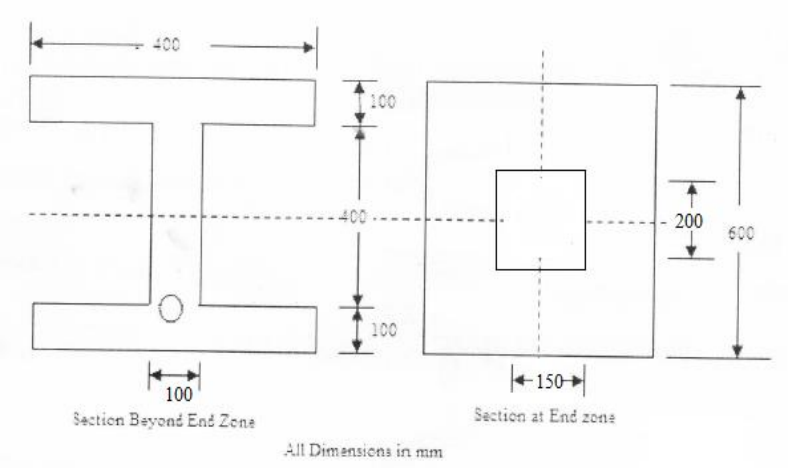


Figure 3

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

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

Assessment Pattern

Course Name	ANALYSIS AND DESIGN OF SUBSTRUCTURES		
Bloom's Category	Continuous Internal 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

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)

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-Borm'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 Sytems : Principles & Practices, Narosa

6. Pile Foundation Analysis and Design" by H.G. Poulos and E.H. Davis,1st Edition, 1980

7. Soil Mechanics and Foundation Engineering" by K.R. Arora,7th Edition, 2009

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No. of Lecture/ Tutorial hours
	Module 1	**7**
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
	Module 2	**7**
2.1	Pile foundation: Introduction- load carrying capacity - Settlement of single pile	2
2.2	Laterally loaded piles-Borm's method-Ultimate lateral resistance of piles	2
2.3	Structural design of straight piles and Structural Design of pile cap	3
	Module 3	**7**
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
	Module 4	**8**
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
	Module 5	**7**
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: 2

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 a 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^2. 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^3, angle of repose as 30˚, allowable bearing capacity of soil equals 150kN/m^2, 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 18kN/m^3 and its angle of repose is 30˚. The embankment is horizontal at its top. The safe bearing capacity of soil may be taken as 100kN/m3 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 ρ=500kN/m2, Outer diameter of the well, D=9.5m, thickness of steining, t=480mm, Downward force at base, W0=28000kN, Net bending moment at base, M0=49000kN-m and height of shaft, H=20m.
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

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

Assessment Pattern

Course Name	**FRACTURE MECHANICS**

Bloom's Category	Continuous Internal 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/ Tutorial hours
	Module 1	**7**
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
	Module 2	**9**
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
	Module 3	**8**
3.1	Introduction to Crack Tip opening Displacement(CTOD) Introduction to J Integral method- Equivalence between CTOD and J-	2

	integral.	
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
	Module 4	**6**
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
	Module 5	**6**
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: 1

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 MPa$\sqrt{m}$
   (b) Determine the critical crack size, and
   (c) Determine the critical crack load
   (Hint: f (α) = 1.12-0.231α + 10.55 α^2 – 21.71α^3 +30.38α^4)
10. Derive an expression relating G_1 and K_1.
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

CO 1	Conceive the fundamentals of cement, aggregates, admixtures, and concrete rheology **(Cognitive knowledge level: Understand)**
CO 2	Design concrete mixes emphasizing particle packing, durability, and strength as per the requirements in the field. **(Cognitive knowledge level: Apply)**
CO 3	Analyze the effects of water-cement ratio, time, and environmental conditions on concrete behavior, including creep, shrinkage, and fresh and hardened concrete properties. **(Cognitive knowledge level: Analyse)**
CO 4	Assess the durability performance of existing concrete structures through the application of non-destructive testing techniques **(Cognitive knowledge level: Evaluate)**
CO 5	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
CO 1	1	1	1	1	1	1
CO 2	3	1	2	3	2	
CO 3	2	1	3	2	1	
CO 4	1	1	2	1	2	2
CO 5		1	2	3	3	

Assessment Pattern

Course Name	**ADVANCED CONCRETE TECHNOLOGY**		
Bloom's Category	**Continuous Internal Evaluation 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	10	10	10
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 (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
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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/ Tutorial hours
	Module 1	**8**
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
	Module 2	**7**
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
	Module 3	**6**
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	1

	strength	
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
	Module 4	**7**
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
	Module 5	**7**
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.

6. What are admixtures in concrete and its classification? Briefly explain superplasticizers and its mechanism of action.
7. Mention the various steps involved in the high strength concrete mix design.
8. What are the transport mechanisms in concrete and describe any one test for each of the mechanisms.
9. In a congested reinforced concrete work which type of concrete will you prefer and why? Explain its mix proportioning, properties, advantages and disadvantages.
10. 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.
11. Why special concretes are needed and explain any three special concretes based on their application.
12. What is the durability of concrete? Describe the factors affecting the durability of concrete structures.

PROGRAMME ELECTIVE II

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 focuses 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

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

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Course Name	**STRUCTURAL DYNAMICS**	
Bloom's Category	**Continuous Internal 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

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)

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/ Tutorial hours
	Module 1	**7**
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
	Module 2	**9**
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
	Module 3	**7**
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
	Module 4	**6**

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
	Module 5	**7**
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 ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

FIRST SEMESTER M.TECH DEGREE EXAMINATION, DECEMBER 2024

Course Code: M24CE1E105A

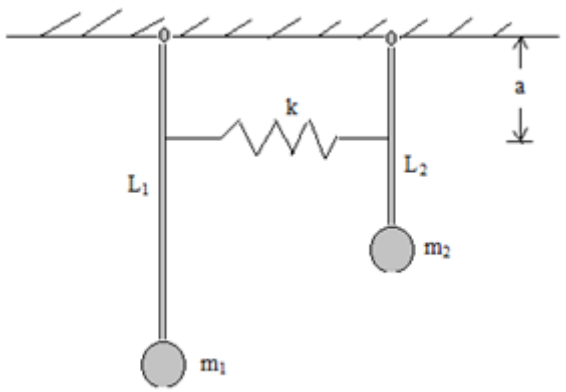
Course Name: STRUCTURAL DYNAMICS

Max. Marks: 60 Duration: 3 hours

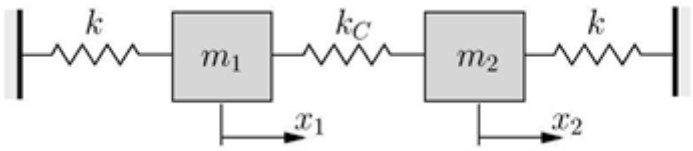
PART A

Answer all questions. Each question carries 4 marks.

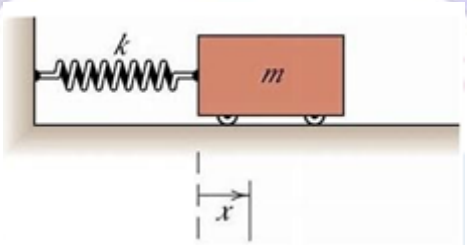
1. Calculate the natural frequency of transverse vibrations of a cantilever beam 40mm diameter circular cross section, carrying a load of 500N at the free end. Span of the cantilever is 800mm. E = 200GPa. If a spring of stiffness 52.75kN/m is introduced between the mass and the beam, calculate the change 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 ζ = 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 = 2.0kg, m_2 = 1.5kg, L_1 = 1.5m, L_2 = 1.0m, a = 0.5m, k = 150N/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 = 10kg, m_2 = 20kg, k = 1500N/m, k_c = 2000N/m.



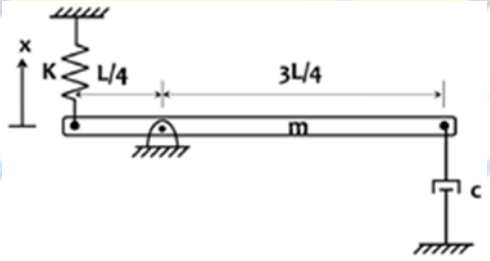
5. Obtain the equation of motion of a SDOF system shown in figure using Lagrange's equation. Take m = 10 kg and k = 5000N/m.



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 θ, the clockwise angular displacement of the bar from the system's equilibrium position, is used as a generalized coordinate. Assume small θ.



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 134kN, you noted down that the frame has displaced 0.76cm. On the first return swing after release, the frame did not come back to the release point but rather it stopped at 0.64cm towards it. You recorded time between the release and the first return as 2s. Determine the following;
    a. Weight of the frame
    b. Natural frequency

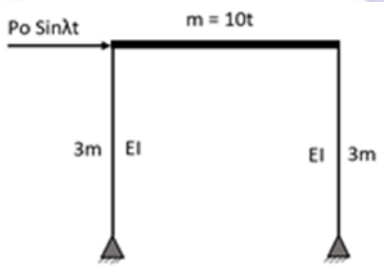
c. Logarithmic decrement

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 Po = 20kN, calculate the dynamic amplification factor and amplitude of steady state response for the following cases. (i) λ = 10rad/s, (ii) λ = 15rad/s, (iii) λ = 20rad/s. Comment on the results. Take ζ = 5% and EI = 1010kNmm^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

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

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	1	1
CO 2	1	1	1	2	2	1
CO 3	1	1	2	2	2	1
CO 4	2	1	2	2	2	1
CO 5	2	1	2	2	2	2

Assessment Pattern

Course Name	MECHANICS OF COMPOSITE STRUCTURES		
Bloom's Category	Continuous Internal 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 (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/ Tutorial hours
	Module 1	**6**
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
	Module 2	**7**
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
	Module 3	**10**
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	2

	nonlinearity,	
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
	Module 4	**7**
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
	Module 5	**6**
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 ATHANASIUS 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.

6. a. Discuss the historical development of composite structures and the key milestones that have led to their widespread use in structural engineering today.

   b. What are the key characteristics of composite materials, and how do they differ from traditional materials like steel and concrete?

   7. 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.

8. 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

9. Compare and contrast linear and nonlinear analysis techniques used for analyzing composite members, discussing their respective advantages and limitations in predicting structural behavior.

10. 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.

11. Design a composite slab system for a building with the following specifications: span = 6 meters, uniformly distributed load = 15 kN/m², 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.

12.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

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

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	2	1
CO 2	1	2	2	2	2	1
CO 3	1	2	2	2	2	1
CO 4	2	2	2	2	2	2
CO 5	2	2	2	2	2	1

Assessment Pattern

Course Name	**Advanced Design of Steel Structures**		
Bloom's Category	**Continuous Internal 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

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)

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 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/ Tutorial hours
	Module 1	**7**
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
	Module 2	**7**
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
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
	Module 3	**8**
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
	Module 4	**6**
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
	Module 5	**8**
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 ATHANASIUS 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 **(Cognitive Knowledge Level: Understand)**
CO 2	Analyze different materials utilising various macroscopic and microscopic techniques. **(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. **(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 Internal 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

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 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/ Tutorial hours
	Module 1	**6**
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
	Module 2	**8**
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	3

	principle	
2.4	Analysis of cementitious systems	3
	Module 3	**8**
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
	Module 4	**7**
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
	Module 5	**7**
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 ATHANASIUS 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.

SEMESTER II

BRANCH : Civil Engineering

SPECIALIZATION : Computer Aided Structural Engineering

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

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

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	2	2
CO 2	2	1	2	2	2	2
CO 3	2	1	2	2	2	2
CO 4	2	1	2	2	2	2
CO 5	2	1	2	2	2	2

Assessment Pattern

Course Name	Advanced Design of Concrete Structures		
Bloom's Category	Continuous Internal 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 defection, immediate and long-term defection, 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

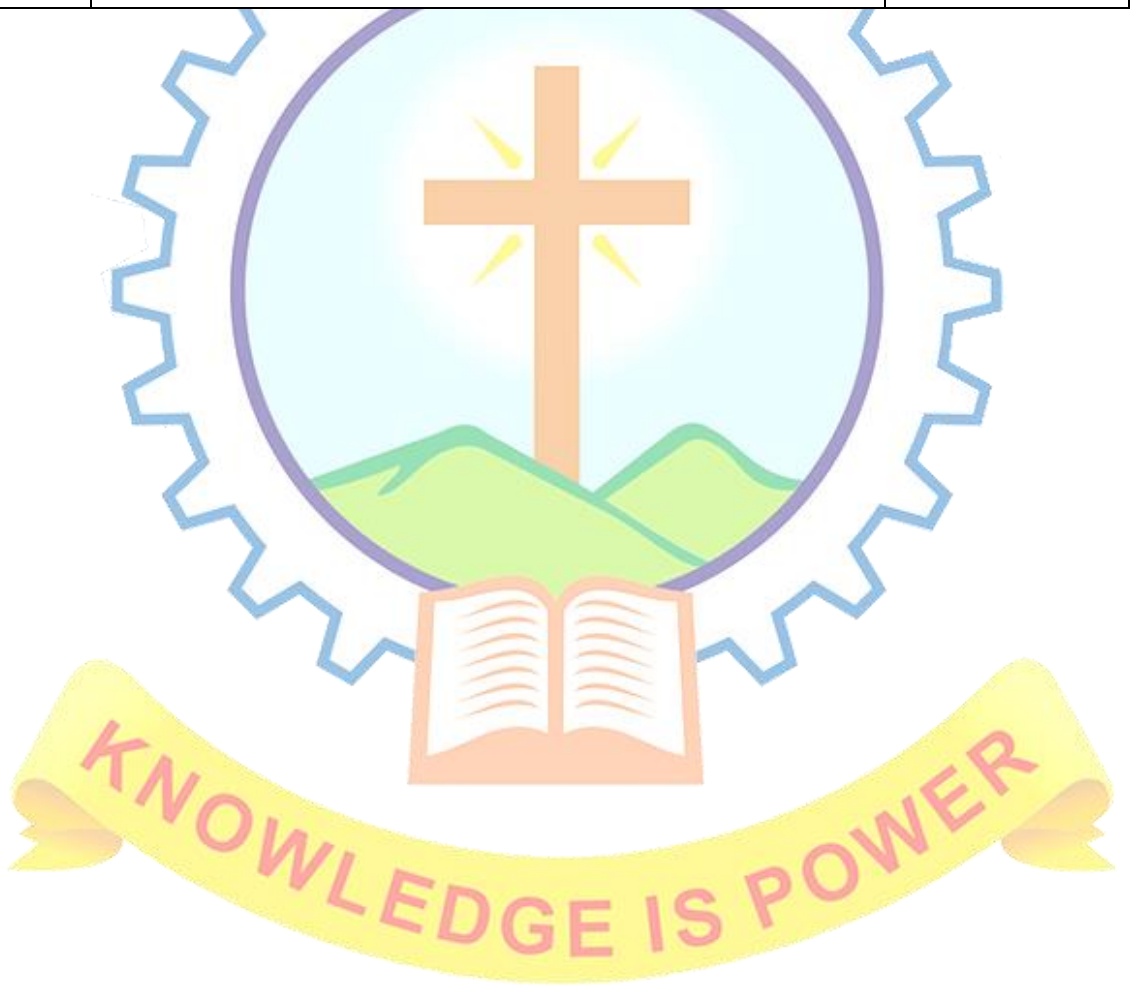
1. Pillai S. U. and Menon D., “Reinforced Concrete Design”, Tata McGraw-Hill (2016).
2. Arthur H. Nilson, David Darwin& Charles W. Dolan, "Design of Concrete Structures", Tata Mcgraw Hill, 2004
3. Park R. & Paulay T., "Design of Concrete Structures",John Wiley & Sons, NewYork, 1975

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 pvt.ltd, 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/ Tutorial hours
	Module 1	**10**
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
	Module 2	**9**
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
	Module 3	**8**
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
	Module 4	**8**
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 defection, control of cracking	1
4.5	Detailing for ductility	1
	Module 5	**10**
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: 3

Reg No.:_____

Name:_____

MAR ATHANASIUS 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-storyed 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^2

RCC Slab continues over the portal frame

SBC = 200 kN/m^2

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.

   a. using interaction charts

   b. using elastic stress distribution, design end portion 600mm length

   c. 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 N/mm^2 and f_y = 415 N/mm^2. L_0 = 7m L_{ex}(on major axis)= 6m,L_{ey}= on minor axis)= 5m. the ultimate moments t top M_x = 40kNm and M_y = 30 kNm , at bottom M_x = 22.5 kNm, M_y= 20kNm, P_u= 1500 kN. (4 marks)

8. a. A rectangular slab with a size of 3mx5m 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 12mx18m. The spacing of ribs in a mutually perpendicular direction is 1.5m c/c LL on the floor is 2kN/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)

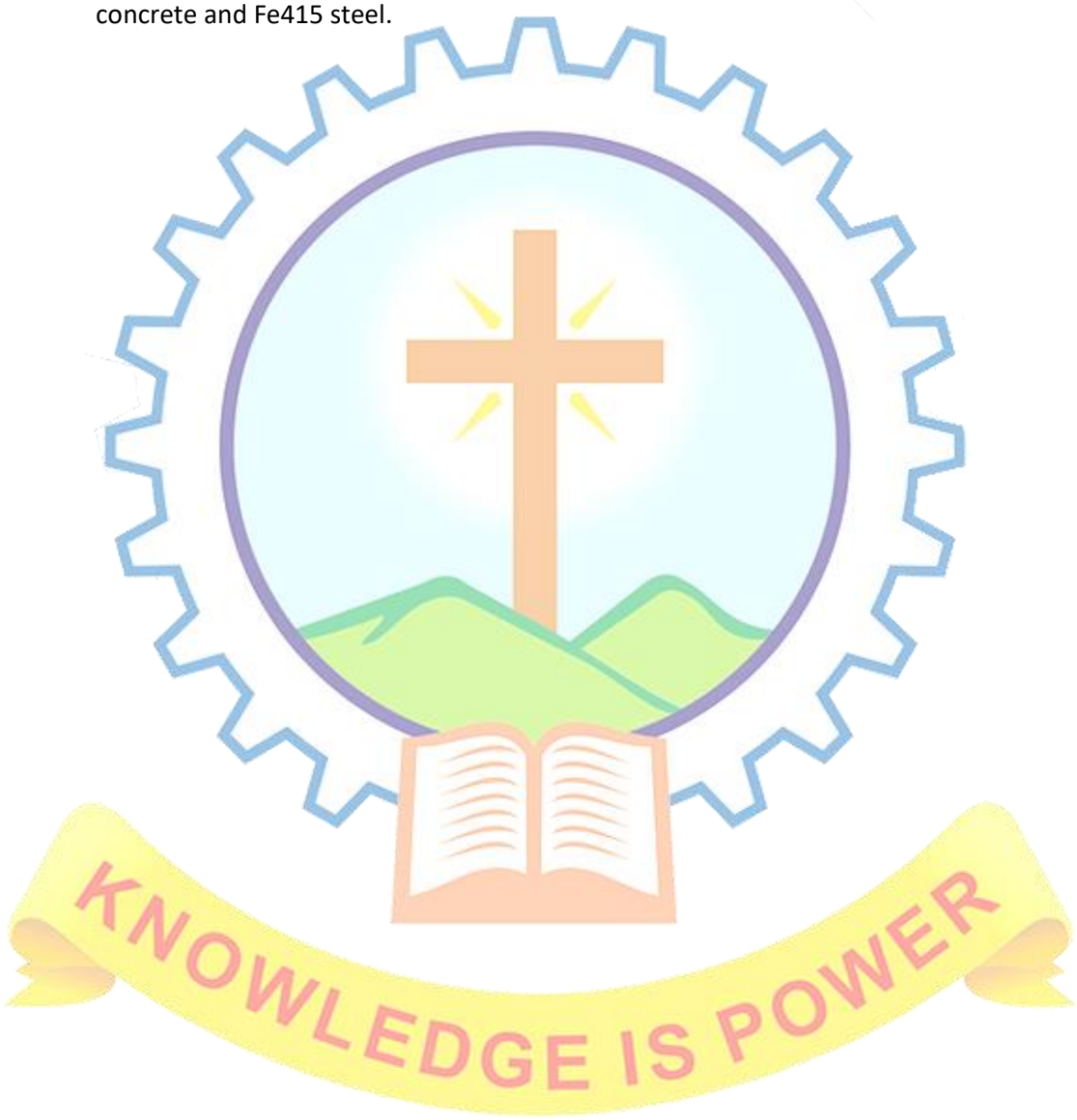
10. Design the interior panel of a flat slab with a panel size 5m×5m with drop and column head. It has to carry a live load of 4kN/m^2 and a floor finish load of 1kN/m^2. The column supporting the system is 450mm×450mm. Use M25 concrete and Fe415 steel and sketch the reinforcement details.

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. **(Cognitive Knowledge Level: Understand)**
CO 2	Analysis and design of earthquake-resistant structures. **(Cognitive Knowledge Level: Apply)**
CO 3	Analyze real-life structures using static and dynamic seismic analysis techniques to evaluate the seismic forces acting on them. **(Cognitive Knowledge Level: Analyze)**
CO 4	Apply construction techniques for earthquake resistance in masonry and reinforced concrete structure. **(Cognitive Knowledge Level: Apply)**
CO 5	Execute seismic response reduction, repair and rehabilitation techniques for existing buildings. **(Cognitive Knowledge Level: Apply)**

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 Internal 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 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", NewDelhi, India, 2021

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lecture/ Tutorial hours
	Module 1, Earthquakes and Response Spectrum	**9**
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
	Module 2 Earthquake Effects and Philosophy of Earthquake Resistant Construction	**9**
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
	Module 3 Design Seismic Force Computation	**10**
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
	Module 4 Ductility Aspects and Ductile Detailing	**7**
4.1	Ductility – significance in earthquake resistant design, Ductility factors.	2
4.2	Ductile detailing considerations as per IS:13920	3
4.3	Detailing of structural members & joints	2
	Module 5 Torsion and Shear Walls	**10**
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 ATHANASIUS 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 structures? Explain the retrofitting methods used for RC columns.

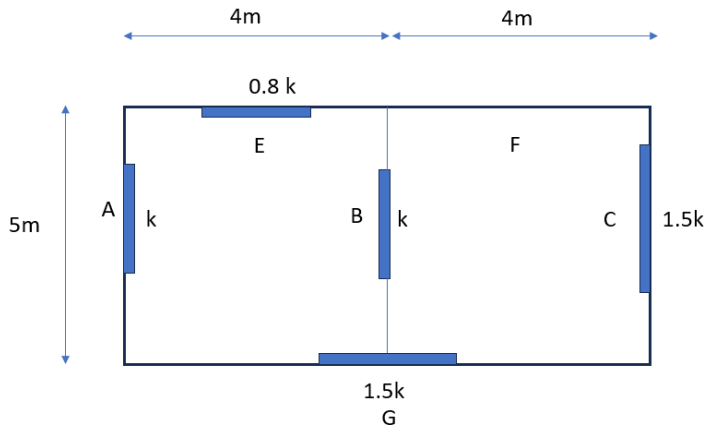
PART B

Answer any five questions. Each question carries 8 marks.

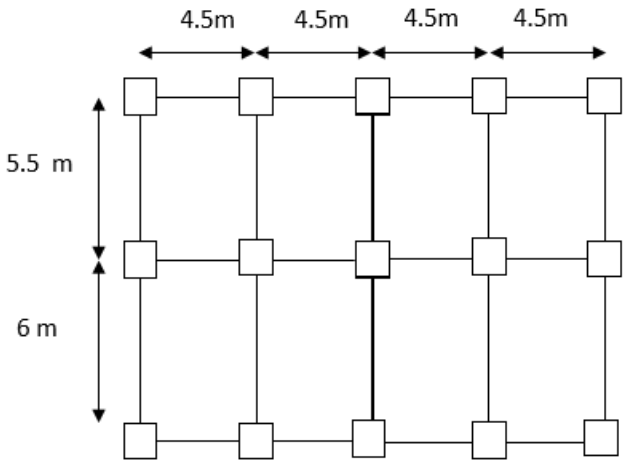
6. Explain the impact of different seismic waves on the structure during an earthquake.

7.How does a soft story influence the response of a structure during an 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^2 on floors and 8 kN/m^2 on roof. Assume a live load of 4kN/m^2 on floors and 1.5kN/m^2 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. (4 Marks)

    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. **(Cognitive Knowledge Level: Understand)**
CO 2	Analyse different data exchange models and standardize product data models for Interoperability and to understand the roles and responsibilities of stake holders **(Cognitive Knowledge Level: Analyse)**
CO 3	Develop a comprehensive BIM execution plan. **(Cognitive Knowledge Level: Create)**
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. **(Cognitive Knowledge Level: Apply)**
CO 5	Solve real life examples using advanced softwares.**(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	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 Internal 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**

Continuous Internal Evaluation Pattern :

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
	Module 1	**7**
1.1	Introduction to BIM - Ensuring BIM Model Quality through Model Checking Processes	1
1.2	- Understanding the Evolution of Building Information Modeling (BIM)	1
1.3	- Exploring the Transition from Traditional AEC Business Models to BIM	1

1.4	- Differentiating BIM from 3D and 2D Approaches-LOD- - Conceptualizing BIM as both a Product and a Process	1
1.5	- Emphasizing BIM as a Lifecycle Platform - 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
	Module 2	**7**
2.1	**Collaboration, Interoperability, and Roles** - 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
	Module 3	**7**
3.1	**BIM Execution Planning** - Developing a Comprehensive BIM Execution Plan (BEP) - 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
	Module 4	**7**
4.1	**Integrated Project Delivery (IPD)** - Understanding the Principles of Integrated Project Delivery (IPD)	1
4.2	- Cultivating Collaboration and Mutual Respect among Project	1

	Stakeholders	
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
	Module 5	**8**
5.1	**BIM Software Training** - 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: 1

M Tech in Computer Aided Structural Engineering

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 the 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	Marks	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	

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M24CE1L207	STRUCTURAL DESIGN STUDIO LAB	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. **(Cognitive Knowledge Level: Analyze)**
CO 2	Analyze and design steel Structures using ETABS/STAAD. **(Cognitive Knowledge Level: Analyze)**
CO 3	Develop structural detailing and design documents. **(Cognitive Knowledge Level: Apply)**
CO4	Model and conduct static analysis of structural elements/ whole structures using ANSYS/ABAQUS. **(Cognitive Knowledge Level: Analyze)**
CO 5	Model and conduct dynamic analysis of structural elements/ whole structures using ANSYS/ABAQUS. **(Cognitive Knowledge Level: Analyze)**

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

Continuous Internal Evaluation Pattern :

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.

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.

PROGRAMME ELECTIVE III

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

CO 1	Decide the structural form for a bridge depending on the functional requirements and site conditions. Identify various structural components of the chosen bridge form. **(Cognitive Knowledge Level: Understand)**
CO 2	Design various components of bridges based on relevant IRC and Indian railway loading standards. **(Cognitive Knowledge Level: Apply)**
CO 3	Design various components of T beam bridge. **(Cognitive Knowledge Level: Analyse)**
CO 4	Comprehend the design principles of long span bridges. **(Cognitive Knowledge Level: Evaluate)**
CO 5	Design bearings, piers and abutments for bridges. **(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	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	Design of Bridges		
Bloom's Category	Continuous Internal 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

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 (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 an D L Keo h, Bri e eck analysis, E& FN pon, 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/ Tutorial hours
	Module 1	**6**
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
	Module 2	**8**
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
	Module 3	**9**
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
	Module 4	**7**
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

	Module 5	**6**
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: 2

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:
   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. **(Cognitive Knowledge Level: Understand)**
CO2	Analyse the working of strain gauges and force transducers.**(Cognitive Knowledge Level: Analyse)**
CO3	Analyse the working of potentiometers and accelerometers.**(Cognitive Knowledge Level: Analyse)**
CO4	Analyse the properties of various materials under consideration utilizing different nondestructive testing techniques. **(Cognitive Knowledge Level: Analyse)**
CO5	Apply two-dimensional photoelasticity in analysing stress or strain and working of recording instruments like chart recorders and CROs.**(Cognitive Knowledge Level: Apply)**

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 Internal 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

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 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 locater- 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 – Polariscopes: 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

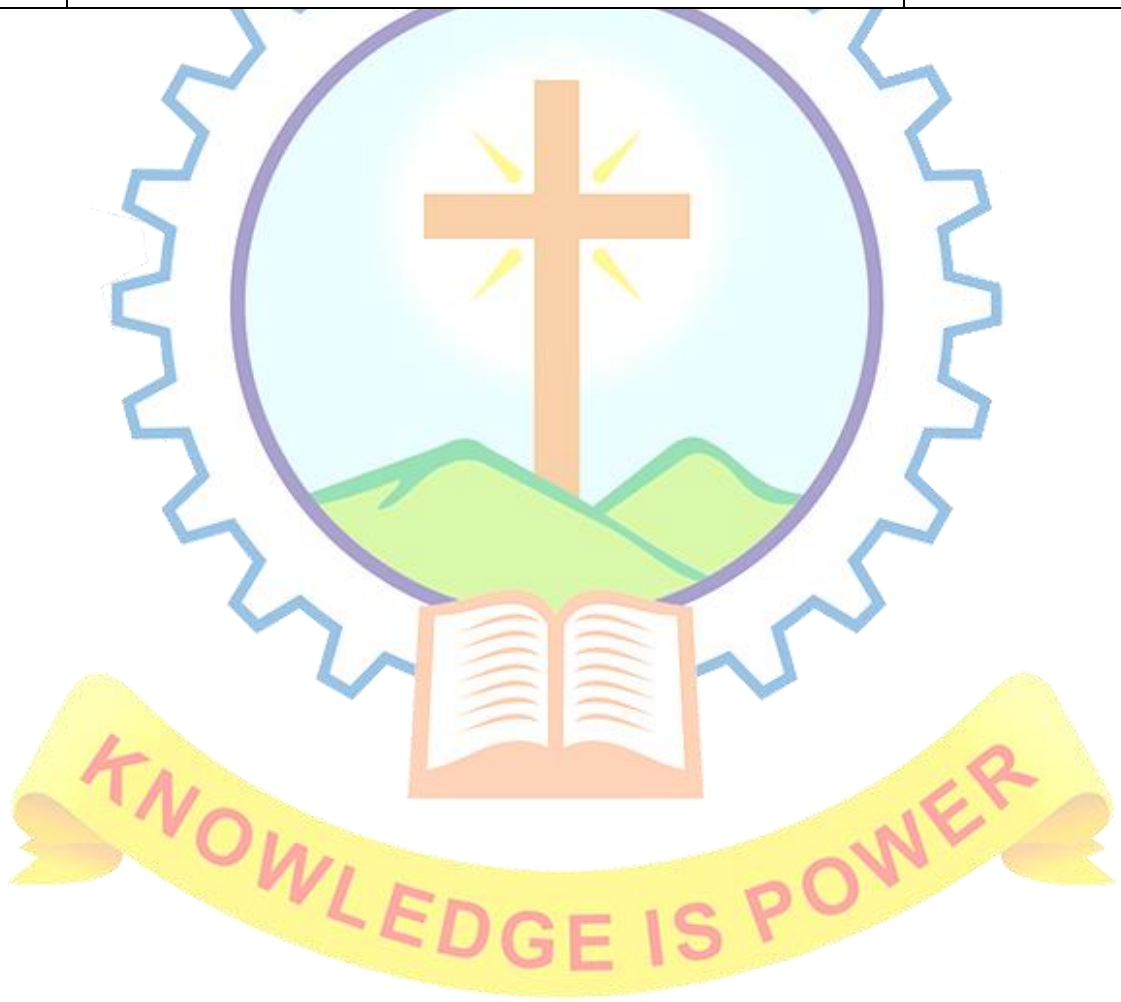
1. Bently JP - Principles of Measurement Systems – Longman, 1995
2. Nakra B. C. &Chaudhry - Instrumentation Measurement & Analysis - Tata McCraw Hill, 2004
3. Adams L F - Engineering Measurements and Instrumentation – English University Press, 1975
4. Doebelin E O - Measurement Systems Application & 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
	Module 1	**6**
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
	Module 2	**8**
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
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
	Module 3	**8**
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
	Module 4	**6**
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 locater	2
4.5	Errors in measurement: Systematic and Random - Uncertainties in measurement- Types; Normal Distribution - Confidence level- determination.	1
	Module 5	**8**

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 Iso chromatics – properties	1
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



M Tech in Computer Aided Structural Engineering

Model Question Paper

QPCODE: Pages: 1

Reg No.:_____

Name:_____

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

SECOND SEMESTER M.TECH DEGREE EXAMINATION, MAY 2025

CourseCode: **M24CE2E203B**

CourseName: **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

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

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	-
CO 2	1	1	1	2	2	2
CO 3	2	1	2	3	2	2
CO 4	1	1	2	3	2	2
CO 5	2	1	3	3	2	2

Assessment Pattern

Course Name	Structural Health Monitoring		
Bloom's Category	Continuous Internal 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 :

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/ Tutorial hours
	Module 1	**6**
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
	Module 2	**8**
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
	Module 3	**8**
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
	Module 4	**7**
4.1	Applications of SHM in Infrastructure	1
4.2	SHM applications in bridges: Monitoring strategies, sensors,	2

	and case studies	
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
	Module 5	**7**
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 ATHANASIUS 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

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

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		1
CO 2	2	1	1	1		1
CO 3	2	1	2	2	1	2
CO 4	2	1	2	2	2	1
CO 5	2	1	2	2	1	1

Assessment Pattern

Course Name	DESIGN OF TALL BUILDINGS		
Bloom's Category	Continuous Internal 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 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

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2. Bungale S Taranath, Structural Analysis and Design of Tall Buildings, Tata McGraw Hill,1988.
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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/ Tutorial hours
	Module 1	**6**
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
	Module 2	**6**
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
	Module 3	**8**
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
	Module 4	**10**
4.1	Dynamic Response Due to Wind and Earthquake-Wind Load: Sensitivity, Characteristics, Codal Provisions	1
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
	Module 5	**6**
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.:_____

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MAR ATHANASIUS 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.

PROGRAMME ELECTIVE IV

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

M Tech in Computer Aided Structural Engineering

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

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

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	1	2

Assessment Pattern

Course Name	**Finite Element Method**	
Bloom's Category	**Continuous Internal 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

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 (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/ Tutorial hours
	Module 1: Introduction to Finite Element Methods	**8**
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
	Module 2: Shape Functions	**7**
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
	Module 3: Displacement (stiffness) method in FEA	**8**

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
	Module 4: Isoparametric formulations and numerical integrations	**7**
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
	Module 5: Plate Bending Elements	**6**
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

Model Question Paper

QP CODE: Pages: 2

M Tech in Computer Aided Structural Engineering

Reg No.:_____

Name:_____

MAR ATHANASIUS 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 Galerkein'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. **(Cognitive Knowledge Level: Understand)**
CO 2	Apply solution techniques in solving plate problems. **(Cognitive Knowledge Level: Apply)**
CO 3	Evaluate symmetrical bending of circular plates and use the concept to analyse annular plates. **(Cognitive Knowledge Level:**analyse**)**
CO 4	Analyse the shell structures using membrane and bending theory. **(Cognitive Knowledge Level: Analyse)**
CO 5	Apply the principles of folded plate structures. **(Cognitive Knowledge Level: Apply)**

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 Internal 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

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 (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 or 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:

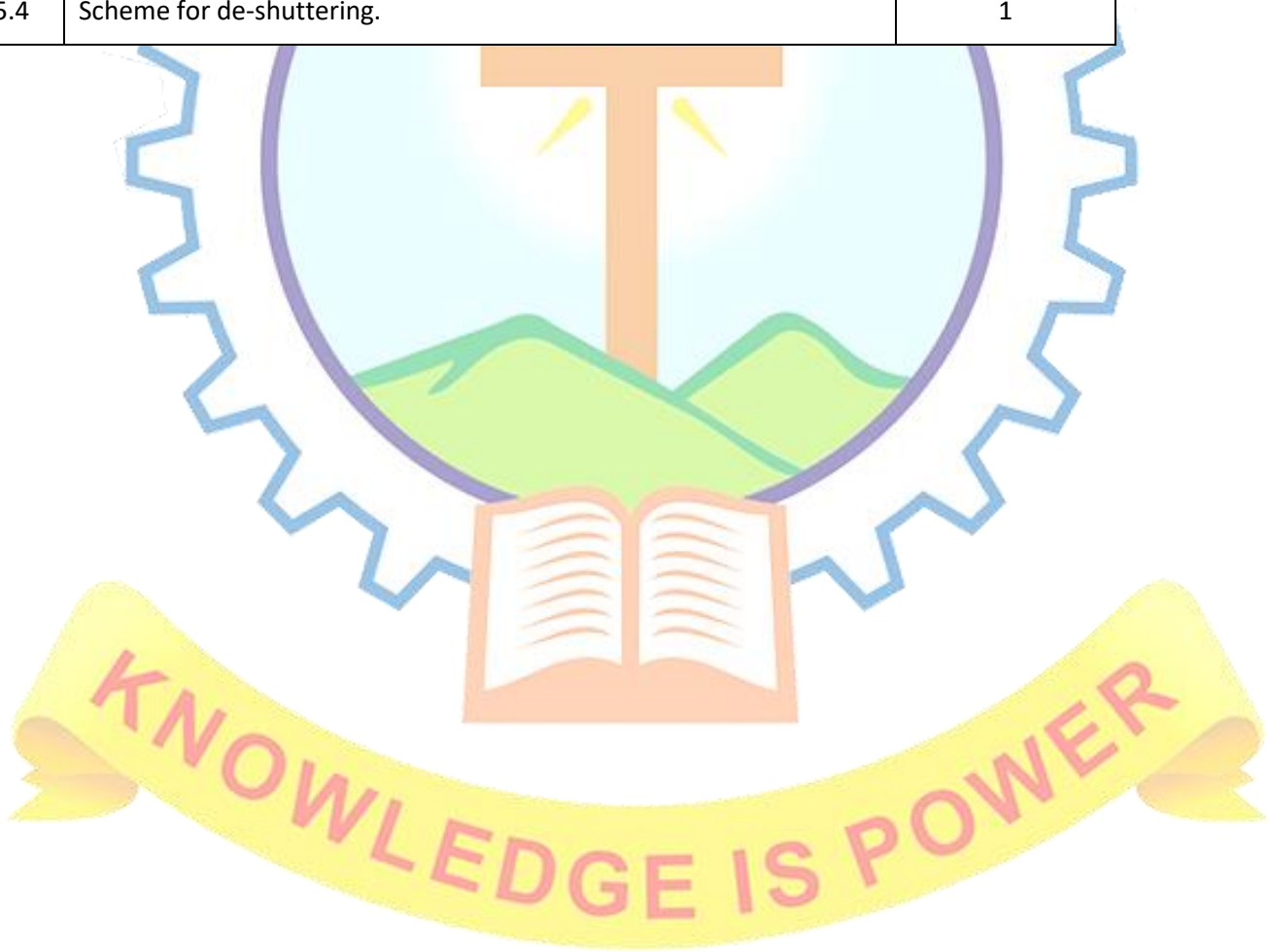
1. Timoshenko, S.P., and Krieger, S.W., Theory of Plates and Shells, McGraw Hill, 1987.
2. Ventsel, E., and Krauthammer, T., Thin plates and shells, Theory, Analysis and Applications,Marcel Dekker,Inc, New York, 2001.

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/ Tutorial hours
	MODULE 1	**5**
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
	MODULE 2	**10**
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
	MODULE 3	**7**
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

	MODULE 4	**7**
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
	MODULE 5	**7**
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

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MAR ATHANASIUS 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 Mx =My= 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 $q(x,y) = q_0 \, sin \, sin \, \frac{\pi x}{a} \, sin \, sin \, \frac{\pi y}{b}$, 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 IN CIVIL ENGINEERING 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

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

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	2	1	2	2	1	1
CO 3	2	1	2	2	1	1
CO 4	1	1	2	2	1	1
CO 5	1	1	2	2	1	1

Assessment Pattern

Course Name	FORENSIC ENGINEERING IN CIVIL ENGINEERING STRUCTURES		
Bloom's Category	Continuous Internal 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

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)

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/ Tutorial hours
	Module 1 Structural Failure Analysis	**7**
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
	Module 2 Distress Diagnosis and Assessment	**7**
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
	Module 3 Environmental Challenges and Natural Hazards	**7**
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

	Module 4 Retrofitting and Rehabilitation Techniques	**8**
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
	Module 5 Case Studies in Structural Failures	**7**
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 ATHANASIUS 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)

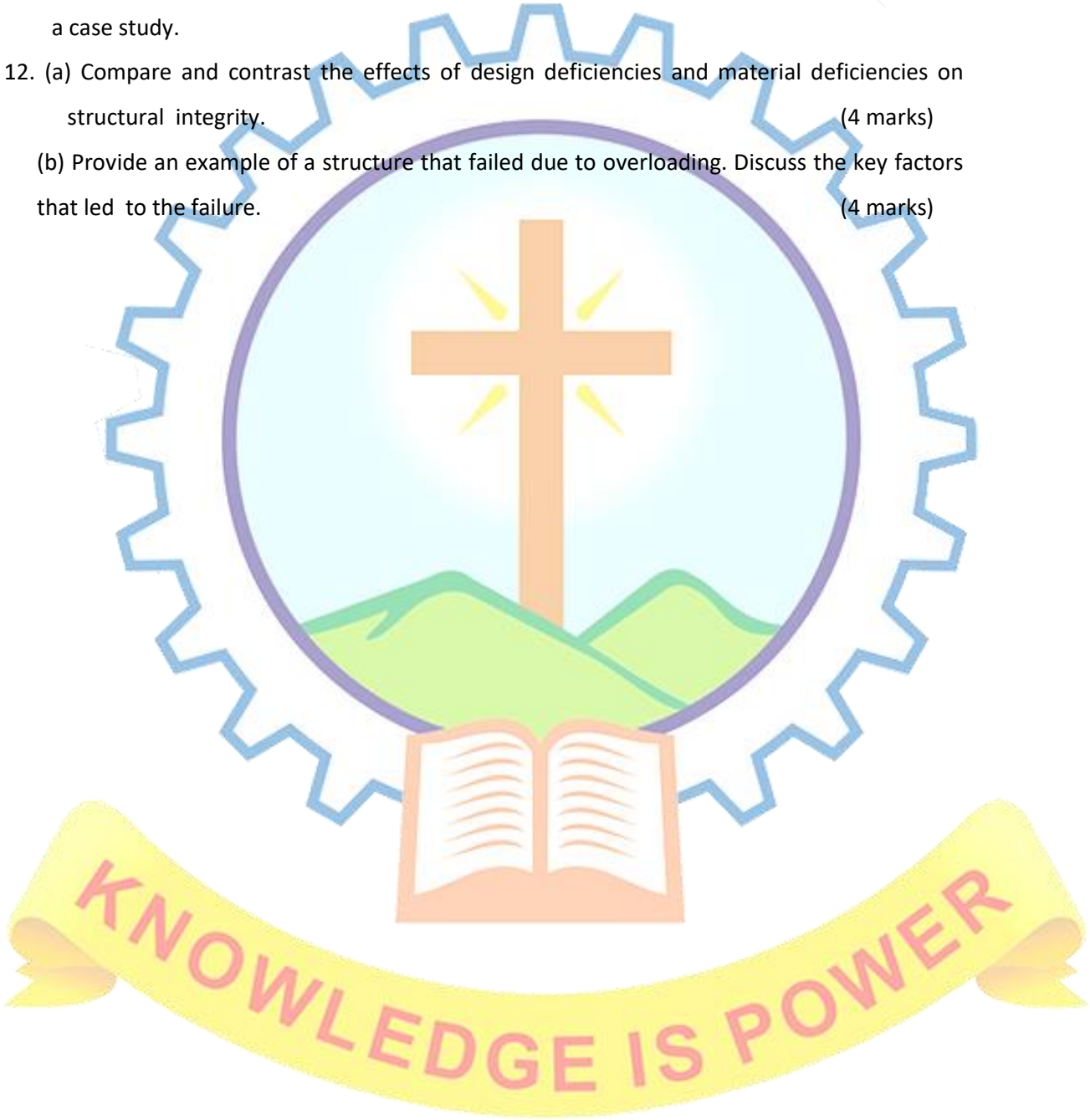
   (b) Explain the importance of durability considerations in the design and maintenance of RCC structures. (4 marks)

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. **(Cognitive Knowledge Level: Understand)**
CO 2	Analyze the design principles and load-bearing behavior of prefabricated concrete elements, including considerations for handling, erection and seismic loads. **(Cognitive Knowledge Level: Analyse)**
CO 3	Identify the types of structural connections in prefabricated systems and understand their design details. **(Cognitive Knowledge Level: Apply)**
CO 4	Plan and execute the logistics, transportation, site preparation and assembly of prefabricated elements and modular units, including the building services and finishes. **(Cognitive Knowledge Level: Apply)**
CO 5	Analyse the applications of prefabrication and modular construction in various types of structures through case studies. **(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	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 Internal 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

Continuous Internal Evaluation :

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, handing 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

OURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lecture/ Tutorial hours
	Module 1	**6**
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
	Module 2	**8**
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
	Module 3	**9**
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
	Module 4	**6**
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
	Module 5	**7**
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.


KNOWLEDGE IS POWER