VISVESVARAYATECHNOLOGICALUNIVERSITY

BELAGAVI

SchemeofTeachingandExaminations(2026)

M.Tech., in Civil Engineering

(SpecializationinStructuralEngineering)

Choice-BasedCreditSystem(CBCS)andOutcome-BasedEducation(OBE)

Specializationin–(StructuralEngineering)

II SEMESTER

Sl.No	Course	CourseCode	CourseTitle	Teaching&LearningScheme					Examination				Credits
				CI		LI	TW&SL	Total Hours	Duration in hours	CIEMarks	SEE Marks	Total Marks	
				L	T	P							
1	IPCC	1MCSE201 / 1MCCS201	StructuralDynamics	42	0	28	50	120	03	50	50	100	4
2	PCC	1MCSE202	AnalysisandDesignofAdvancedReinforced Concrete Structures	42	0	0	48	90	03	50	50	100	3
3	PCC	1MCSE203	AnalysisandDesignofAdvancedSteeland Composite Structures	42	0	0	48	90	03	50	50	100	3
4	PCC	1MCSE204 / 1MCAS204 / 1MCCS204	ContinuumMechanics	42	0	0	48	90	03	50	50	100	3
5	PEC	1MCSE205X	ProfessionalElective–III	42	0	0	48	90	03	50	50	100	3
6	PEC	1MCSE206X	ProfessionalElective–IV	42	0	0	48	90	03	50	50	100	3
7	PCCL	1MCSEL207	SoftComputingTechniquesinStructural Engineering Laboratory	0	0	28	02	30	03	50	50	100	1
8	PCC	1MCSES208	Minor Project/Skill DevelopmentProject	0	0	0	60	60	03	50	50	100	2
									Total	**400**	**400**	**800**	**22**

ProfessionalElectiveCourses(PECs)			
PEC-III		PEC-IV	
Code	Titleofthe Course	Code	TitleoftheCourse
1MCSE205A / 1MCAS205A / 1MCCS205A	FiniteElementMethodsinStructuralAnalysis	1MCSE206A / 1MCAS206B	ConstructionMaterialsandtheirProperties
1MCSE205B / 1MCAS205C	AdvancedStructuralAnalysis(NonlinearandStability)	1MCSE206B / 1MCAS206C / 1MCCS206A	AdvancedConstructionMaterialCharacterizationTechniques
1MCSE205C / 1MCCS205C	AnalysisandDesignofReinforcedConcreteBridges	1MCSE206C / 1MCAS206D / 1MCCS206C	DesignofPrecast and CompositeStructures
1MCSE205D	AnalysisandDesignofMasonryStructures	1MCSE206D / 1MCCS206D	AnalysisandDesignofPlatesandShells
1MCSE205E / 1MCCS205E	AdvanceddesignofPre-stressedConcreteStructures	1MCSE206E / 1MCAS206A	ComputationalStructuralMechanics
1MCSE205F / 1MCCS205F / 1MCAS205F	StructuralReliabilityAnalysisandDesign	1MCSE206F / 1MCAS206F / 1MCCS206F	FiberReinforcedPolymersandMechanicsofComposite Materials

STRUCTURALDYNAMICS			
Course Code	**1MCSE201 / 1MCCS201**	Scheme	2026
TypeofCourse	IntegratedProfessionalCoreCourses(IPCC**)**	Semester	II
TeachingHours/Week(L:T:P)	70(3:0:2)	CIEMarks	50
TotalHoursofPedagogyper SemesterCI(L/T):LI(P):TW&SL	120(42:0:28:50)	SEEMarks	50
Credits	4	TotalMarks	100
TypeofExamination(IPCC):	Theory-CIE+SEE,andLab-CIEonly.	Exam Hours	03

Courseoutcome (CourseSkillSet):

Attheendofthecourse,thestudentwillbeableto:

1. CO1L3-FormulatemathematicalmodelsforSingleDegreeofFreedom(SDOF)and MultiDegreeof Freedom (MDOF) systems.
2. CO2L4-AnalyzefreeandforcedvibrationresponsesofdampedandundampedSDOFsystemsunder harmonic and general excitations.
3. CO3L4-DeterminenaturalfrequenciesandmodeshapesofMDOFsystemsusinganalyticaland numerical methods.
4. CO4L5-Evaluatethedynamicresponseofshearbuildingsusingnormalmodesuperposition.
5. CO5L3-Applyapproximatemethods(Rayleigh's,Dunkerley's,Stodola's)andanalyzecontinuous systems like beams.

Module-1

Introduction&DynamicsofSDOFSystems

- Introductiontodynamic problems inCivil Engineering,Conceptof degrees offreedom,D'Alembert's principle, Principle of virtual displacement, Energy principles.
- Dynamics of SDOF systems: Mathematical modeling, Free vibration response of undamped and damped systems (under-damped, critically damped, over-damped), Methods for evaluation of damping (Logarithmic decrement).

LinkedCOs:CO1, CO2 **NumberofHours:8**

Module-2

ResponseofSDOFSystemstoHarmonic&GeneralLoads:

- Responsetoharmonicloading(Magnificationfactor,resonance,bandwidth),Supportmotion(Base excitation), Vibration isolation and Transmissibility.
- NumericalmethodsappliedtoSDOFsystems–Duhamelintegral(Impulseresponse).
- Principleofvibrationmeasuringinstruments–SeismometerandAccelerometer.

LinkedCOs:CO2 **NumberofHours:10**

Module-3

DynamicsofMultiDegreeofFreedom(MDOF)Systems:

- MathematicalmodelsofMDOFsystems,Shearbuildingconcept(2-Storeyand3-Storey).
- FreevibrationofundampedMDOFsystems–DerivationofEigenvalueproblem,Naturalfrequenciesand Mode shapes (Eigenvalues and Eigenvectors).
- Orthogonalityofmodes.

LinkedCOs:CO3 **NumberofHours:8**

Module-4

ForcedVibrationAnalysisofMDOFSystems:

- Responseofshearbuildings toharmonicloadingwithoutdampingusingnormalmodeapproach(Modal decomposition).

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- Responseofshearbuildings toforcedvibrationforharmonicloadingwithdampingusingnormalmode approach.

LinkedCOs:CO4 **NumberofHours:8**

Module-5

ApproximateMethods&DynamicsofContinuousSystems:

- **Approximate methods:**Rayleigh's method (Fundamental frequency), Dunkerley's method, Stodola's method (Iterative).
- **Dynamics of Continuous systems:** Flexural vibration of uniform beams with different end conditions (Simply supported, Cantilever), Derivation of governing differential equation. Stiffness matrix and Mass matrix (Lumped and Consistent mass matrices) for beam elements.

LinkedCOs:CO5 **NumberofHours:8**

PRACTICALCOMPONENTSOFIPCC(LI=28Hrs)

LISTOFEXPERIMENTS

Studentsshallperformpractical6-8exercisesrelatedto:

1. Determinationofnaturalfrequencyofacantileverbeam(Freevibrationtest).
2. Determinationofdampingratiousinglogarithmicdecrementmethod(Spring-masssystem).
3. ForcedvibrationresponseofSDOFsystem(Amplitudevs.Frequencyplottofindresonance).
4. Experimentalverificationofvibrationisolationandtransmissibility.
5. Modalanalysisofa2-storeyshearbuildingmodel(Experimentaldeterminationofnaturalfrequencies and mode shapes using FFT analyzer/sensors).
6. DevelopmentofaMATLAB/Pythonprogramtosolvefornaturalfrequenciesofa3-storeyshear building.
7. Numericalsimulation(usingMATLAB/OpenSees)ofa2-storeyshearbuildingunderharmonicloading to compute displacement response.
8. Parametricstudyofdampingeffectonmdofsystemresponseusingsimulation.
9. Determinationoffundamentalfrequencyofasimplysupportedbeamusing Rayleigh'smethod(Manual calculation + validation using FEM software).
10. ModalanalysisofacontinuousbeamusingANSYS/STAADPro(Extractionoffirst3modeshapes).

SuggestedLearningResources

TextBooks

1. Chopra,A.K.(2020).*DynamicsofStructures:TheoryandApplicationstoEarthquakeEngineering*. Pearson Education.Remote Sensing and GIS — OUP India, 3rd edition.
2. Clough,R.W.,&Penzien,J.(2013).*DynamicsofStructures*.Computers&StructuresInc.

ReferenceBooks/ Manuals

1. Humar,J.L.(2012).*DynamicsofStructures*.CRCPress.
2. Paz,M.,&Kim,Y.H.(2018).*StructuralDynamics:TheoryandComputation*.Springer.
3. Craig,R.R.,&Kurdila,A.J.(2011).*FundamentalsofStructuralDynamics*.Wiley.

WeblinksandVideoLectures(e-Resources)&Softwaretools

1. NPTELCourse:"StructuralDynamics"byProf.P.Banerjee,IITBombay: https://nptel.ac.in/courses/105101004
2. NPTELCourse:"DynamicsofStructures"byProf.ManishKumar,IITRoorkee.
3. YouTube:"StructuralDynamics"playlistbyDr.J.S.KalyanaRama,IITMadras.
4. OpenSeesWiki:https://opensees.berkeley.edu

Teaching-LearningProcess(InnovativeDeliveryMethods):

1. LecturewithChalk&Talk+PPTfortheoreticalderivations.
2. Tutorial/ProblemsolvingsessionsforSDOF/MDOFcalculations.
3. Simulation-basedlearningusingMATLAB/OpenSees/ANSYS.
4. Laboratorydemonstrationofshakingtableand FFTanalyzerformodeshapes.
5. Mini-projectonvibrationisolationorbaseisolation(OpenEndedExperiment).

AssessmentStructure(bothCIEandSEE)
TheweightageassignedtoContinuousInternalEvaluation(CIE)andSemesterEndExamination(SEE)shallbe 50%each.Astudentshallsecureaminimumof50%ofthemaximummarksprescribedforCIEandaminimum of40%ofthemaximummarksprescribedforSEEtobeeligibleforapassinthecourse.
Astudentshallbedeemedtohavesatisfiedtheacademicrequirementsandearnedthecreditsallottedtoa subject/course onlyifhe/shesecuresnotlessthan50%oftheaggregatemarksobtainedinCIEandSEEtaken together.

ContinuousInternalEvaluation:
(i) Theorycomponent
TheCIEmarksof25shallbeearmarkedfortwotests.
Thefirsttestshallbeconductedaftercompletingtwomodulesofthesyllabusandthesecondoneafter completing the rest three modules.
Eachtestshallbeconductedfor25marks.Theaverage ofthetwotestsscaleddownto25marksshallconstitute the test marks for a maximum of 25 marks.
(ii) Laboratorycomponent
Outof25marks,15marksshallbeassignedforassessmentofregularlaboratoryclassworkasperthe rubrics listed in Table - ICs/IPCCs1.
Theremaining10marksshallbebasedonthepracticaltestconductedbytwoInternalexaminersappointedby theHoD.Theallotmentofmarksshallbeasperthe rubricsdefinedforthepracticaltestasindicatedinthe Table – ICs/IPCCs 1.
Toqualifyand becomeeligibletoappearforthe SEEoftheIC/IPCC,astudentshallsecureatleast13marksout of25intheCIEtheorycomponent,andatleast12marksintheCIEPracticalcomponent.

Table–ICs/IPCCs1Distributionofmarkscorrespondingtolaboratorycomponent

Component	Description	Marks
Allotmentofmarksforregularclasswork		
AbilityinConducting Experiments	Initiative,skill,safetypractices,teamwork,and independenthandlingofequipmentduringregularlab sessions.	5 marks
LaboratoryRecord/ Journal	Regularandneatmaintenanceoflabrecord,accuracyof results, and timely submission.	10 marks
Subtotal		15
AllotmentofmarksforCIEpracticaltest		
LaboratoryTest/ Experiment Performance	Abilitytosetupapparatus,followprocedure,take observations,andobtaincorrectresultsinthetest experiment.	5 marks
Viva-Voce	Understanding of theory, concepts, and experimental procedure;abilitytoexplainresultsandanswerrelated questions.	5 marks
Subtotal		10
Total		25

Students'activitiesforTW/SLunderNCrF:
AsperNationalcreditframework(NCrF)studentsmustspend120hoursofstudyfor4creditcourses,which includeCourseinstructions(CI-70hour)andTeamwork/Selflearning(TW/SL-50hours).Hence,studentsmust completeminimumof twoactivitiesaspartofNCrF.The evaluation activitieswillbedoneusingsetof rubrics

developedforeachactivity.Thefollowingsampleactivitiesarelistedbelow.Thecoursecoordinatorcanalso designlearningactivitiesbasedoncourseoutcomes.		
Sl. No.	**TermWork(TW)Activity**	**NumberofHours/Semester**
1	**TW Activity 1 — Experimental modal identification of anSDOFstructure:** Studentsformteams(3–4).Buildoruse an SDOF lab rig (mass-spring-damper or cantilever beam + tip mass), excite by impulse or shaker, record time-history using accelerometer/DAQ, compute frequency response and identifynaturalfrequencyanddamping(logdecrementand curvefitting).Compareexperimentalvaluestoanalytical predictionsandprovideashortreportandoralpresentation	24
2	**TW Activity 2 — Forced vibration and frequency response function (FRF) measurement of a MDOF frame:** Teams testa small framed model (2-DOFor3-DOF) on a shaker or with harmonic excitation using a tone generator, record response, compute FRFs, and validate modelpredictionsusingmodalsuperposition.Producea technicalreportandashortdemonstration.	24
3	**TWActivity3-Micro-project:**Designandfabricationofa small-scaleTunedMassDamper(TMD)foracantilever beam to mitigate vibration.	24
4	**TW Activity 4 - Industrial Visit / Expert Lecture:**Visitto a vibration testing laboratory on "Structural Health MonitoringusingDynamicCharacteristics".Reportshould besubmittedattheendalongwithlearningoutcomes.	24
SL:SelfLearning,MOOCs,spokentutorials,onlineeducationalresourcesetc.		
Sl. No.	**Self-Learning(SL)Activity**	**NumberofHours/Semester**
1	NPTELCourse:Enrollin"StructuralDynamics"by Prof.P.Banerjee,IITBombay(NPTEL).Completemodules on SDOF, MDOF, and earthquake response.	24
2	SWAYAM Course:"DynamicsofStructures"by Prof. ManishKumar,IITRoorkee.Completecertification.	24
3	Online Tutorials: Self-paced learning of MATLAB/OpenSees for dynamic analysis (YouTube/edX).Attheendstudentsneedto demonstratewithacasestudy	24

SamplerubricsforTWactivities:

Criteria	4-Excellent	3-Good	2-Satisfactory	1 - Needs Improvement
Concept understanding	Demonstrates clear understandingofthe transportGIS problem,objectives, and workflow.	Shows good understanding withminorgaps.	Basic understanding with limited clarity.	Understandingisweak orincorrect.
Taskcompletion	Activityiscompleted fully, correctly, and	Activityismostly complete with	Activityis partially	Activityisincomplete ormissing.

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Criteria	4-Excellent	3-Good	2-Satisfactory	1 - Needs Improvement
	ontime.	minoromissions.	complete.	
Technical accuracy	GISlayers, maps, or analysisarecorrect, properlyprocessed, and well justified.	Mostly correct with few technicalerrors.	Contains noticeableerrors butshowspartial correctness.	Majortechnicalerrors or no meaningful attempt.
Datahandling andworkflow	Uses data systematically, follows proper workflow,and maintainsgood map/database structure.	Workflowisclear with minor gaps.	Workflowis incompleteor inconsistently followed.	Poor workflow and weakdatahandling.
Interpretation and analysis	Provides strong interpretation of spatialresultsand transport implications.	Givesreasonable interpretation with some analysis.	Interpretationis briefand descriptive.	Interpretation is minimalorabsent.
Presentation and documentation	Work is neat, well structured, and easy tofollowwithproper maps, legends, and notes.	Organizedwell with minor formatting issues.	Acceptable presentationwith several issues.	Poorlyorganizedor difficult to read.

SamplerubricsforSelf-Learningactivities:

Criteria	4-Excellent	3-Good	2-Satisfactory	1-NeedsImprovement
Concept understanding	Demonstratesclear and accurate understanding of the assigned concept.	Shows good understanding withminorgaps.	Basic understanding with limited detail.	Understandingisweak orincorrect.
Independent learning	Exploresbeyondthe minimum requirementand shows initiative in learning.	Shows good initiative with someadditional effort.	Completes the assignedtaskwith limited exploration.	Relies heavily on guidanceorshows little effort.
Task completion	Activity is completed fully, correctly,andon time.	Activityismostly complete with minoromissions.	Activity ispartiallycomplet e.	Activityisincomplete ormissing.
Technical accuracy	Workflow,tooluse, or analysis is correct and well justified.	Mostly correct with few technicalerrors.	Contains noticeableerrors butshowspartial correctness.	Majortechnicalerrors or no meaningful attempt.

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Criteria	4-Excellent	3-Good	2-Satisfactory	1-NeedsImprovement
Reflectionand analysis	Provides strong reflection, interpretation,and learningoutcomes.	Givesreasonable reflectionwith some analysis.	Reflectionisbrief and descriptive.	Reflectionisminimal orabsent.
Presentation and organization	Work is neat, well structured,andeasy tofollow.	Organized well with minor formattingissues.	Acceptable presentationwith several issues.	Poorlyorganizedor difficult to read.

SuggestedrubricsforPracticalcontinuousassessment:

Performance Indicators	Excellent	VeryGood	Good	Satisfactory
Fundamental Knowledge(4) (PO1)	Thestudenthaswell depth knowledge of construction planning, BIM-enabled 4D/5D workflows, project controls and site logistics.(4)	Student has good knowledgeofsome topics related to construction planning and BIM workflows. (3)	Studentiscapable of narrating the answer but not capable to showindepth knowledge. (2)	Student has not understood the conceptsclearly.(1)
DesignOf Experiment(5) (PO2 & PO3)	Studentiscapableof discussing morethan one planning workflow/designfor the problem statementand selecting the best suitable approach with proper reason. (5)	Student is capable ofdiscussingafew workflowsbutnot fully capable of selecting the best. (4)	Studentiscapable of discussing a single planning workflowwith merits and demerits. (3)	Student can explain the planning/design approachonlypartly. (1-2)
Implementation (8)(PO3&PO8)	Studentiscapableof implementing WBS, schedule logic, model linkage, resource mapping and issue tracking with an optimal and traceable workflow. (7-8)	Studentiscapable ofimplementing the workflow and explaining it with minor gaps. (5-6)	Studentiscapable ofimplementing the workflowwith partial explanation.(3-4)	Student can implementonly limitedpartsofthe workflow.(1-2)
Result&Analysis (5)(PO4)	Student is able toruntheworkflowfo r various cases and compare 4D sequence, resource, progress and logisticsresultswith properanalysis.(5)	Student will be able to run the workflowforall the cases. (4)	Studentwillbe abletorunthe workflowfora few cases and analyze the output. (3)	Studentwillbeable toruntheworkflow but not able to analyze the output. (1-2)

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Demonstration (8)(PO9)	The lab record/portfolio is wellorganized,with clear sections such as brief, method, WBS,schedule, model QA, 4D output, resource sheet, issue log, results and conclusion.(7-8)	The lab record/portfoliois organized, with clear sections, but some sections are not well-defined. (5-6)	The lab record lacks clear organization or structure. Some sections are unclearor incomplete.(3-4)	The lab record is poorly organized, with missing or unclearsections.(1-2)

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ANALYSISANDDESIGNOFADVANCEDREINFORCEDCONCRETESTRUCTURES			
Course Code	**1MCSE202**	Scheme	2026
TypeofCourse	**ProfessionalCoreCourse**	Semester	II
TeachingHours/Week(L:T:P)	42(3:0:0)	CIEMarks	50
TotalHoursofPedagogyper SemesterCI(L/T):LI(P):TW&SL	90(42:0:0:48)	SEEMarks	50
Credits	3	TotalMarks	100
TypeofExamination(IPCC):	Theory	ExamHours	03

Courseoutcome (CourseSkillSet):

Attheendofthecourse,thestudentwillbeableto:

1. CO1:Explainthebehavior,analysisprinciples,anddesignphilosophyofadvancedreinforcedconcrete structural systems.
2. CO2:AnalyzeanddesignRCmembersandstructuralcomponentsconsideringstrength,serviceability, and ductility requirements.
3. CO3:ApplyadvancedanalyticalmethodsforindeterminateRCstructures,slabs,frames,andcore systems.
4. CO4:DesignRCstructuralelementsanddetailingsystemsforpracticalbuildingapplicationsin accordance with codal provisions.
5. CO5:Evaluateloadcombinations,stability,robustness,durability,andconstructabilityinRCstructural design.
6. CO6:Preparecomprehensivedesigncalculations,structuraldrawings,anddetailingnotessuitablefor industry practice.

Module-1

AdvancedRCDesignPhilosophyandLoadAnalysis:

Behavior of reinforced concrete under flexure, shear, axial load, and combined actions; limit state design approach; materialstress-strainmodels;partialsafetyfactors;loadcombinationsandserviceabilitycriteria;introductionto codal provisions relevant to advanced RC design; structural idealization for analysis; load paths in buildings; gravity and lateral load assessment; concept of robustness and redundancy in RC structures.

LinkedCOs:CO1,CO3,CO5 **NumberofHours:08**

Module-2

AnalysisandDesignofAdvancedBeamsandSlabs:

Analysis of singly and doubly reinforced beams; flanged beams and deep beams; shear, torsion, and combined action;span-to-depthcontrolanddeflectionchecks;designofcontinuousbeamsandredistributionconcepts;one-way and two-way slabs; flat slabs and flat plates; punching shear; design for serviceability, crack control, and durability; detailing requirements for constructability and long-term performance.

LinkedCOs:CO2,CO4,CO6 **NumberofHours: 09**

Module-3

Columns,ShortandSlenderMembers,andRCFrames:

Analysisofshortandslendercolumnsunderuniaxialandbiaxialbending;interactiondiagrams;effectivelengthand stability; column design under axial load with moments; design of RC beam-column joints; analysis and design of moment-resisting frames; concept of strong column-weak beam design; ductility and confinement requirements; detailing of reinforcement in frames for seismic and non-seismic applications.

LinkedCOs:CO1,CO2,CO4,CO5 **NumberofHours:09**

Module-4

AdvancedStructuralSystemsinRCBuildings:

Analysisanddesignprinciplesofshearwalls,coupledshearwalls,corewalls,liftwalls,andtransfergirders;RC staircasesandspecialstructuralcomponents;designofpilecapsandcombinedfootings;matfoundationsandraft systems;designconsiderationsforbasementsandpodiumslabs;structuralcontinuity,loadtransfer,anddifferential

settlementeffects;introductiontoanalysisusingstructuralsoftwareandvalidationofresultsbyhandchecks.

LinkedCOs:CO2,CO3,CO4,CO6 **NumberofHours:09**

Module-5

DesignIntegration,Detailing,andIndustryPractice:

Design optimization and economy in RC structures; durability, fire resistance, corrosion protection, and sustainabilityinRCdesign;constructionsequenceandstagingeffects;coordinationwitharchitecturalandMEP systems;drawingpreparation, barbendingschedules,andreinforcement detailing; qualityassuranceindesign output; review of real building cases and failure lessons; introduction to BIM-enabled structural coordination and digital deliverables in professional practice.

LinkedCOs:CO4,CO5,CO6 **NumberofHours:07**

SuggestedLearningResources:

Textbooks

1. KrishnaRaju,N.,AdvancedReinforcedConcreteDesign,CBSPublishers.
2. Pillai,S.U.andMenon,D.,ReinforcedConcreteDesign,McGraw-Hill.
3. Varghese,P.C.,AdvancedReinforcedConcreteDesign,PHILearning.
4. Punmia,B.C.,Jain,A.K.,andJain,A.K.,ReinforcedConcreteStructures,LaxmiPublications.

ReferenceBooks

1. Park,R.andPaulay,T.,ReinforcedConcreteStructures,Wiley.
2. MacGregor,J.G.andWight,J.K.,ReinforcedConcrete:MechanicsandDesign,Pearson.
3. Nilson,A.H.,Darwin,D.,andDolan,C.W.,DesignofConcreteStructures,McGraw-Hill.
4. ACI/relevantdesignguidesandcodaldocumentsasapplicableNilson,A.H.,Darwin,D.&Dolan,C.W.– DesignofConcreteStructures,TataMcGrawHill,2004.

WeblinksandVideo Lectures(e-Resources):

1. NPTEL/SWAYAMcoursesonreinforcedconcretedesignandstructuralanalysis.
2. Relevantcodalprovisionsandofficialtechnicalguidelines.
3. Structuraldesigncasestudiesandindustrydesignmanuals.

Teaching-LearningProcess(InnovativeDeliveryMethods):

Thefollowingaresamplestrategiesthateducatorsmayadopttoenhancetheeffectivenessoftheteaching-learning processandfacilitatetheachievementofcourseoutcomes.SuggestedInnovativeDeliveryMethodsmayinclude(but are not limited to):

- FlippedClassroom
- Problem-BasedLearning(PBL)
- Case-BasedTeaching
- SimulationandVirtualLabs
- PartialDeliveryofcoursebyIndustryexpert/industrialvisits
- ICT-EnabledTeaching
- RolePlay

AssessmentStructure(bothCIEandSEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/courseonlyifhe/shesecuresnotlessthan50% oftheaggregatemarksobtainedinCIEandSEEtaken together.

ContinuousInternalEvaluation:

ContinuousComprehensiveAssessments(CCA)+InternalAssessmentTest(IA)=ContinuousInternal Evaluation

CIE [25+25=50 marks]

AminimumoftwoInternalAssessmentTests(IA)shallbeconducted.Eachtestshallbeconductedforamaximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.

Inaddition,ContinuousComprehensiveAssessment(CCA)shallbeconductedforatotalof25marks

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Students'activitiesforTW/SLunderNCrF:Samplesonly

AsperNationalcreditformwork(NCrF)studentsmustspend90hoursofstudyfor3creditcourses,whichinclude Courseinstructions(CI-42hour)andTeamwork/Selflearning(TW/Sl-48hours).Hence,studentsmustcomplete minimum of two actives as partof NCrF. These learningactivities shall beconsidered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities arelisted below. Thesample activities aregivenbelow. The course coordinatorcanalso givetheir own TW/SLactivitiesasperthecourseoutcomes.

Sl. No.	TermWork(TW)Activity	NumberofHours/ Semester
1	**TW-1**: Detailed design and drawing set for a continuous two-storey RC frame bay including beam, slab and column designs, reinforcement schedules and bar bending schedule; hand calculations + ETABS model printouts.	24
2	**TW-2:**Strut-and-tiemodelanddesignreportfora deep beam/corbel or discontinuity region including checks for local failure and detailing.	24
3	**TW-3:**Flatslabpunchingsheardesignandreinforcementlayout including column head detailing and moment redistribution study	24
SL:SelfLearning,MOOCs,spokentutorials,onlineeducationalresourcesetc.		
Sl. No.	**Self-Learning(SL)Activity**	**NumberofHours/ Semester**
1	**SL-1**:Casestudy:forensicanalysisofarealRCstructurefailureorretrofit project; prepare cause, remedial measures and lessons learned	24
2	**SL-2**:MOOCmodule+assessmentonadvancedRCtopics(selectNPTEL or international equivalent) and reflection report	24
3	**SL-3:**Literaturereviewandshortpresentationon FRPstrengtheningor externalprestressingforRCrehabilitation	24

SamplerubricsforTWactivities:

Criteria	4-Excellent	3-Good	2-Satisfactory	1 - Needs Improvement
Problem understanding	Clearproblem framing with strong justification.	Mostlyclearwith minorgaps.	Basicattemptwith limited clarity.	Poorlydefined problem.
Dataandmethod	Appropriatedata and sound methodology.	Mostly appropriatewith minorissues.	Limiteddataor partialmethod.	Inadequate or incorrectmethod.
Analysis	Robust interpretationand validresults.	Generallysound with minor errors.	Partialanalysis with gaps.	Weakorincorrect analysis.
Recommendations	Strong,feasible, and context-specific.	Relevantwith minorlimitations.	Generic recommendations.	Incompleteor unrealistic.
Presentation	Well organized andprofessional.	Good organizationwith minorissues.	Acceptablebut uneven.	Poorlypresented.

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ANALYSISANDDESIGNOFADVANCEDSTEELANDCOMPOSITESTRUCTURES			
Course Code	**1MCSE203**	Scheme	2026
TypeofCourse	**ProfessionalCoreCourse**	Semester	II
TeachingHours/Week(L:T:P)	42(3:0:0)	CIEMarks	50
TotalHoursofPedagogyper SemesterCI(L/T):LI(P):TW&SL	90(42:0:0:48)	SEEMarks	50
Credits	3	TotalMarks	100
TypeofExamination(IPCC):	Theory	Exam Hours	03

Courseoutcome (CourseSkillSet):

Attheendofthecourse,thestudentwillbeableto:

1. CO1:Explainadvancedsteelandcompositestructuralsystems,materialbehaviour,andrelevantdesign provisions for industrial applications.
2. CO2:Analyzesteelandcompositemembersandsystemsforgravity,lateral,stability,andserviceability effects using appropriate idealizations and code-based methods.
3. CO3:Designtension,compression,flexural,andbeam-columnmembers,includingadvanced connections and composite elements, for strength and serviceability.
4. CO4:Evaluatestability,second-ordereffects,fatigue,andfire-relatedconsiderationsinsteeland composite structures.
5. CO5:Designpracticalstructuralcomponentssuchastrusses,portalframes,industrialbuildings,and composite floor systems using industry-relevant workflows.
6. CO6:Integrateanalysisoutput,detailing,constructability,sustainability,anddigitaltoolsforeffective structural design decisions.

Module-1

AdvancedSteelStructuralBehaviourandCodes:

Steelgrades,structuralforms,limitstate concepts,design philosophy,load combinations,materialproperties,residual stresses, local buckling, imperfections, member classification, and code-based design workflow. Introduction to industrial steel systems, fabrication constraints, erection considerations, and design deliverables.

LinkedCOs:CO1,CO2. **NumberofHours: 08**

Module-2

AnalysisofSteelMembersandSystems:

Analysis of tension members, compression members, beams, beam-columns, and laterally unsupported members. Effectivelength,slenderness,stability,lateraltorsionalbuckling,frameaction,idealizationofindustrialframes,andload path evaluation. Introduction to second-order effects and elastic-plastic response.

LinkedCOs:CO2,CO3,CO4. **NumberofHours: 08**

Module-3

DesignofSteelMembersandConnections:

Design of tension and compression members, laterally supported and unsupported beams, column bases, gusseted and momentconnections,splices,andend-plateconnections.Detailingrequirements,welds,bolts,bearing,blockshear,and connection behaviour under combined actions.

LinkedCOs:CO3,CO5. **NumberofHours: 08**

Module-4

CompositeStructuralSystems:

Composite action in beams and slabs, shear connectors, composite floor systems, composite beams, composite columns,slab-deckinteraction,partialinteraction,constructionstages,andlong-termeffects.Analysisanddesignof composite members for serviceability, strength, and economy.

LinkedCOs:CO1,CO2,CO3,CO5. **NumberofHours:08**

Module-5

AdvancedApplicationsandIndustryPractice:

Analysisanddesignofindustrialbuildings,trusses,gantrygirders,portalframes,cranesupports,andbracedsystems. Stability under lateral loads, fatigue, fire design concepts, robustness, constructability, and introduction to BIM-enabled structural coordination and documentation. Case studies from real projects and design review workflow.

LinkedCOs:CO4,CO5,CO6. **NumberofHours: 10**

SuggestedLearningResources Textbooks

1. Duggal,S.K.,LimitStateDesignofSteelStructures,3rdEdition,McGrawHillEducation.
2. Owens,G.W.andCheal,B.D.,StructuralSteelworkDesigntoLimitStateTheory,4thEdition,Butterworth-Heinemann.
3. Johnson,R.P.,CompositeStructuresofSteelandConcrete,4thEdition,Wiley-Blackwell.
4. Redwood,R.G.andChajes,M.,SteelandCompositeStructures,2ndEdition,CRCPress.

ReferenceBooks

1. Kodur,V.K.R.andVenkatesh,R.,CompositeConstructioninSteelandConcrete,2ndEdition,Elsevier.
2. Narayanan,R.,Steel-ConcreteCompositeStructures,1stEdition,S.ChandPublishing.
3. INSDAG,HandbookonSteelStructures,LatestEdition,INSDAG.
4. IS800,GeneralConstructioninSteel-CodeofPractice,LatestEdition,BureauofIndianStandards.
5. IS11384,CodeofPracticeforCompositeConstructioninStructuralSteelandConcrete,LatestEdition,Bureau of Indian Standards.

WeblinksandVideoLectures(e-Resources)

1. NPTEL:DesignofSteelStructures(IITMadras)
2. NPTEL:CompositeSteel-ConcreteStructures(IITGuwahati)
3. Coursera:SteelDesignforEngineers
4. SCI(SteelConstructionInstitute)–Compositebeamdesignguides
5. VirtualLabs:Steelbeam-columninteraction
6. IScodesfreedownloadresources(BIS).

Teaching-LearningProcess(InnovativeDeliveryMethods):

Thefollowingaresamplestrategiesthateducatorsmayadopttoenhancetheeffectivenessoftheteaching-learning processandfacilitatetheachievementofcourseoutcomes.SuggestedInnovativeDeliveryMethodsmayinclude(but are not limited to):

- FlippedClassroom
- Problem-BasedLearning(PBL)
- Case-BasedTeaching
- SimulationandVirtualLabs
- PartialDeliveryofcoursebyIndustryexpert/industrialvisits
- ICT-EnabledTeaching
- RolePlay

AssessmentStructure(bothCIEandSEE)

The weightage assigned to Continuous Internal Evaluation(CIE) and SemesterEnd Examination (SEE) shall be 50%each.Astudentshallsecureaminimumof50%ofthemaximummarksprescribedforCIEandaminimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/courseonlyifhe/shesecuresnotlessthan50% oftheaggregatemarksobtainedinCIEandSEEtaken together.

ContinuousInternalEvaluation:

ContinuousComprehensiveAssessments(CCA)+InternalAssessmentTest(IA)=ContinuousInternal Evaluation CIE [25+25=50 marks]

AminimumoftwoInternalAssessmentTests(IA)shallbeconducted.Eachtestshallbeconductedfora maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.

Inaddition,ContinuousComprehensiveAssessment(CCA)shallbeconductedforatotalof25marks

Students'activitiesforTW/SLunderNCrF:Samplesonly

AsperNationalcreditformwork(NCrF)studentsmustspend90hoursofstudyfor3creditcourses,whichinclude Course instructions (CI-42hour) and Teamwork/ Self learning(TW/Sl-48hours).Hence,students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. Theevaluationactivities will bedoneusing setofrubricsdeveloped foreachactivity. Thefollowingsampleactivities arelistedbelow.Thesampleactivitiesaregivenbelow.Thecoursecoordinatorcanalsogivetheirown TW/SL activitiesasperthecourseoutcomes.

Sl. No.	TermWork(TW)Activity	NumberofHours/ Semester
1	**TW-1: Analysis of a Steel Industrial Frame:** Students shall model and analyze a portal/industrial frame for dead load, live load, wind load, and craneloadeffects.Theyshallidentifycriticalmembers,supportreactions, andgoverningloadcombinations.	24
2	**TW-2:DesignofSteelBeam-ColumnandConnection:**Studentsshall designabeam-columnmemberandaconnectedjointforagivenloading case,includingmemberchecks,connectiondesign,anddetailingdrawings.	24
3	**TW-3:CompositeBeamandSlabDesignWorksheet:**Studentsshall prepare acomposite beam designworksheet including effectivewidth,shear connectorselection,constructionstage,andserviceabilitychecks.	24
	TW-4:StabilityandFire/RobustnessReview: Studentsshallevaluate stabilityissues,lateraltorsionalbuckling,fireresistanceprovisions,and robustness measures for a selected steel/composite structure**.**	24
SL:SelfLearning,MOOCs,spokentutorials,onlineeducationalresourcesetc.		
Sl. No.	**Self-Learning(SL)Activity**	**NumberofHours/ Semester**
1	**SL-1:CaseStudyonanIndustrialSteelBuilding**:Studentsshallstudyan industrialsteelstructureandpresentthestructuralsystem,loadtransferpath, design challenges, and constructability issues.	24
2	**SL-2:BIM-BasedSteelCoordinationReview:**Studentsshallreview structuraldetailing,clashconcerns,andcoordinationissuesusingBIM-basedordrawing-baseddigitalrecords.	24
3	**SL-3:CompositeFloorSystemReview:**Studentsshallcompare conventionalandcompositefloorsystemsforstrength,economy,speedof construction,andserviceability.	24
4	**SL-4:CodeProvisionsPresentation:**Studentsshallpresentselected clausesfromsteel/compositedesigncodesandexplaintheirpractical implication in design decisions.	24

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SamplerubricsforTWactivities:

Criteria	Excellent(4)	Good(3)	Satisfactory(2)	NeedsImprovement (1)
Structural understanding	Correctlyidentifies analysisanddesign requirements with clearstructural logic.	Minor omissions ininterpretation.	Basic understanding with partial coverage.	Incorrectorincomplete understanding.
Analytical accuracy	Correctloadpath, modellingassumptions,and memberchecks.	Minorcalculation or modellingerrors.	Severalgapsin analysis.	Majorconceptualor calculationerrors.
Designquality	Design is code-compliant,practical, and well detailed.	Mostlycompliant with small omissions.	Acceptablebut not robustly justified.	Poorly supported or non-compliantdesign.
Documentation andpresentation	Clear,professional, andwell-organized submission.	Mostlyclearand complete.	Adequatebut inconsistent.	Disorganizedor incomplete.

SamplerubricsforSL activities:

Criteria	Excellent(4)	Good(3)	Satisfactory (2)	NeedsImprovement(1)
Conceptual clarity	Explains concepts withstrongtechnical depth.	Adequate explanationwith minorgaps.	Basic explanation only.	Limitedorinaccurate explanation.
Industry linkage	Strongconnectionto real projects and practice.	Goodlinkage with some relevance.	Limited practical linkage.	Nomeaningfulindustry connection.
Referenceuse	Uses standards, drawings,orcredible sources effectively.	Usesrelevant sources with minorgaps.	Limited sourceuse.	Poororabsentsource use.
Communication	Clearpresentation and logical organization.	Mostlyclear.	Acceptable butuneven.	Weakcommunication.

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CONTINUUMMECHANICS			
Course Code	**1MCSE204 / 1MCAS204 / 1MCCS204**	Scheme	2026
TypeofCourse	**ProfessionalCoreCourse**	Semester	II
TeachingHours/Week(L:T:P)	42(3:0:0)	CIEMarks	50
TotalHoursofPedagogyper SemesterCI(L/T):LI(P):TW&SL	90(42:0:0:48)	SEEMarks	50
Credits	3	TotalMarks	100
TypeofExamination(IPCC):	Theory	ExamHours	03

Courseoutcome (CourseSkillSet):

Attheendofthecourse,thestudentwillbeableto:

1. CO1:Explainthefundamentalsofclimatesystem,climatevariability,andclimatechangedrivers.
2. CO2:Analyzeclimatedataandidentifytrends,extremes,andanomaliesrelevanttohazardassessment.
3. CO3:Developbasicclimatechangemodelsandinterpretsimulationoutputsforengineeringand environmental applications.
4. CO4:Assessvulnerability,exposure,andriskforselectednaturalhazardsusingappropriateframeworks.
5. CO5:Applydisasterriskreductionconcepts,mitigation,adaptation,andresiliencestrategiesinreal-world contexts.
6. CO6:Criticallyevaluateintegratedclimate-riskscenariosandproposesustainable,evidence-based interventions.

Module-1

BasicConceptsofStressandStrain:

- Definition ofstress and strainata point,components of stress and strainat a point,straindisplacement relationsinCartesiancoordinates,constitutiverelations,equilibriumequations,compatibilityequations and boundary conditions in 2D and 3D cases, plane stress, plane strain.

Self-studycomponent: Constitutiverelationsforanisotropicmaterialsandfordifferentcasesoforthotropy.

LinkedCOs: CO1 **NumberofHours:8hrs**

Module-2

2DProblemsinRectangularCoordinates:

- Airy'sstressfunctionapproachto2Dproblemsofelasticity.Solutionbypolynomials.Endeffects,Saint-Venant's principle.
- Solutionofsimplebeamproblemsincludingworkingoutofdisplacementcomponents.

Self-studycomponent: Analysisofstressesforasimplysupportedbeamsubjectedtoconcentratedload,beams subjected to hydrostatic loads, Fourier series and forms of stress functions.

LinkedCOs: CO2 **NumberofHours:10hrs**

Module-3

2DProblemsinPolarCoordinates:

- Generalequationsinpolarcoordinates–strainanddisplacementrelations,equilibriumequations.Stress distribution symmetrical about an axis – pure bending of curved bars.
- Displacementsforsymmetricalstressdistributions.Effectofasmallcircularholeonstressdistributionina large plate subjected to uniaxial tension and pure shear.

Self-studycomponent: Analysisofnon-axis-symmetricproblems,Boussinesq'sproblem,wedgeandgroove problems

LinkedCOs:CO3 **NumberofHours:8hrs**

Module-4

3DAnalysisofStressandStrain:

- Stressatapointinanyarbitrarydirection.
- Principalstressesandcorrespondingdirections.

- Determinationofprincipalstressesandprincipalplanes
- Stressinvariants.
- Determinationofmaximumshearingstress.
- Octahedralstresscomponents.
- Strainatapointinanyarbitrarysection.
- Principalstrainsandcorrespondingdirections.Straininvariants.

Self-studycomponent: Failuretheoriesinageneralstateofstressforductileandbrittlematerials
LinkedCOs:CO4 **NumberofHours:8hrs**

Module-5

TorsionofNon-CircularSections:

- St.Venant'ssemi-inversemethodandPrandtl'sstressfunctionapproach.
- Torsionofstraightprismaticbarsofellipticcrosssection.
- Membraneanalogy.
- Torsionofabarofnarrowrectangularcrosssection.
- Torsionofthin-walledopencrosssections.
- Torsionofthin-walledtubes.

Self-studycomponent: Torsionofmulticellproblemsasinmulticellgirdersusedinbridgesandflyovers. **Linked COs: CO5** **Number of Hours: 8 hrs**

SuggestedLearningResources Textbooks

1. Timoshenko,S.&Goodier,J.N.–TheoryofElasticity,McGraw-Hill,IIIEdition,1983.
2. Valliappan,S.–ContinuumMechanicsFundamentals,BalkemaAcademic&TechnicalPublications,1981

ReferenceBooks

1. Sitharam,T.G.&Govindaraju,L.–ElasticityforEngineers,IKInternationalPublisher,2017
2. Singh,Sadhu–TheoryofElasticity,FourthEdition,KhannaPublishers,1979.
3. Verma,P.D.S.–TheoryofElasticity,SangamBooksLimited,1997.

WeblinksandVideoLectures(e-Resources)

1. NPTEL:ContinuumMechanics–https://nptel.ac.in/courses/112103167
2. NPTEL:AdvancedElasticity–https://archive.nptel.ac.in/courses/112/103/112103296/
3. NPTEL:TheoryofElasticity–https://archive.nptel.ac.in/courses/103/106/103106159/

Teaching-LearningProcess(InnovativeDeliveryMethods):

Thefollowingaresamplestrategiesthateducatorsmayadopttoenhancetheeffectivenessoftheteaching-learning processandfacilitatetheachievementofcourseoutcomes.SuggestedInnovativeDeliveryMethodsmayinclude(butare not limited to):

- FlippedClassroom
- Problem-BasedLearning(PBL)
- Case-BasedTeaching
- SimulationandVirtualLabs
- PartialDeliveryofcoursebyIndustryexpert/industrialvisits
- ICT-EnabledTeaching
- RolePlay

AssessmentStructure(bothCIEandSEE)

TheweightageassignedtoContinuousInternalEvaluation(CIE)andSemesterEndExamination(SEE)shallbe50% each.Astudentshall secure a minimum of50%ofthe maximum marks prescribedforCIE anda minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/courseonlyifhe/shesecuresnotlessthan50% oftheaggregatemarksobtainedinCIEandSEEtaken together.

ContinuousInternalEvaluation:

ContinuousComprehensiveAssessments(CCA)+InternalAssessmentTest(IA)=ContinuousInternalEvaluation CIE [25+25=50 marks]
AminimumoftwoInternalAssessmentTests(IA)shallbeconducted.Eachtestshallbeconductedforamaximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.
Inaddition,ContinuousComprehensiveAssessment(CCA)shallbeconductedforatotalof25marks

Students'activitiesforTW/SLunderNCrF:Samplesonly

As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimumoftwoactivesaspartofNCrF.TheselearningactivitiesshallbeconsideredasCCAcomponentsofCIE.The evaluationactivitieswillbedoneusingsetofrubricsdevelopedforeachactivity.Thefollowingsampleactivitiesare listedbelow.Thesampleactivitiesaregivenbelow.The coursecoordinatorcanalsogivetheirownTW/SLactivities asperthecourseoutcomes.

Sl. No.	TermWork(TW)Activity	NumberofHours/ Semester
1	Assignments: 1. Compatibilityequationsandboundaryconditions(Mod1/CO1)–8h 2. Airy'sstressfunctionforacantileverbeam(Mod2/CO2)–8h 3. TorsionofellipticsectionusingPrandtl'sfunction(Mod5/CO5)–8h	24
2	Seminars: 1. Constitutiverelationsfororthotropicmaterials(Mod1/CO1)–8h 2. Failuretheoriesforductileandbrittlematerials(Mod4/CO4)–8h 3. Membraneanalogyfortorsion(Mod5/CO5)–8h	24
3	Micro-Project: 1. Stressdistributionaroundacircularholeusing Python(Mod3/CO3) – 12h 2. Torsionanalysisofthin-walledopensection(Mod5/CO5)–12h	24

SL:SelfLearning,MOOCs,spokentutorials,onlineeducationalresourcesetc.

Sl. No.	Self-Learning(SL)Activity	NumberofHours/ Semester
1	NPTEL:ContinuumMechanics(IITMadras)	24
2	NPTEL:TheoryofElasticity	24
3	Derivationpractice–Airy'sfunction&polarcoordinates	24

SamplerubricsforTWactivities:

Criteria	4-Excellent	3-Good	2-Satisfactory	1 - Needs Improvement
Problem understanding	Clearproblem framing with strong justification.	Mostlyclear with minor gaps.	Basicattemptwith limited clarity.	Poorlydefined problem.
Dataandmethod	Appropriatedata and sound methodology.	Mostly appropriate with minor issues.	Limiteddataor partialmethod.	Inadequate or incorrectmethod.
Analysis	Robust	Generally	Partialanalysiswith	Weakorincorrect

Criteria	4-Excellent	3-Good	2-Satisfactory	1 - Needs Improvement
	interpretationand validresults.	sound with minorerrors.	gaps.	analysis.
Recommendations	Strong,feasible, and context-specific.	Relevantwith minor limitations.	Generic recommendations.	Incompleteor unrealistic.
Presentation	Well organized andprofessional.	Good organization with minor issues.	Acceptablebut uneven.	Poorlypresented.

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FINITEELEMENTMETHODSINSTRUCTURALANALYSIS			
Course Code	**1MCSE205A / 1MCAS205A / 1MCCS205A**	Scheme	2026
TypeofCourse	**ProfessionalElectiveCourse**	Semester	II
TeachingHours/Week(L:T:P)	42(3:0:0)	CIEMarks	50
TotalHoursofPedagogyper SemesterCI(L/T):LI(P):TW&SL	90(42:0:0:48)	SEEMarks	50
Credits	3	TotalMarks	100
TypeofExamination(IPCC):	Theory	ExamHours	03

Courseoutcome (CourseSkillSet):

Attheendofthecourse,thestudentwillbeableto:

1. CO1:Applyprinciplesofelasticityandenergymethods(Rayleigh-Ritz,FiniteDifference)toformulate structural problems.
2. CO2:Developshapefunctionsfor1D,2D,and3Delementsusinggeneralized,natural,andLagrangian coordinates ensuring convergence.
3. CO3:Formulateisoparametric,subparametric,andsuper-parametricelementsusingJacobian transformation and numerical integration.
4. CO4:ExecuteFEMprocedureforbeams,trusses,andplanestress/strainproblemsusingCSTand quadrilateral elements.
5. CO5:Evaluateplates,shells,andselectappropriatetechniquesfornon-linearstructuralanalysis.

Module-1

BasicConceptsofElasticity,ApproximateMethods&FEMFundamentals:

- Kinematicandstaticvariablesforstructuralproblems.Approximatemethods –Rayleigh-Ritz method, Finite difference method.
- Variationmethodandminimizationofenergyapproachforelementformulation.
- PrinciplesofFEM–advantages&disadvantages.
- GeneralFEMprocedure.
- Finiteelementsfor1D,2D& 3Dproblems –elementaspectratio,meshrefinementvs.higherorder elements, node numbering to minimize bandwidth.

Self-study:CompareRayleigh-RitzandFDMforasimplysupportedbeam..

LinkedCOs:CO1 **NumberofHours:9hrs**

Module-2

DisplacementFunctions,ShapeFunctions&CoordinateSystems

- Nodaldisplacementparameters.Convergencecriterion –completenessandcompatibilityrequirements. Geometric invariance.
- Shapefunctions–polynomialformofdisplacementfunction.Generalizedandnaturalcoordinates.
- Lagrangianinterpolationfunction–shapefunctionsfor1D,2D&3Delements

Self-study:Deriveshapefunctionsfora3-nodequadratic1Dbarelement.

LinkedCOs:CO2 **NumberofHours:9hrs**

Module-3

IsoparametricFormulation,JacobianTransformation&NumericalIntegration:

- Isoparametricelements–internalnodesandhigherorderelements.SerendipityandLagrangianfamily of elements. Subparametric and super-parametric elements.
- Condensationofinternalnodes.Jacobiantransformationmatrix –strain-displacementmatrixand stiffness matrix. Consistent load vector. Numerical integration – Gaussian quadrature.

Self-study:Perform2x2Gaussianquadratureforaquadrilateralelement.

LinkedCOs:CO3 **NumberofHours:8hrs**

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Module-4

FEMApplicationto1D&2DProblems–Beams,Trusses,CST&QuadrilateralElements:

- ApplicationofFEMforanalysisof1Dand2Dproblems.
- Analysisofsimplebeamsandplanetrusses.Applicationtoplanestress,planestrain,andaxisymmetric problems using Constant Strain Triangle (CST) and quadrilateral elements.

Self-study:AnalyzeaplanetrussusingCSTelementsandverifyresults

LinkedCOs: CO4 **NumberofHours:8hrs**

Module-5

FEMforPlates,Shells&IntroductiontoNon-linearAnalysis:

- ApplicationofFEMtoplatesandshells.Choiceofdisplacementfunction–C_0,C_1,andC_2type continuityrequirements.
- Techniquesfornon-linearstructuralanalysis–geometricnon-linearity,materialnon-linearity,and solution methods (Newton-Raphson, modified Newton-Raphson).

Self-study:Comparelinearvsnon-linearanalysisofacantileverbeamunderlargedeflection.

LinkedCOs: CO5 **NumberofHours:8hrs**

SuggestedLearningResources:

Textbooks

1. Krishnamoorthy,C.S.–FiniteElementAnalysis,TataMcGrawHill.
2. Desai,C.&Abel,J.F.–IntroductiontotheFiniteElementMethod,EastWestPressPvt.Ltd.,1972.
3. Bathe,K.J.–FiniteElementProceduresinEngineeringAnalysis,PrenticeHall.

ReferenceBooks

4. Rajasekaran,S.–FiniteElementAnalysisinEngineeringDesign,WheelerPublishing.
5. Cook,R.D.,Malkus,D.S.&Plesha,M.E. –ConceptsandApplicationofFiniteElementAnalysis,3rd Edition, John Wiley and Sons, 1989.
6. Shames,I.H.&Dym,C.J.–EnergyandFiniteElementMethodsinStructuralMechanics,McGrawHill, New York, 1985.

WeblinksandVideoLectures(e-Resources)

1. https://nptel.ac.in/courses/112104193
2. https://www.youtube.com/watch?v=h2JaOBIguVI
3. https://onlinecourses.nptel.ac.in/noc25_ce21/preview
4. https://www.youtube.com/watch?v=N6rt_YxXuoA
5. https://www.youtube.com/watch?v=KZhXK40drqg.

Teaching-LearningProcess(InnovativeDeliveryMethods):

Thefollowingaresamplestrategiesthateducatorsmayadopttoenhancetheeffectivenessoftheteaching-learning processandfacilitatetheachievementofcourseoutcomes.SuggestedInnovativeDeliveryMethodsmayinclude (but are not limited to):

- FlippedClassroom
- Problem-BasedLearning(PBL)
- Case-BasedTeaching
- SimulationandVirtualLabs
- PartialDeliveryofcoursebyIndustryexpert/industrialvisits
- ICT-EnabledTeaching
- RolePlay

AssessmentStructure(bothCIEandSEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.
Astudentshallbedeemedtohavesatisfiedtheacademicrequirementsandearnedthecreditsallottedtoa subject/courseonlyifhe/shesecuresnotlessthan50%oftheaggregatemarksobtainedinCIEandSEE

takentogether.

ContinuousInternalEvaluation:

ContinuousComprehensiveAssessments(CCA)+InternalAssessmentTest(IA)=ContinuousInternal Evaluation CIE [25+25=50 marks]

AminimumoftwoInternalAssessmentTests(IA)shallbeconducted.Eachtestshallbeconductedfora maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.

Inaddition,ContinuousComprehensiveAssessment(CCA)shallbeconductedforatotalof25marks

Students'activitiesforTW/SLunderNCrF:Samplesonly

As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which includeCourseinstructions(CI-42hour)andTeamwork/Selflearning(TW/Sl-48hours).Hence,studentsmust complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The followingsampleactivitiesarelisted below. Thesampleactivitiesaregivenbelow. The coursecoordinatorcan alsogivetheirownTW/SLactivitiesasperthecourseoutcomes.

Sl. No.	TermWork(TW)Activity	NumberofHours/Semester
1	Assignments: 1. Rayleigh-Ritzsolutionforbeam(Mod1/CO1)–8h 2. Shapefunctionsfor2Delement(Mod2/CO2)–8h 3. CSTanalysisofplanestressproblem(Mod4/CO4)–8h	24
2	Seminars: 1. Isoparametric formulation (Mod3/CO3) – 8h 2. Non-linearsolutionmethods(Mod5/CO5)–8h 3. Platesandshellsanalysis(Mod5/CO5)–8h	24
3	Micro-Project: 1. MATLABprogramfortrussanalysis(Mod4/CO4)–12h 2. FEAofplatewithholeusingANSYS(Mod5/CO5)–12h.	24
SL:SelfLearning,MOOCs,spokentutorials,onlineeducationalresourcesetc.		
Sl. No.	**Self-Learning(SL)Activity**	**NumberofHours/Semester**
1	NPTEL:FiniteElementAnalysis(IITKharagpur)	8
2	NPTEL:Non-linearFEM(IITMadras)	8
3	FEAsoftwarepractice(ANSYS/ABAQUS)	8

SamplerubricsforTWactivities:

Criteria	4-Excellent	3-Good	2-Satisfactory	1 - Needs Improvement
Problem understanding	Clearproblem framing with strong justification.	Mostlyclear with minor gaps.	Basicattemptwith limited clarity.	Poorlydefined problem.
Dataandmethod	Appropriatedata and sound methodology.	Mostly appropriate with minor issues.	Limiteddataor partialmethod.	Inadequate or incorrectmethod.
Analysis	Robust interpretationand	Generally soundwith	Partialanalysiswith gaps.	Weakorincorrect analysis.

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Criteria	4-Excellent	3-Good	2-Satisfactory	1 - Needs Improvement
	validresults.	minorerrors.		
Recommendations	Strong,feasible, and context-specific.	Relevantwith minor limitations.	Generic recommendations.	Incompleteor unrealistic.
Presentation	Well organized andprofessional.	Good organization with minor issues.	Acceptablebut uneven.	Poorlypresented.

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ADVANCEDSTRUCTURALANALYSIS(NONLINEARANDSTABILITY)			
Course Code	**1MCSE205B / 1MCAS205C**	Scheme	2026
TypeofCourse	**ProfessionalElectiveCourse**	Semester	II
TeachingHours/Week(L:T:P)	42(3:0:0)	CIEMarks	50
TotalHoursofPedagogyper SemesterCI(L/T):LI(P):TW&SL	90(42:0:0:48)	SEEMarks	50
Credits	3	TotalMarks	100
TypeofExamination(IPCC):	Theory	ExamHours	03

Courseoutcome (CourseSkillSet):

Attheendofthecourse,thestudentwillbeableto:

1. CO1:Derivedifferentialequationsofbeam-columnssubjectedtodifferentloadsandendconditions.
2. CO2:Approximatecalculationofcriticalloadsforframesandcontinuousbeamsbyelasticenergy methods
3. CO3:Applyfiniteelementmethodtostabilityanalysisofstructuralelements.
4. CO4:Bucklingofrectangularplateswithvariousedgeconditions
5. CO5:Bucklingofrectangularplatesundercombinedloads.

Module-1

NonlinearAnalysis–Beam-Column:

- Differentialequationofbeamcolumnsubjectedto:(i)lateralconcentratedload,(ii)several concentrated loads, (iii) continuous lateral load. Application of trigonometric series.
- Euler'sformulationusingfourthorderdifferentialequationforpinned-pinned,fixed-fixed,fixed-free, and fixed-pinned columns.

Self-study: Developaprogramfordifferentialequationfordifferentloadingandendconditions.

LinkedCOs: CO1 **NumberofHours:8hrs**

Module-2

NonlinearAnalysis–BucklingofFrames&ContinuousBeams:

- Approximatecalculationofcriticalloadsforacantilever.Exactcriticalloadforhinged-hingedcolumn using energy approach.
- Bucklingofbaroninelasticfoundation.Bucklingofcantilevercolumnunderdistributedloads.
- Determinationofcriticalloadsbysuccessiveapproximation.Barswithvaryingcrosssection.
- Effectofshearforceoncriticalload.Columnssubjectedtonon-conservative,follower,andpulsating forces.

Self-study: Preparareportontheconceptofbucklingof RCstructures.

LinkedCOs: CO2 **NumberofHours:10hrs**

Module-3

StabilityAnalysisbyFiniteElementApproach:

- Derivationofshapefunctionsforatwo-nodedBernoulli-Eulerbeamelement(lateralandtranslational DOF). Element stiffness and element geometric stiffness matrices.
- Assembledstiffnessandgeometricstiffnessmatricesforadiscretisedcolumnwithdifferentboundary conditions.
- Evaluationofcriticalloadsforadiscretised(twoelements)column(bothendsbuilt-in).Algorithmto generate geometric stiffness matrix for four-noded and eight-nodedisoparametric plate elements.
- Bucklingofpin-jointedframes(maximumoftwoactiveDOF)–symmetricalsinglebayportalframe.

Self-study: Obtainsolutionforthecolumnwithdifferentboundaryconditionsusingreferencematerial.

LinkedCOs:CO3 **NumberofHours:8hrs**

Module-4

BucklingofSimplySupportedRectangularPlates:

- Buckling of uniformly compressed rectangular plate simply supported along two opposite edges perpendiculartothedirectionofcompressionandhavingvariousedgeconditionsalongtheothertwo edges.
- Bucklingofarectangularplatesimplysupportedalongtwooppositesidesanduniformlycompressedin the direction parallel to those sides.

Self-study: Preparareportonbucklingofsimplysupportedrectangularplate.

LinkedCOs: CO4 **NumberofHours:8hrs**

Module-5

BucklingofRectangularPlates–CombinedEffects:

- Bucklingofasimplysupportedrectangularplateundercombinedbendingandcompression.
- Bucklingofrectangularplatesunderthe actionofshearingstresses.Othercasesofbucklingof rectangularplates.

Self-study: Obtainsolutionforothercasesofbucklingofrectangularplatesusingreferencematerial

LinkedCOs: CO5 **NumberofHours:8hrs**

SuggestedLearningResources Textbooks

1. Timoshenko,S.P.&Gere,J.M.–TheoryofElasticStability,2ndEdition,McGraw-Hill,NewDelhi,1998.
2. Zeiglar,H.–PrinciplesofStructuralStability,BlaisdallPublication,Waltham,Mass.,1968.
3. Cook,R.D.etal.–ConceptsandApplicationsofFiniteElementAnalysis,3rdEdition,JohnWileyandSons, New York, 2001

ReferenceBooks

1. Rajasekaran,S.–ComputationalStructuralMechanics,Prentice-Hall,India,2001.
2. Clough,R.W.&Penzien,J.–DynamicsofStructures,2ndEdition,McGraw-Hill,NewDelhi,1993.

WeblinksandVideoLectures(e-Resources)

1. NPTEL:StructuralStability–https://archive.nptel.ac.in/courses/105/105/105105217/
2. NPTEL:AdvancedStructuralStability–https://onlinecourses.nptel.ac.in/noc22_ce91/previewNPTEL
3. Syllabus:https://archive.nptel.ac.in/content/syllabus_pdf/105105217.pdf

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Teaching-LearningProcess(InnovativeDeliveryMethods):

Thefollowingaresamplestrategiesthateducatorsmayadopttoenhancetheeffectivenessoftheteaching-learning processandfacilitatetheachievementofcourseoutcomes.SuggestedInnovativeDeliveryMethodsmayinclude(but are not limited to):

- FlippedClassroom
- Problem-BasedLearning(PBL)
- Case-BasedTeaching
- SimulationandVirtualLabs
- PartialDeliveryofcoursebyIndustryexpert/industrialvisits
- ICT-EnabledTeaching
- RolePlay

AssessmentStructure(bothCIEandSEE)

The weightage assigned to Continuous Internal Evaluation(CIE) and SemesterEnd Examination (SEE) shall be 50%each.Astudentshallsecureaminimumof50%ofthemaximummarksprescribedforCIEandaminimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.

Astudentshallbedeemedtohavesatisfiedtheacademicrequirementsandearnedthecreditsallottedtoa subject/courseonlyifhe/shesecuresnotlessthan50% oftheaggregatemarksobtainedinCIEandSEEtaken together.

ContinuousInternalEvaluation:
ContinuousComprehensiveAssessments(CCA)+InternalAssessmentTest(IA)=ContinuousInternal Evaluation
CIE [25+25=50 marks]
AminimumoftwoInternalAssessmentTests(IA)shallbeconducted.Eachtestshallbeconductedfora maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.
Inaddition,ContinuousComprehensiveAssessment(CCA)shallbeconductedforatotalof25marks

Students'activitiesforTW/SLunderNCrF:Samplesonly
AsperNationalcreditformwork(NCrF)studentsmustspend90hoursofstudyfor3creditcourses,whichinclude Courseinstructions(CI-42hour)andTeamwork/Selflearning(TW/Sl-48hours).Hence,studentsmustcomplete minimumoftwoactivesaspartof NCrF.Theselearningactivitiesshallbeconsidered asCCAcomponentsofCIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activitiesarelistedbelow.Thesampleactivitiesaregivenbelow.The coursecoordinatorcanalsogivetheirown TW/SLactivitiesasperthecourseoutcomes.

Sl. No.	TermWork(TW)Activity	Numberof Hours / Semester
1	Assignments: 1. Euler'sformulationfordifferentendconditions(Mod1/CO1)–8h 2. Energymethodcriticalloadforhinged-hingedcolumn(Mod2/CO2)– 8h 3. FEAcriticalloadfortwo-elementcolumn(Mod3/CO3)–8h	24
2	Seminars: 1. Non-conservativeandfollowerforces(Mod2/CO2)–8h 2. Isoparametricplateelementsforstability(Mod3/CO3)–8h 3. Bucklingofplatesundercombinedloads(Mod5/CO5)–8h	24
3	Micro-Project: 1. MATLABprogramforcolumnbucklingwithvariousBCs(Mod1/CO1)–12h 2. FEAofportalframebuckling(Mod3/CO3)–12h	24

SL:SelfLearning,MOOCs,spokentutorials,onlineeducationalresourcesetc.

Sl. No.	Self-Learning(SL)Activity	Numberof Hours / Semester
1	NPTEL:StructuralStability(IITMadras)	8
2	NPTEL:AdvancedStructuralStability	8
3	FEAsoftwarepractice(ANSYS/ABAQUS)forbuckling	8

SamplerubricsforTWactivities:

Criteria	4-Excellent	3-Good	2-Satisfactory	1 - Needs Improvement
Problem understanding	Clearproblem framing with strong justification.	Mostlyclear with minor gaps.	Basicattemptwith limited clarity.	Poorlydefined problem.
Dataandmethod	Appropriatedata and sound methodology.	Mostly appropriate with minor issues.	Limiteddataor partialmethod.	Inadequate or incorrectmethod.
Analysis	Robust interpretationand validresults.	Generally sound with minorerrors.	Partialanalysiswith gaps.	Weakorincorrect analysis.
Recommendations	Strong,feasible, and context-specific.	Relevantwith minor limitations.	Generic recommendations.	Incompleteor unrealistic.
Presentation	Well organized andprofessional.	Good organization with minor issues.	Acceptablebut uneven.	Poorlypresented.

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ANALYSISANDDESIGNOFREINFORCEDCONCRETEBRIDGES			
Course Code	**1MCSE205C / 1MCCS205C**	Scheme	2026
TypeofCourse	**ProfessionalElectiveCourse**	Semester	II
TeachingHours/Week(L:T:P)	42(3:0:0)	CIEMarks	50
TotalHoursofPedagogyper SemesterCI(L/T):LI(P):TW&SL	90(42:0:0:48)	SEEMarks	50
Credits	3	TotalMarks	100
TypeofExamination(IPCC):	Theory	ExamHours	03

Courseoutcome (CourseSkillSet):

Attheendofthecourse,thestudentwillbeableto:

1. CO1:Selectappropriatebridgesitesanddeterminepreliminarydimensionsforvariousbridgetypes based on functional requirements.
2. CO2:Analyzeforcesonpiers,abutments,andwingwallsandperformstructuraldesignincluding bridge bearings.
3. CO3:EvaluateworstcaseloadingcombinationsusingIRCstandardsandperformdesignofboxand slabculverts.
4. CO4:Applyclassicalmethods(Courbon,Hendry-Jaeger,Morice-Little)forloaddistributioninT-beam bridge girders
5. CO5:Designprestressedconcretebridgecomponentsincludingprestressingforce,cableprofiles,and end blocks

Module-1

BridgeFundamentals,Substructures&Bearings :

- Introduction–historicaldevelopments,siteselectionforbridges,classificationofbridges,forceson bridges. Bridge substructures – abutments, piers, and wing walls.
- Balancedcantileverbridge–introductionandproportioningofcomponents.Forcesonpiersand abutments – design of piers and abutments.
- Typesofwingwalls.Typesofbearings–designofbearings.

Self-study:Collectsitedetailsofalocalbridgeandidentifyitstypeandcomponents.

LinkedCOs: CO1 **NumberofHours:8hrs**

Module-2

BoxCulvert&SlabCulvertDesignusingIRCLoading:

- DifferentloadingcasesIRCClassAA(trackedandwheeled)andClassAloading.Workingouttheworst combination of loading. Moment distribution method.
- Calculationofbendingmomentandshearforce.Structuraldesignofslabculvertwithreinforcement details.

Self-study:CompareIRCClassAAandClassAloadingforagivenspan.

LinkedCOs: CO2 **NumberofHours:8hrs**

Module-3

T-BeamBridge–Slab&CrossGirderDesign:

- Slabdesign:Proportioningofcomponents.Analysisofinteriorslabandcantileverslabusing IRCClass AA tracked, wheeled, and Class A loading. Structural design of slab with reinforcement details.
- Crossgirderdesign:Analysisofcross girderfordeadloadandliveloadusingIRCClassAAtracked, wheeled, and Class A loading. Structural design of cross girder with reinforcement details.

Self-study:AnalyzeacantileverslabofaT-beambridgeunderIRCloading.

LinkedCOs:CO3,CO4 **NumberofHours:9hrs**

Module-4

T-BeamBridge–MainGirderDesignusingClassicalMethods:

- Analysisofmaingirderfordeadloadandliveloadusing IRCClassAAtracked,wheeled,andClassA loading using Courbon's method.
- AnalysisofmaingirderusingHendry-JaegerandMorice-LittlemethodforIRCClassAAtrackedvehicle only. Bending moment and shear force for different loads. Structural design of main girder with reinforcementdetails.

Self-study:CompareCourbon'smethodwithHendry-Jaegermethodforloaddistribution.

LinkedCOs:CO4 **NumberofHours:9hrs**

Module-5

PrestressedConcrete(PSC)Bridges:

- Introductiontopre-tensioningandpost-tensioning.Proportioningofcomponents.Analysisand structural design of slab.
- AnalysisofmaingirderusingCourbon's methodforIRCClassAAtrackedvehicle.Calculationof prestressingforce,cableprofile,andcalculationofstresses.Designofendblockanddetailingof maingirder.

Self-study:Calculateprestressingforceforasimplysupported PSCbridgegirder

LinkedCOs:CO5 **NumberofHours:8hrs**

SuggestedLearningResources:

Textbooks

1. Victor,D.J.–EssentialsofBridgeEngineering,Oxford&IBHPublishingCo.,NewDelhi.
2. KrishnaRaju,N.–DesignofBridges,Oxford&IBHPublishingCo.,NewDelhi.
3. Bindra,S.P.–PrinciplesandPracticeofBridgeEngineering,DhanpatRai&Sons,NewDelhi.
4. IRC6–2017–StandardSpecificationsandCodeofPracticeforRoadBridges,SectionII –LoadsandLoad Combinations (Seventh Revision), IRC, New Delhi.
5. IRC112-2011–CodeofPracticeforConcreteRoadBridges,IRC,NewDelhi.
6. IS456–2000–IndianStandardPlainandReinforcedConcreteCodeofPractice(FourthRevision),BIS, NewDelhi.
7. IS1343–IndianStandardPrestressedConcreteCodeofPractice,BIS,NewDelhi.

ReferenceBooks

8. Raina,V.K.–ConcreteBridgePractice,TataMcGrawHill.
9. Bakht,B.&Jaeggar–BridgeAnalysisSimplified,McGrawHill.
10. Ponnuswamy,S.–BridgeEngineering,TataMcGrawHill.
11. Beckett,D.–AnIntroductiontoStructuralDesignofConcreteBridges,SurreyUniversityPress.

WeblinksandVideoLectures(e-Resources)

1. http://www.digimat.in/nptel/courses/video/105105165/105105165.html
2. https://onlinecourses.nptel.ac.in/noc22_ce63/preview
3. https://www.youtube.com/watch?v=JE23FlY7glI

Teaching-LearningProcess(InnovativeDeliveryMethods):

Thefollowingaresamplestrategiesthateducatorsmayadopttoenhancetheeffectivenessoftheteaching-learning processandfacilitatetheachievementofcourseoutcomes.SuggestedInnovativeDeliveryMethodsmayinclude (but are not limited to):

- FlippedClassroom
- Problem-BasedLearning(PBL)
- Case-BasedTeaching
- SimulationandVirtualLabs
- PartialDeliveryofcoursebyIndustryexpert/industrialvisits
- ICT-EnabledTeaching
- RolePlay

AssessmentStructure(bothCIEandSEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.

AstudentshallbedeemedtohavesatisfiedtheacademicrequirementsandearnedthecreditsallottedtoA subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE takentogether.

ContinuousInternalEvaluation:

ContinuousComprehensiveAssessments(CCA)+InternalAssessmentTest(IA)=ContinuousInternal Evaluation CIE [25+25=50 marks]

AminimumoftwoInternalAssessmentTests(IA)shallbeconducted.Eachtestshallbeconductedfora maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.

Inaddition,ContinuousComprehensiveAssessment(CCA)shallbeconductedforatotalof25marks

Students'activitiesforTW/SLunderNCrF:Samplesonly

As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which includeCourseinstructions(CI-42hour)andTeamwork/Selflearning(TW/Sl-48hours).Hence,studentsmust complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The followingsampleactivitiesarelisted below. Thesampleactivitiesaregivenbelow. The coursecoordinatorcan alsogivetheirownTW/SLactivitiesasperthecourseoutcomes.

Sl. No.	TermWork(TW)Activity	NumberofHours/ Semester
1	Assignments: 1. IRCloadcombinationforboxculvert(Mod2/CO3)–8h 2. Courbon'smethodformaingirder(Mod4/CO4)–8h 3. PrestressingforcecalculationforPSCgirder(Mod5/CO5)–8h	24
2	Seminars 1. Bridgesiteselectionandpierdesign(Mod1/CO1,CO2)–8h 2. Hendry-JaegervsMorice-Littlemethods(Mod4/CO4)–8h 3. EndblockdesigninPSCbridges(Mod5/CO5)– 8h	24
3	Micro-Project 1. CompletedesignofaslabculvertwithCADdrawing (Mod2/CO3) – 12h 2. T-beambridgeanalysisusingCourbon'smethod+STAAD validation(Mod4/CO4)–12h	24

SL:SelfLearning,MOOCs,spokentutorials,onlineeducationalresourcesetc.

Sl. No.	Self-Learning(SL)Activity	NumberofHours/ Semester
1	NPTEL:BridgeEngineering(IITRoorkee)	8
2	IRC6&IRC112codeself-study	8
3	CSIBridge/STAADpracticeforbridgemodeling	8

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SamplerubricsforTWactivities:

Criteria	4-Excellent	3-Good	2-Satisfactory	1 - Needs Improvement
Problem understanding	Clearproblem framing with strong justification.	Mostlyclear with minor gaps.	Basicattemptwith limited clarity.	Poorlydefined problem.
Dataandmethod	Appropriatedata and sound methodology.	Mostly appropriate with minor issues.	Limiteddataor partialmethod.	Inadequate or incorrectmethod.
Analysis	Robust interpretationand validresults.	Generally sound with minorerrors.	Partialanalysiswith gaps.	Weakorincorrect analysis.
Recommendations	Strong,feasible, and context-specific.	Relevantwith minor limitations.	Generic recommendations.	Incompleteor unrealistic.
Presentation	Well organized andprofessional.	Good organization with minor issues.	Acceptablebut uneven.	Poorlypresented.

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ANALYSISANDDESIGNOFMASONRYSTRUCTURES			
Course Code	**1MCSE205D**	Scheme	2026
TypeofCourse	**ProfessionalElectiveCourse**	Semester	II
TeachingHours/Week(L:T:P)	42(3:0:0)	CIEMarks	50
TotalHoursofPedagogyper SemesterCI(L/T):LI(P):TW&SL	90(42:0:0:48)	SEEMarks	50
Credits	3	TotalMarks	100
TypeofExamination(IPCC):	Theory	ExamHours	03

Courseoutcome (CourseSkillSet):

Attheendofthecourse,thestudentwillbeableto:

1. CO1:Knowledgeofanalysis,design,anddevelopmentofproblemsolvingskillsformasonry structures
2. CO2:Principlesofanalysisanddesignofmasonrystructures.
3. CO3:Analyticalskillsformasonrystructuralbehavioranddesign
4. CO4:Masonrycharacteristicsandtheirinfluenceonstructuralperformance.
5. CO5:Strengthandstabilityofmasonrystructuresthroughanalyticalmethods.

Module-1

Introduction–MasonryUnits,Materials,Types&CrackAnalysis:

- Historyofmasonry;Bricktypes&tests;Otherunits(stone,clayblock,concreteblock,lateriteblock, stabilized mud block); Mortar classification, properties & selection; Cracks (types, causes, prevention); Stress analysis basics, load paths, failure mechanisms.

Self-study:Collectmasonrycrackphotosfromfieldandanalyzepossiblecauses.

LinkedCOs:CO1,CO4 **NumberofHours:8hrs**

Module-2

AnalysisofStrengthofMasonryinCompression,Bond,Shear&Flexure:

- Compression behavior, strength & elastic properties; Unit/mortar characteristics; Height, bonding patterns,strengthprediction(Indiancontext),failuretheories;Slenderness,eccentricity,absorption, curing, ageing, workmanship; Analytical models.
- Bondstrength(unit-mortar),tests,factors;Orthotropicflexure,shearstrength,testprocedures; Analytical expressions for shear/flexure.

Self-study:Deriveanalyticalexpressionforcompressivestrengthofmasonrybasedonunitandmortarstrength.

LinkedCOs:CO2,CO5 **NumberofHours:10hrs**

Module-3

AnalysisandDesignofLoadBearingMasonryWalls:

- Permissible stresses (compression, tension, shear), stress reduction & shape modification factors; Effectiveheight/length/thickness,slendernessratio,eccentricity, loaddispersion,archingactionin lintels;Designconsiderationsforsolidwalls,cavity walls,wallswithpillars;Axialloaddesign(UDL, solid/cavity walls, cross-wall supported, walls with piers); Stress distribution & load transfer mechanisms.

Self-study:Performstructuralanalysisofaloadbearingwallwithopeningsusingsimpleanalyticalmethods.

LinkedCOs:CO3,CO5 **NumberofHours:8hrs**

Module-4

AnalysisandDesignofWallsunderConcentrated,Eccentric,Lateral&TransverseLoads:

- Concentratedaxialloads(solidwalls,cavitywalls,cross-wallsupported,wallswithpiers,wallswith openings);Eccentricloads(stressdistribution,solid/cavitywalls,wallswithpiers);Combinedaxial&bendi ngstresses;Lateral/transverseloads(solidwallunderwind,shearwall,compoundwalls);Lateral load distribution & stability.

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Self-study:Analyzeamasonryshearwallsubjectedtowindandearthquakeloadsusingcodalprovisions.

LinkedCOs:CO3,CO5 **NumberofHours:8hrs**

Module-5

EarthquakeResistantAnalysis&DesignofMasonryandReinforcedBrickMasonry:

- Earthquakebehavior,concepts&designprocedure,BIScodalprovisions;Seismicanalysismethods; Infilled frames (types, failure modes).
- Reinforcedbrickmasonry:reinforcingmethods,analysisunderaxial/flexural/shearloading, analytical methods for reinforced sections.

Self-study:Performseismicanalysisofasmallmasonrybuildingusingequivalentstaticmethod.

LinkedCOs:CO2,CO5 **NumberofHours:8hrs**

SuggestedLearningResources:

Textbooks/ReferenceBooks

1. Henry,A.W.–StructuralMasonry,MacmillanEducationLtd.,1990.
2. Jagadish,K.S.–StructuralMasonry,I.K.InternationalPublishingHousePvt.Ltd.
3. Dayaratnam,P.–BrickandReinforcedBrickStructures,Oxford&IBH,1987.
4. Gambhir,M.L.–BuildingandConstructionMaterials,McGrawHillEducationPvt.Ltd.

Codes&Guidelines:

5. IS1905–1987–CodeofPracticeforStructuralUseofUn-reinforcedMasonry(3rdRevision),BIS,New Delhi.
6. SP20(S&T)–1991–HandbookonMasonryDesignandConstruction(1stRevision),BIS,NewDelhi.

WeblinksandVideoLectures(e-Resources)

1. NPTEL:MasonryStructures–IITGuwahati
2. NPTEL:EarthquakeResistantMasonryBuildings
3. BISe-booksforIS1905.

Teaching-LearningProcess(InnovativeDeliveryMethods):

Thefollowingaresamplestrategiesthateducatorsmayadopttoenhancetheeffectivenessoftheteaching-learning processandfacilitatetheachievementofcourseoutcomes.SuggestedInnovativeDeliveryMethodsmayinclude (but are not limited to):

- FlippedClassroom
- Problem-BasedLearning(PBL)
- Case-BasedTeaching
- SimulationandVirtualLabs
- PartialDeliveryofcoursebyIndustryexpert/industrialvisits
- ICT-EnabledTeaching
- RolePlay

AssessmentStructure(bothCIEandSEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.

Astudentshallbedeemedtohavesatisfiedtheacademicrequirementsandearnedthecreditsallottedtoa subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE takentogether.

ContinuousInternalEvaluation:

ContinuousComprehensiveAssessments(CCA)+InternalAssessmentTest(IA)=ContinuousInternal Evaluation CIE [25+25=50 marks]

AminimumoftwoInternalAssessmentTests(IA)shallbeconducted.Eachtestshallbeconductedfora maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.

Inaddition,ContinuousComprehensiveAssessment(CCA)shallbeconductedforatotalof25marks

Students'activitiesforTW/SLunderNCrF:Samplesonly AsperNationalcreditformwork(NCrF)studentsmustspend90hoursofstudyfor3creditcourses,whichinclude Courseinstructions(CI-42hour)andTeamwork/Selflearning(TW/Sl-48hours).Hence,studentsmustcomplete minimumoftwoactivesaspartofNCrF.Theselearningactivitiesshallbeconsidered asCCAcomponentsofCIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities arelisted below.Thesampleactivities aregivenbelow.The coursecoordinatorcanalsogivetheirown TW/SLactivitiesasperthecourseoutcomes.		
Sl. No.	**TermWork(TW)Activity**	**Numberof Hours / Semester**
1	Assignments**:** 1. Cracktypeidentificationandanalysis(Mod1/CO1)–8h 2. Compressivestrengthpredictionusinganalyticalmodels(Mod2/CO2)–8h 3. Designofsolidwallunderaxial+windload(Mod4/CO3)– 8h	24
2	Seminars**:** 1. Failuretheoriesofmasonryundercompression(Mod2/CO5)–8h 2. Archingactionandloaddispersioninlintels(Mod3/CO5)–8h 3. Seismicbehaviorofinfilledframes(Mod5/CO2)–8h	24
3	Micro-Project**:** 1. Analyticalmodelformasonrystrengthpredictionusing Python(Mod2/CO5) – 12h 2. Seismicanalysisofasmallmasonrybuilding(Mod5/CO2)–12h	24
SL:SelfLearning,MOOCs,spokentutorials,onlineeducationalresourcesetc.		
Sl. No.	**Self-Learning(SL)Activity**	**Numberof Hours / Semester**
1	NPTEL:MasonryStructures(IITGuwahati)	24
2	IS1905codeself-study	24
3	Seismicanalysispracticeusingequivalentstaticmethod	24

SamplerubricsforTWactivities:

Criteria	4-Excellent	3-Good	2-Satisfactory	1 - Needs Improvement
Problem understanding	Clearproblem framing with strong justification.	Mostlyclear with minor gaps.	Basicattemptwith limited clarity.	Poorlydefined problem.
Dataandmethod	Appropriatedata and sound methodology.	Mostly appropriate with minor issues.	Limiteddataor partialmethod.	Inadequate or incorrectmethod.
Analysis	Robust interpretationand validresults.	Generally sound with minorerrors.	Partialanalysiswith gaps.	Weakorincorrect analysis.
Recommendations	Strong,feasible,	Relevantwith	Generic	Incompleteor

Criteria	4-Excellent	3-Good	2-Satisfactory	1 - Needs Improvement
	andcontext-specific.	minor limitations.	recommendations.	unrealistic.
Presentation	Well organized andprofessional.	Good organization with minor issues.	Acceptablebut uneven.	Poorlypresented.

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ADVANCEDDESIGNOFPRE-STRESSEDCONCRETESTRUCTURES			
Course Code	**1MCSE205E / 1MCCS205E**	Scheme	2026
TypeofCourse	**ProfessionalElectiveCourse**	Semester	II
TeachingHours/Week(L:T:P)	42(3:0:0)	CIEMarks	50
TotalHoursofPedagogyper SemesterCI(L/T):LI(P):TW&SL	90(42:0:0:48)	SEEMarks	50
Credits	3	TotalMarks	100
TypeofExamination(IPCC):	Theory	ExamHours	03

Courseoutcome (CourseSkillSet):

Attheendofthecourse,thestudentwillbeableto:

1. CO1:Understandandapplyadvancedprestressedconcreteprinciples.
2. CO2:Analyzemembersunderaxialloadandflexureusingadvancedmethods
3. CO3:Determinebehaviorofprestressedconcretemembersundervariousloadingconditions
4. CO4:Applyadvancedanalysisanddesignmethodsforshear,torsion,deflection,andcracking
5. CO5:Solvecomplexnumericalproblemsanddesigncontinuousandcantileverbeams.

Module-1

AdvancedAnalysisofMembersUnderAxialLoadandFlexure:

- Introduction to design of prestressed concrete structures. Analysis of Members Under Axial Load: Introduction,analysisattransfer,analysisatserviceloads,analysisofultimatestrength,analysisof behavior.
- Analysis of Members Under Flexure: Introduction, analysis at service loads – based on stress concept, based on force concept, based on load balancing concept, cracking moment, kern point, pressure line, variationofstressinsteel,conditionatultimatelimitstate,analysisofrectangularsections,analysisof flanged sections, analysis of partially prestressed sections, analysis of un-bonded post-tensioned beams, analysis of behavior. Numerical problems.

Self-study:Deriveexpressionsforkernpointsandpressurelinefordifferentcableprofiles.

LinkedCOs:CO1 **NumberofHours:8hrs**

Module-2

AdvancedDesignofMembersforAxialTensionandFlexure:

- Designofmembersforaxialtension:Designofprestressingforce,analysisofultimatestrength.Designof members for flexure – calculation of moment demand: Preliminary design.
- Designof sectionsfor flexure (PartI):Final designfortype1members,special case,final designoftype2 members,choiceofsections,determinationoflimitingzone,post-tensioninginstages,Magnel'sgraphical method. Detailing requirements for flexure, shear, and torsion. Numerical problems.

Self-study:ApplyMagnel'sgraphicalmethodforagivenbeamsectionandloading.

LinkedCOs:CO2, CO4 **NumberofHours:10hrs**

Module-3

AdvancedAnalysisandDesignforShearandTorsion:

- Analysisforshear:Introduction,stressinanuncrackedbeam,typesofcracks,componentsofshear resistance, modes of failure, effect of prestressing force.
- Designforshear:Limitstateofcollapseforshear,maximumpermissibleshearstress,designoftransverse reinforcement, detailing requirement for shear, general comments, design steps, design of stirrups for flange.
- Analysisfortorsion:Introduction,stressesinanuncrackedbeam,crackpatternunderpuretorsion, components of resistance for pure torsion, modes of failure, effect of prestressing force.
- Design for torsion: Limit state of collapse for torsion, design of longitudinal reinforcement, design of transversereinforcement,detailingrequirements,generalcomments,designsteps.Numericalproblems.

*Self-study:CompareshearandtorsiondesignprovisionsbetweenIS1343andACIcodes.

LinkedCOs:CO3,CO4 **NumberofHours:8hrs**

Module-4

AdvancedCalculationsofDeflection,CrackWidth&TransmissionofPrestress

- Calculation of deflection: Deflection due to gravity loads, deflection due to prestressing force, total deflection,limitsofdeflection,determinationofmoment ofinertia,limitsofspan-to-effectivedepthratio.
- Calculationofcrackwidth:Methodofcalculation,limitsofcrackwidth.
- Transmissionofprestress:Introduction,pre-tensionedmembers,transmissionlength,development length, end zone reinforcement, post-tensioned members, end zone reinforcement, bearing plate. Numerical problems.

Self-study:DevelopanExcelsheetfordeflectioncalculationofaprestressedconcretebeam.

LinkedCOs:CO3,CO4 **NumberofHours:8hrs**

Module-5

AdvancedDesignofCantileverandContinuousBeams

- Cantileverbeams:Introduction,analysis,determinationoflimitingzone,cableprofile.
- Continuousbeams:Introduction,analysis,incorporationofmomentduetoreactions,pressureline due to prestressing force, concordant cable profile, cable profiles, partially continuous beams, analysis at ultimate limit state, moment redistribution. Numerical problems.

Self-study:Analyzeatwo-spancontinuousprestressedbeamusingconcordantcableprofile.

LinkedCOs:CO4, CO5 **NumberofHours:8hrs**

SuggestedLearningResources:

Textbooks

1. Nagarajan,Praveen–AdvancedConcreteDesign,Pearson.
2. Dayaratnam,P.–PrestressedConcreteStructures,Oxford&IBHPublishingCompany,Delhi.
3. Lin,T.Y.&Burns,N.H.–DesignofPre-stressedConcreteStructures,JohnWileyandSons,NewYork.

ReferenceBooks

3. IS1343:2012–CodeofPracticeforPrestressedConcrete,BIS,NewDelhi.
4. Collins,M.P.&Mitchell,D.–PrestressedConcreteStructures,ResponsePublications

WeblinksandVideoLectures(e-Resources)

1. NPTEL:PrestressedConcreteStructures–IITMadras
2. YouTube
   Playlist:
   https://www.youtube.com/watch?v=undsd92MM8w&list=PLbQO4xhI7wEDIYv90NoF7veaJIohpuf0Q
3. IS1343codesummaryanddesignexamples

Teaching-LearningProcess(InnovativeDeliveryMethods):

Thefollowingaresamplestrategiesthateducatorsmayadopttoenhancetheeffectivenessoftheteaching-learning processandfacilitatetheachievementofcourseoutcomes.SuggestedInnovativeDeliveryMethodsmayinclude(but are not limited to):

- FlippedClassroom
- Problem-BasedLearning(PBL)
- Case-BasedTeaching
- SimulationandVirtualLabs
- PartialDeliveryofcoursebyIndustryexpert/industrialvisits
- ICT-EnabledTeaching
- RolePlay

AssessmentStructure(bothCIEandSEE)

The weightage assigned to Continuous Internal Evaluation(CIE) and SemesterEnd Examination (SEE) shall be 50%each.Astudentshallsecureaminimumof50%ofthemaximummarksprescribedforCIEandaminimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/courseonlyifhe/shesecuresnotlessthan50% oftheaggregatemarksobtainedinCIEandSEEtaken together.

ContinuousInternalEvaluation:

ContinuousComprehensiveAssessments(CCA)+InternalAssessmentTest(IA)=ContinuousInternal Evaluation CIE [25+25=50 marks]

AminimumoftwoInternalAssessmentTests(IA)shallbeconducted.Eachtestshallbeconductedfora maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.

Inaddition,ContinuousComprehensiveAssessment(CCA)shallbeconductedforatotalof25marks

Students'activitiesforTW/SLunderNCrF:Samplesonly

AsperNationalcreditformwork(NCrF)studentsmustspend90hoursofstudyfor3creditcourses,whichinclude Courseinstructions(CI-42hour)andTeamwork/Selflearning(TW/Sl-48hours).Hence,studentsmustcomplete minimumoftwoactivesaspartofNCrF.Theselearningactivitiesshallbeconsidered asCCAcomponentsofCIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities arelisted below.Thesampleactivities aregivenbelow.The coursecoordinatorcanalsogivetheirown TW/SLactivitiesasperthecourseoutcomes.

Sl. No.	TermWork(TW)Activity	NumberofHours /Semester
1	Assignments: 1. Analysisofrectangularflangedsectionunderflexure(Mod1/CO2)–8h 2. Magnel'sgraphicalmethodforlimitingzone(Mod2/CO4)–8h 3. Designoftransversereinforcementforshearandtorsion(Mod3/CO4)–8h	24
2	Seminars: 1. Comparisonofstress,force,andloadbalancingconcepts(Mod1/CO1)–8h 2. Endzonereinforcementinpost-tensionedmembers(Mod4/CO3)–8h 3. Concordantcableprofileandmomentredistribution(Mod5/CO5)–8h	24
3	Micro-Project: 1. Excel-baseddesigntoolforprestressedrectangularbeam(Mod2/CO4)–12h 2. Continuousbeamanalysisusingconcordantprofile(Mod5/CO5)–12h	24

SL:SelfLearning,MOOCs,spokentutorials,onlineeducationalresourcesetc.

Sl. No.	Self-Learning(SL)Activity	NumberofHours /Semester
1	NPTEL:PrestressedConcreteStructures(IITMadras)	24
2	IS1343:2012codeself-study	24
3	YouTubeplayliston advancedprestressed concrete	24

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SamplerubricsforTWactivities:

Criteria	4-Excellent	3-Good	2-Satisfactory	1 - Needs Improvement
Problem understanding	Clearproblem framing with strong justification.	Mostlyclear with minor gaps.	Basicattemptwith limited clarity.	Poorlydefined problem.
Dataandmethod	Appropriatedata and sound methodology.	Mostly appropriate with minor issues.	Limiteddataor partialmethod.	Inadequate or incorrectmethod.
Analysis	Robust interpretationand validresults.	Generally sound with minorerrors.	Partialanalysiswith gaps.	Weakorincorrect analysis.
Recommendations	Strong,feasible, and context-specific.	Relevantwith minor limitations.	Generic recommendations.	Incompleteor unrealistic.
Presentation	Well organized andprofessional.	Good organization with minor issues.	Acceptablebut uneven.	Poorlypresented.

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STRUCTURALRELIABILITYANALYSISANDDESIGN			
Course Code	**1MCSE205F / 1MCCS205F / 1MCAS205F**	Scheme	2026
TypeofCourse	**ProfessionalElectiveCourse**	Semester	II
TeachingHours/Week(L:T:P)	42(3:0:0)	CIEMarks	50
TotalHoursofPedagogyper SemesterCI(L/T):LI(P):TW&SL	90(42:0:0:48)	SEEMarks	50
Credits	3	TotalMarks	100
TypeofExamination(IPCC):	Theory	ExamHours	03

Courseoutcome (CourseSkillSet):

Attheendofthecourse,thestudentwillbeableto:

1. CO1:Explaintheconceptsofstructuralreliability,uncertainty,probabilitytheory,andsafetyformatsin structural design.
2. CO2:Evaluatestatisticalcharacteristicsofloads,materialstrengths,andstructuralresistancefor engineering applications.
3. CO3:Applyreliabilitymethodsforsafetyassessmentanddesignofstructuralcomponentsandsystems.
4. CO4:Analyzefailureprobability,reliabilityindex,andriskmeasuresforstructuralperformance evaluation.
5. CO5:Integratereliability-basedconceptsintolimitstatedesign,loadcombination,anddecision-making.
6. CO6:Interpretstructuralsafetyandserviceabilityrequirementsusingprobabilisticdesignphilosophy.

Module-1

IntroductiontoStructuralReliability:

Need for reliability analysis in structural engineering, uncertainty in loads, material properties, geometry, modelling, and workmanship. Deterministic versus probabilistic design, concepts of safety, failure, and performance.Basicprobabilitytheory,randomvariables,probabilitydistributions,mean,variance,covariance, and correlation. Reliability concepts, failure domain, safety margin, and performance functions.

LinkedCOs:CO1,CO6. **NumberofHours: 08**

Module-2

StatisticalCharacterizationofLoadsandResistance:

Statistical modelling of dead load, live load, wind load, earthquake load, and environmental actions. Statistical properties of concrete, steel, timber, and other structural materials. Resistance modelling, bias factors, and coefficientofvariation.Data fitting,estimationofparameters,andinterpretationofprobabilisticinputvariables. Load and resistance uncertainty in structural design.

LinkedCOs:CO2,CO6. **NumberofHours:08**

Module-3

ReliabilityMethodsandFailureProbability:

First-orderandsecond-orderreliabilityconcepts,safetyindex,probabilityoffailure,andreliabilityindex.Analytical and numerical methods for reliability evaluation. Mean value approach, level I, level II, and level III methods. FORM and SORM concepts, transformation of variables, design point, and sensitivity factors. Monte Carlo simulation and basic simulation-based reliability estimation.

LinkedCOs:CO3,CO4. **NumberofHours: 08**

Module-4

Reliability-BasedDesignofStructuralElements:

Reliability-basedlimitstatedesign,ultimateandserviceabilitylimitstates,partialsafetyfactors,targetreliability,and calibrationconcepts.Reliabilityanalysisofbeams,columns,slabs,andconnections.Loadcombinations,resistance factors,anddesigncheckunderuncertainty.Applicationofreliabilityconceptstoreinforcedconcreteandsteel structures.

LinkedCOs:CO3,CO5,CO6. **NumberofHours:08**

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Module-5

SystemReliability,Risk,andDecisionMaking:

Systemreliabilityofstructuralassemblies,seriesandparallelsystems,redundancy,andcomponentinteraction. Deterioration,ageing,fatigue,corrosion,andtime-dependentreliability.Risk,consequenceoffailure,inspection planning, maintenance, and life-cycle performance. Reliability updating, Bayesian concepts, anddecision-making under uncertainty. Case studies on structural safety assessment and reliability-based design.

LinkedCOs:CO4,CO5,CO6. **NumberofHours: 08**

SuggestedLearningResources:

Textbooks

1. Melchers,R.E.andBeck,A.T.,StructuralReliabilityAnalysisandPrediction,3rdEdition,Wiley.
2. Ang,A.H.S.andTang,W.H.,ProbabilityConceptsinEngineeringPlanningandDesign,Vol.IandII,Wiley.
3. Kapoor,V.K.,StructuralReliability:TheoryandApplications,StandardPublishers.
4. Trivedi,R.K.,Probability,StatisticsandReliabilityforEngineers,McGraw-HillEducation.

ReferenceBooks

1. Nowak,A.S.andCollins,K.R.,ReliabilityofStructures,2ndEdition,CRCPress.
2. Benjamin,J.R.andCornell,C.A.,Probability,Statistics,andDecisionforCivilEngineers,DoverPublications.
3. Ditlevsen,O.andMadsen,H.O.,StructuralReliabilityMethods,Wiley.
4. ISO2394,GeneralPrinciplesonReliabilityforStructures,LatestEdition.

WeblinksandVideoLectures(e-Resources)

1. NPTEL/SWAYAMcoursesonprobabilisticmethodsandstructuralreliability.
2. Professionallecturesonreliability-baseddesignandstructuralsafetyassessment.
3. Referencematerialsonprobabilisticstructuraldesignandlife-cycleassessment.

Teaching-LearningProcess(InnovativeDeliveryMethods):

Thefollowingaresamplestrategiesthateducatorsmayadopttoenhancetheeffectivenessoftheteaching-learning processandfacilitatetheachievementofcourseoutcomes.SuggestedInnovativeDeliveryMethodsmayinclude(but are not limited to):

- FlippedClassroom
- Problem-BasedLearning(PBL)
- Case-BasedTeaching
- SimulationandVirtualLabs
- PartialDeliveryofcoursebyIndustryexpert/industrialvisits
- ICT-EnabledTeaching
- RolePlay

AssessmentStructure(bothCIEandSEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/courseonlyifhe/shesecuresnotlessthan50% oftheaggregatemarksobtainedinCIEandSEEtaken together.

ContinuousInternalEvaluation:

ContinuousComprehensiveAssessments(CCA)+InternalAssessmentTest(IA)=ContinuousInternal Evaluation CIE [25+25=50 marks]

AminimumoftwoInternalAssessmentTests(IA)shallbeconducted.Eachtestshallbeconductedforamaximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.

Inaddition,ContinuousComprehensiveAssessment(CCA)shallbeconductedforatotalof25marks

Students'activitiesforTW/SLunderNCrF:Samplesonly

AsperNationalcreditformwork(NCrF)studentsmustspend90hoursofstudyfor3creditcourses,whichinclude Courseinstructions(CI-42hour)andTeamwork/Selflearning(TW/Sl-48hours).Hence,studentsmust complete

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minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. Theevaluationactivities will bedoneusing setof rubricsdeveloped foreachactivity. Thefollowingsampleactivities arelistedbelow.Thesampleactivitiesaregivenbelow.Thecoursecoordinatorcanalsogivetheirown TW/SL activitiesasperthecourseoutcomes.		
Sl. No.	**TermWork(TW)Activity**	**NumberofHours /Semester**
1	**TW-1:ProbabilityDistributionExercise:**Studentsshallanalyzesampledata for load or material strength and fit an appropriate probability distribution. Theyshallcomputemean,variance,standarddeviation,andcommentonthe suitabilityofthefittedmodel.	24
2	**TW-2:ReliabilityIndexCalculation:**Studentsshallevaluatereliabilityindex andprobabilityoffailureforasimplestructuralelementusinggivenloadand resistance data.	24
3	**TW-3:FORM-BasedStructuralCheck**:StudentsshallperformabasicFORM-basedreliabilityassessmentforastructuralmemberandinterpretthedesign point and sensitivity factors.	24
4	**TW-4:Reliability-BasedDesignComparison:**Studentsshallcompare deterministicdesignandreliability-baseddesignforachosenstructural componentandpresentdesignimplications.	24
SL:SelfLearning,MOOCs,spokentutorials,onlineeducationalresourcesetc.		
Sl. No.	**Self-Learning(SL)Activity**	**NumberofHours /Semester**
1	**SL-1:CaseStudyonStructuralFailure:**Studentsshallstudyastructural failurecaseandidentifytheroleofuncertainty,modellingerror,material variation, and design assumptions.	24
2	**SL-2:ReliabilityofStructuralSystems:**Studentsshallpreparareporton series and parallel system reliability with examples from buildings, bridges, or frames.	24
3	**SL-3:MaintenanceandInspectionPlanning:**Studentsshallproposean inspection andmaintenanceplan foradeterioratingstructureusingreliability concepts.	24
3	**SL-4:Software/SpreadsheetImplementation:**Studentsshalldevelopa spreadsheetorsimplecomputationalmodeltoestimatereliabilityindexfora structuralelement.	24

SamplerubricsforTWactivities:

Criteria	4-Excellent	3-Good	2-Satisfactory	1 - Needs Improvement
Problem understanding	Clearproblem framing with strong justification.	Mostlyclear with minor gaps.	Basicattemptwith limited clarity.	Poorlydefined problem.
Dataandmethod	Appropriatedata and sound methodology.	Mostly appropriate with minor issues.	Limiteddataor partialmethod.	Inadequate or incorrectmethod.
Analysis	Robust interpretationand	Generallysound with minor	Partialanalysiswith gaps.	Weakorincorrect analysis.

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Criteria	4-Excellent	3-Good	2-Satisfactory	1 - Needs Improvement
	validresults.	errors.		
Recommendations	Strong,feasible, and context-specific.	Relevantwith minor limitations.	Generic recommendations.	Incompleteor unrealistic.
Presentation	Well organized andprofessional.	Good organization with minor issues.	Acceptablebut uneven.	Poorlypresented.

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CONSTRUCTIONMATERIALSANDTHEIRPROPERTIES			
Course Code	**1MCSE206A / 1MCAS206B**	Scheme	2026
TypeofCourse	**ProfessionalElectiveCourse**	Semester	II
TeachingHours/Week(L:T:P)	42(3:0:0)	CIEMarks	50
TotalHoursofPedagogyper SemesterCI(L/T):LI(P):TW&SL	90(42:0:0:48)	SEEMarks	50
Credits	3	TotalMarks	100
TypeofExamination(IPCC):	Theory	ExamHours	03

Courseoutcome (CourseSkillSet):

Attheendofthecourse,thestudentwillbeableto:

1. CO1:Analyzematerialpropertiesfrommicrostructuretomacro-performancefordesignandspecification.
2. CO2:Selectandjustifyadvancedmaterialsforperformance,durability,andsustainabilityincivil applications.
3. CO3:Interpretlaboratoryandnon-destructivetestdataandrelatetoservicebehaviour.
4. CO4:Formulatematerialspecification,mix/designproceduresandqualitycontrolforadvancedconcretes and composites.
5. CO5:Assesslife-cycle,environmentalanddurabilityaspectsandproposeremediationormitigation strategies.

Module-1

FundamentalsandMaterialScience:

- Atomic/bondingandcrystal/amorphousstructuresrelevanttoceramics,metals,polymersand composites.
- Phaseformation,microstructure,porosityandtheirinfluenceonmechanicalandtransportproperties.
- Thermomechanicalproperties,creep,fatigueandfracturemechanicsbasicsforconstructionmaterials.
- Standards,specificationsandqualityassuranceframeworks(nationalandinternational)relevantto materials.

Learningoutcomes:

- **Explainhowmicrostructurecontrolsstiffness,strength,toughnessandtransportproperties.**
- **Relatebasicmaterialsscienceprinciplestoselectionofmaterialsforstructuralandnon-structural components.**

LinkedCOs:CO1 **NumberofHours:8hrs**

Module-2

TraditionalMaterials:CementitiousSystems,Aggregates,Mortars:

- OrdinaryPortlandcementchemistry,hydration,microstructureevolution,heatofhydration,andphase assemblages.
- Supplementarycementitiousmaterials(flyash,GGBS,silicafume,metakaolin):rolesandreaction mechanisms.
- Aggregates:mineralogy,grading,physicalandmechanicaltests,alkali-aggregatereaction.
- Mortars:types,interfaces(mortar–unit,aggregate–paste),bond,andshrinkage/creepphenomena.
- Mixdesignprinciplesforconventionalandblendedcementconcretes;freshandhardened **propertiestests.**

Learning outcomes:

- EvaluatecementandSCMselectionfortargetedperformanceanddurability.
- Performmix-designreasoningforspecificstrength/durabilitytargetsandinterpretstandardtestresults.

LinkedCOs: CO2 **NumberofHours:8hrs**

Module-3

AdvancedandHigh-PerformanceMaterials:

- High-performanceconcrete(HPC),high-strengthconcrete(HSC),ultra-highperformanceconcrete(UHPC):

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constituents,fiberreinforcement,andmicrostructuraltailoring.

- Engineeredcementitiouscomposites(ECC),self-consolidatingconcrete(SCC),geopolymerbindersand alkali-activated materials.
- Cementless/low-carbonbinders,carboncapture/utilizationinbinders,andrecycle-basedbinders.
- Fiber-reinforcedpolymers(FRP),FRP-concreteinterfaces,polymer-modifiedmortars,andadvanced adhesives/sealants.

Learningoutcomes:

- Differentiateadvancedcementitioussystemsandcompositesbymechanismsandapplications.
- Proposeanadvancedmaterialsolution(e.g.,UHPC,ECC,geopolymer)foraspecifiedperformance requirement.

LinkedCOs:CO3 **NumberofHours:9hrs**

Module-4

Durability,Degradation,TestingandNon-DestructiveEvaluation:

- Durabilitymechanisms:chlorideingressandcorrosion,carbonation,sulfateattack,alkali-silicareaction, freeze–thaw, sulfate and acid environments.
- Long-termperformance:creep,shrinkage,thermaleffects,andfatiguefordifferentmaterialclasses.
- Laboratoryandfieldtests:acceleratedddurabilitytests,permeability,diffusion,electricalresistivity,heatof hydration, and micro-analysis (SEM, XRD, TGA).
- Non-destructivetesting(NDT):ultrasonicpulsevelocity,reboundhammer,GPR,corrosionpotential mapping, acoustic emission, and sensor-based monitoring.

Learningoutcomes:

- Interpretdurabilitytestdataandpredictservicelifeusingappropriatemodelsorindices.
- Recommendinspection,monitoringandrehabilitationstrategiesbasedonNDTfindings.

LinkedCOs:CO2 **NumberofHours:9hrs**

Module-5

Sustainability,Life-Cycle,StandardsandApplications:

- Environmentalimpacts,embodiedcarbon,life-cycleassessment(LCA)formaterials,andstrategiesfor low-carbon design.
- Recycledandwaste-derivedmaterials:recycledaggregates,wasteglass,slag,flyash,andindustrial by-products.
- Smartmaterialsandsensors(self-healingconcretes,phasechangematerials,embeddedsensors,andIoT for materials health).
- Designcodes,materialspecifications,procurement,QC/QA,andcasestudiesofadvancedmaterial applications in bridges, high-rise, marine and seismic regions.

Learningoutcomes:

- ConductabasicLCAcomparisonandrecommendmaterialchoicestolowerenvironmentalfootprint.
- Criticallyassesspracticalconstraints,standardscompliance,andqualitycontrolforusingadvanced materials in projects.

LinkedCOs: CO5 **NumberofHours:8hrs**

SuggestedLearningResources:

Textbooks

1. Mamlouk,M.S.andZaniewski,J.P.,MaterialsforCivilandConstructionEngineers,4thEdition,Pearson.
2. Soutsos,M.andDomone,P.,ConstructionMaterials:TheirNatureandBehaviour,5thEdition,CRCPress.
3. Claisse,P.A.,CivilEngineeringMaterials:FromTheorytoPractice,1stEdition,Elsevier.

4. Duggal,S.K.,BuildingMaterials,3rdEdition,NewAgeInternationalPublishers.
5. Varghese,P.C.,BuildingMaterials,2ndEdition,Prentice-HallofIndia.

ReferenceBooks

1. Gonçalves,M.C.andMargarido,F.(Eds.),MaterialsforConstructionandCivilEngineering:Science, Processing, and Design, 1st Edition, Springer Cham.
2. Illston,J.M.andDomone,P.L.J.,ConstructionMaterials:TheirNatureandBehaviour,3rdEdition,E&FN Spon.
3. Mamlouk,M.S.andZaniewski,J.P.,MaterialsforCivilandConstructionEngineers,3rdEdition,Pearson.
4. A.M.Neville,PropertiesofConcrete,5thEdition,Pearson.
5. Mehta,P.K.andMonteiro,P.J.M.,Concrete:Microstructure,Properties,andMaterials,4thEdition,McGraw-Hill Education.

Weblinks andVideoLectures(e-Resources):

1. Springer:*MaterialsforConstructionandCivilEngineering*—**SpringerCham**.
2. Taylor&Francis/CRCPress:*ConstructionMaterials:TheirNatureandBehaviour*—**CRCPress**.
3. Pearson:*MaterialsforCivilandConstructionEngineers*—**Pearson**.
4. VTUsyllabusportalandcivilengineeringsyllabuspagesforformatalignment
5. NPTELanduniversitylecture-noterepositoriesforenrichmentandlabsupport.

Teaching-LearningProcess(InnovativeDeliveryMethods):
Thefollowingaresamplestrategiesthateducatorsmayadopttoenhancetheeffectivenessoftheteaching-learning processandfacilitatetheachievementofcourseoutcomes.SuggestedInnovativeDeliveryMethodsmayinclude(butare not limited to):

- FlippedClassroom
- Problem-BasedLearning(PBL)
- Case-BasedTeaching
- SimulationandVirtualLabs
- PartialDeliveryofcoursebyIndustryexpert/industrialvisits
- ICT-EnabledTeaching
- RolePlay

AssessmentStructure(bothCIEandSEE)
TheweightageassignedtoContinuousInternalEvaluation(CIE)andSemesterEndExamination(SEE)shallbe50% each.Astudentshall secure a minimum of50%ofthe maximum marks prescribedforCIE anda minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.
A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/courseonlyifhe/shesecuresnotlessthan50% oftheaggregatemarksobtainedinCIEandSEEtaken together.
ContinuousInternalEvaluation:
ContinuousComprehensiveAssessments(CCA)+InternalAssessmentTest(IA)=ContinuousInternalEvaluation CIE [25+25=50 marks]
AminimumoftwoInternalAssessmentTests(IA)shallbeconducted.Eachtestshallbeconductedforamaximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.
Inaddition,ContinuousComprehensiveAssessment(CCA)shallbeconductedforatotalof25marks

Students'activitiesforTW/SLunderNCrF:Samplesonly
As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimumoftwoactivesaspartofNCrF.TheselearningactivitiesshallbeconsideredasCCAcomponentsofCIE.The evaluationactivitieswillbedoneusingsetofrubricsdevelopedforeachactivity.Thefollowingsampleactivitiesare

listedbelow.Thesampleactivitiesaregivenbelow.Thecoursecoordinatorcanalsogivetheirown TW/SLactivities asperthecourseoutcomes.		
Sl. No.	**TermWork(TW)Activity**	**NumberofHours/ Semester**
1	Materialpropertycomparisonchartforconventionaland advancedmaterials.	24
2	Mix-designexerciseforconventionalconcrete,SCC,or geopolymerconcrete.	24
3	LabdatainterpretationworksheetonUPV,reboundhammer, chloride ingress, or sorptivity.	24
SL:SelfLearning,MOOCs,spokentutorials,onlineeducationalresourcesetc.		
Sl. No.	**Self-Learning(SL)Activity**	**NumberofHours/ Semester**
1	Seminarononeadvancedmaterial:UHPC,ECC,FRP,geopolymer, self-healing concrete, or smart concrete.	24
2	Grouppresentationonsustainabilityandlife-cycleassessmentof construction materials.	24
3	Mini-projectonselectionofmaterialsforamarine,bridge,or high-riseapplication.	24

SamplerubricsforTWactivities:

Criteria	**Excellent(4)**	**Good(3)**	**Satisfactory (2)**	**NeedsImprovement (1)**
Technicalaccuracy	All concepts correct,precise, and complete.	Minor errors, mostlycorrect.	Some gaps in understanding.	Majorconceptual errors.
Analysisandapplication	Deepanalysis, strong applicationto civilproblems.	Good applicationwith minorgaps.	Limited application.	Poor or no application.
Presentation/format	Clear, well-organized, professional format.	Mostly clear andorganized.	Acceptablebut inconsistent.	Poorstructureand readability.
Datainterpretation	Correct interpretationof results and trends.	Mostlycorrect interpretation.	Partial interpretation.	Incorrectorabsent interpretation.
Timelinessand completeness	Submitted on time,complete, and neat.	Minor delay or minoromission.	Severalmissing elements.	Lateorincomplete.

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ADVANCEDCONSTRUCTIONMATERIALCHARACTERIZATIONTECHNIQUES			
Course Code	**1MCSE206B / 1MCAS206C / 1MCCS206A**	Scheme	2026
TypeofCourse	**ProfessionalElectiveCourse**	Semester	II
TeachingHours/Week(L:T:P)	42(3:0:0)	CIEMarks	50
Total HoursofPedagogyper SemesterCI(L/T):LI(P):TW&SL	90(42:0:0:48)	SEEMarks	50
Credits	3	TotalMarks	100
TypeofExamination(IPCC):	Theory	ExamHours	03

Courseoutcome(CourseSkill Set):

Attheendofthecourse,thestudentwillbeableto:

1. CO1:Selectadvancedconstructionmaterialsforspecificcivilengineeringapplications.
2. CO2:Explainthebehavior,properties,andperformanceofspecialconcretesandalternativematerials.
3. CO3:Applyappropriatelaboratoryandfieldcharacterizationtechniquesforconstructionmaterials.
4. CO4:Interprettestresultstoassessdurability,quality,andservice-lifeperformance.
5. CO5:Recommendsustainableandindustry-relevantmaterialsolutionsformodernconstruction.

Module-1

Advanced CementitiousMaterials:

- Overview of advanced construction materials, performance requirements, and industry drivers. Blended cements,silicafume,GGBS,flyash,metakaolin,ricehusk ash,andlimestonecalcinedclaysystems.Chemical admixtures, mineral admixtures, hydration modification, and durability enhancement. Alkali-activated binders and geopolymer basics, with emphasis on CO2 reduction and service-life improvement

LinkedCOs:CO1,CO2 **NumberofHours:8hrs**

Module-2

SpecialConcretesandComposites:

- High-performance concrete, self-compacting concrete, high-strength concrete, lightweight concrete, fiber reinforcedconcrete,ferrocement,ultra-high-performanceconcrete,androllercompactedconcrete.Mixdesign principles,fresh andhardened properties,applicationsinbuildings, bridges, pavements,and precastsystems. Introductiontoemergingmaterialssuchas3D-printableconcreteandmultifunctionalcementitiouscomposites.

LinkedCOs:CO1,CO2 **NumberofHours:8hrs**

Module-3

SustainableAlternativeMaterials:

- Recycledconcreteaggregate,manufacturedsand,industrialby-products,demolitionwasteutilization,and earth-based/low-carbonmaterials.Agro-wasteandmine-waste-basedbuildingproducts,stabilizedblocks,and masonryunits.Geosynthetics,stabilizationadditives,andcircularconstructionconceptsforresourceefficiency and waste minimization.

LinkedCOs:CO1,CO2,CO5 **NumberofHours:8hrs**

Module-4

CharacterizationTechniquesI:

- Samplingandspecimenpreparationforcement,concrete,aggregates,andcompositematerials.Mechanicaland physical tests: compressive strength, split tensile strength, flexural strength, modulus of elasticity, sorptivity, permeability, RCPT, shrinkage, and abrasion. Fresh concrete characterization, rheology, workability, and durability assessment. Introduction to QA/QC protocols and correlation of lab tests with field performance

LinkedCOs:CO3,CO4 **NumberofHours:8hrs**

Module-5

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CharacterizationTechniquesII:
Opticalmicroscopy,SEM,TEM,andimageanalysisformicrostructure study.XRDforphaseidentification,XRF/EDS/FTIR for chemical characterization, TGA/DTA/DSC for thermal behavior, and pore structure interpretation. NDT and in-situ methods such as rebound hammer, UPV, cover meter, GPR, half-cell potential, carbonation depth, and corrosion assessment. Selectionoftechniquesbasedonthematerialproblemandindustryapplication.

LinkedCOs:CO3,CO54,CO5 **NumberofHours:8hrs**

SuggestedLearningResources:

Textbooks

1. **A.M.Neville**,*PropertiesofConcrete*,Pearson,**5thEdition**.
2. **M.L.Gambhir**,*ConcreteTechnology:TheoryandPractice*,McGrawHillEducation,**5thEdition**.
3. **P.K.MehtaandP.J.M.Monteiro**,*Concrete:Microstructure,Properties,andMaterials*,McGrawHillEducation, **4thEdition**.
4. **JohnNewmanandBanSengChoo**,*AdvancedConcreteTechnology*,CRCPress,**1stEdition**.
5. **K.Ramamurthy**,*MaterialsandEngineeringCharacterization*,relevantuniversity-leveledition/printmaybe used where available.

ReferenceBooks

1. **R.Dayal**,*SpecialConcreteandSustainabilityinConstruction*,NewAgeInternational,**latestedition**.
2. **N.KrishnaRaju**,*AdvancedReinforcedConcreteDesign*,CBSPublishers,**latestedition**.
3. **J.FrancisYoungandS.Mindess**,*Concrete*,PrenticeHall,**latestedition**.
4. **M.S.Shetty**,*ConcreteTechnology:TheoryandPractice*,S.Chand,**latestedition**.
5. **B.S.NarayananandP.Azhagusundaram**,*TestingofMaterialsandStructures*,**latestedition**.

WeblinksandVideoLectures(e-Resources)

1. VTUConsortiume-resourcesforaccesstoIEEE,ScienceDirect,Springer,Taylor&Francis,Emerald,EBSCO, and other scholarly content.
2. NPTEL/SWAYAMmodulesonconcrete technology,material characterization,anddurabilityassessment.
3. IScodesandASTMstandardsfortestingofcement,concrete,aggregates,durability,andNDTmethods.

Teaching-LearningProcess(InnovativeDeliveryMethods):
Thefollowingaresamplestrategiesthateducatorsmayadopttoenhancetheeffectivenessoftheteaching-learning processandfacilitatetheachievementofcourseoutcomes.SuggestedInnovativeDeliveryMethodsmayinclude(butare not limited to):

- FlippedClassroom
- Problem-BasedLearning(PBL)
- Case-BasedTeaching
- SimulationandVirtualLabs
- PartialDeliveryofcoursebyIndustryexpert/industrialvisits
- ICT-EnabledTeaching
- RolePlay

AssessmentStructure(bothCIEandSEE):
TheweightageassignedtoContinuousInternalEvaluation(CIE)andSemesterEndExamination(SEE) shallbe50% each.Astudentshallsecureaminimumof50%ofthemaximummarksprescribedforCIEandaminimumof40%of the maximum marks prescribed for SEE to be eligible for passing.
A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/courseonlyifhe/shesecuresnotlessthan50%oftheaggregatemarksobtainedinCIEandSEEtaken together.

ContinuousInternalEvaluation:
ContinuousComprehensiveAssessments(CCA)+InternalAssessmentTest(IA)=ContinuousInternalEvaluation CIE [25+25=50 marks]
AminimumoftwoInternalAssessmentTests(IA)shallbeconducted.Eachtestshallbeconductedforamaximumof 25 marks. The average of the two test marks shall be the marks secured by a student in IA.
Inaddition,ContinuousComprehensiveAssessment(CCA)shallbeconductedforatotalof25marks

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Students'activitiesforTW/SLunderNCrF:Samplesonly AsperNationalcreditformwork(NCrF)studentsmustspend90hoursofstudyfor3creditcourses,whichinclude		
Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listedbelow.Thesampleactivitiesaregivenbelow.Thecoursecoordinatorcanalsogivetheirown TW/SLactivitiesas perthecourseoutcomes.		
Sl. No.	**TermWork(TW)Activity**	**NumberofHours/ Semester**
1	MixdesignexerciseforHPC,SCC,andgeopolymerconcreteusing given material data.	24
2	CharacterizationdatainterpretationfromXRD,SEM,UPV,and RCPT test reports.	24
3	**Durability-baseddesignworksheet**comparingconventional and sustainable mixes.	24
4	Labrecordanalysisofstrengthanddurabilityperformanceof alternate materials.	24
SL:SelfLearning,MOOCs,spokentutorials,onlineeducationalresourcesetc.		
Sl. No.	**Self-Learning(SL)Activity**	**NumberofHours/ Semester**
1	Reviewoneresearchpaperon**geopolymerorUHPC**and prepare a summary report	24
2	YouTubeplaylistonXRDandSEManalysis	24
3	MIPdataanalysispracticeusingopendatasets	24

SamplerubricsforTWactivities:

Criterion	Excellent	Good	Satisfactory	NeedsImprovement
Technicalcorrectness	Accurate,complete, and well-justified	Minoromissions	Partially correct	Majorerrors
Method/application	Appropriatemethod selectedandapplied	Mostly appropriate	Limited application	Inappropriatemethod
Analysisandinterpretation	Clear,logical,and insightful	Adequate interpretation	Basic interpretation	Weakorabsent
Presentation	Neat,structured, andprofessional	Mostlyneat	Acceptable	Poorlyorganized
Timeliness	Submittedontime	Minordelay	Late submission	Notsubmitted

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DESIGNOFPRECAST and COMPOSITESTRUCTURES			
Course Code	**1MCSE206C / 1MCAS206D / 1MCCS206C**	Scheme	2026
TypeofCourse	**ProfessionalElectiveCourse**	Semester	II
TeachingHours/Week(L:T:P)	42(3:0:0)	CIEMarks	50
TotalHoursofPedagogyper SemesterCI(L/T):LI(P):TW&SL	90(42:0:0:48)	SEEMarks	50
Credits	3	TotalMarks	100
TypeofExamination(IPCC):	Theory	ExamHours	03

Courseoutcome (CourseSkillSet):

Attheendofthecourse,thestudentwillbeableto:

1. Explainthebasicconcepts,advantages,limitations,andapplicationsofprecastandcompositestructures.
2. Designprecaststructuralelementsandtheirconnectionsconsideringhandling,erection,andservice conditions.
3. Analyzeanddesigncompositebeams,slabs,andfloorsystemsfordifferentloadingconditions.
4. Evaluatejointbehavior,diaphragmaction,andstabilityrequirementsinprecastandcompositebuildings.
5. Preparedesignanddetailingrequirementsforpracticalprecastandcompositeconstructionsystems.

Module-1

Fundamentalsofprecastconstruction:

Introduction to precast concrete systems, advantages and limitations, applications in buildings and infrastructure, classificationofprecastelements,materialsforprecastconstruction, manufacturing andqualitycontrol,tolerances, storage,transportation,lifting,anderectionconsiderations.Planningofprecastsystems,modularcoordination,and concept of structural integrity in precast buildings.

LinkedCOs:CO1,CO5 **NumberofHours:08**

Module-2

Precaststructuralelementsandconnections:

Designprinciplesforprecastbeams,columns,slabs,walls,stairs,corbels,andsecondarymembers.Designforhandling, lifting, transportation, and erection loads. Connections in precast construction: dry joints, wet joints, bearing details, moment-resisting connections, shear transfer, continuity, and joint detailing. Seismic considerations in precast joints and structural robustness.

LinkedCOs:CO2,CO4,CO5 **NumberofHours:08**

Module-3

Compositeconstructionsystems:

Introduction to composite construction, materials and forms of composite action, advantages of composite systems, andapplicationsinfloorsandbridges.Analysisofcompositebeams,partialandfullinteraction,shearconnectors,slip effects, and serviceability checks. Composite slab systems, profiled steel decking, and composite floor construction.

LinkedCOs:CO1,CO3 **NumberofHours:08**

Module-4

Designofcompositebeamsandslabs:

Design of steel–concrete composite beams under bending, shear, and serviceability limit states. Design of shear connectors,effectiveflangewidth,constructionstages,shoringandunshoredsystems,deflectioncontrol,andvibration considerations. Design of composite slabs, one-way and two-way behavior, fire resistance, and construction-stage analysis.

LinkedCOs:CO3,CO4,CO5 **NumberofHours:08**

Module-5

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Precast-compositebuildingsystemsanddetailing:
Precast and composite building frames, floor systems, diaphragm action, stability bracing, progressive collapse resistance, and durability considerations. Design and detailing of precast-composite structural systems for buildings. Production, erection sequence, inspection, maintenance, and sustainability aspects of precast and composite construction.Casestudiesofprecastandcompositebuildingsandpracticaldesignexamples.

LinkedCOs:CO2,CO4,CO5 **NumberofHours:08**

SuggestedLearningResources:

Textbooks

1. Elliott,K.S.,PrecastConcreteStructures,2ndEdition,Taylor&Francis,2019.
2. Johnson,R.P.,CompositeStructuresofSteelandConcrete:Beams,Slabs,ColumnsandFramesforBuildings, 4th Edition, John Wiley & Sons, 2019.
3. Steinle,A.,Bachmann,H.,Tillmann,M.,andThrift,P.,PrecastConcreteStructures,2ndEdition,Wiley-VCH/ Wiley India, 2019.
4. Narayanan,R.(Ed.),Steel-ConcreteCompositeStructures,IllustratedEdition,CRCPress,1988.HassA.M.–PrecastConcrete–DesignandapplicationsAppliedScience,1983.
5. DavidSheppard–"Plantcast,PrecastandPrestressedconcrete–McGrawHill;1989.
6. R.P.Johnson:CompositeStructureofSteelandConcrete(Volume1),BlackwellScientificPublication(Second Edition), U.K., 1994.

ReferenceBooks

1. Elliott,K.S.,PrecastConcreteStructures,2ndEdition,Taylor&Francis,2019.
2. Johnson,R.P.,CompositeStructuresofSteelandConcrete,4thEdition,JohnWiley&Sons,2019.
3. Narayanan,R.(Ed.),Steel-ConcreteCompositeStructures,CRCPress,1988.
4. Wu,G.,Feng,D.-C.,andWang,C.-L.,NovelPrecastConcreteStructureSystems,1stEdition,SpringerSingapore, 2023.NBC – 2005 (Part I to Part VII) BIS Publications, New Delhi.
5. IS15916-2011,IS11447,IS6061–IandIII.
6. IS:11384-1985,CodeofPracticeforCompositeConstructioninStructuralSteelandConcrete.
7. INSDAGTeachingResourceChapter21to27:www.steel-insdag.org.

WeblinksandVideo Lectures(e-Resources)

1. https://www.youtube.com/watch?v=2qV4osntg6g&t=2558s
2. https://www.youtube.com/watch?v=fRqxXkxApSY&t=74s
3. NPTELcoursesonPrecastandCompositeStructures.
4. INSDAGpublicationsandresourcesoncompositeconstruction.

Teaching-LearningProcess(InnovativeDeliveryMethods):
Thefollowingaresamplestrategiesthateducatorsmayadopttoenhancetheeffectivenessoftheteaching-learning processandfacilitatetheachievementofcourseoutcomes.SuggestedInnovativeDeliveryMethodsmayinclude(butare not limited to):

- FlippedClassroom
- Problem-BasedLearning(PBL)
- Case-BasedTeaching
- SimulationandVirtualLabs
- PartialDeliveryofcoursebyIndustryexpert/industrialvisits
- ICT-EnabledTeaching
- RolePlay

AssessmentStructure(bothCIEandSEE)
TheweightageassignedtoContinuousInternalEvaluation(CIE)andSemesterEndExamination(SEE)shallbe50% each.Astudentshallsecureaminimumof50%ofthemaximummarksprescribedforCIEandaminimumof40%of the maximum marks prescribed for SEE to be eligible for passing.
A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/courseonlyifhe/shesecuresnotlessthan50% oftheaggregatemarksobtainedinCIEandSEEtaken together.
ContinuousInternalEvaluation:

ContinuousComprehensiveAssessments(CCA)+InternalAssessmentTest(IA)=ContinuousInternalEvaluation CIE [25+25=50 marks]
AminimumoftwoInternalAssessmentTests(IA)shallbeconducted.Eachtestshallbeconductedforamaximumof 25 marks. The average of the two test marks shall be the marks secured by a student in IA.
Inaddition,ContinuousComprehensiveAssessment(CCA)shallbeconductedforatotalof25marks

Students'activitiesforTW/SLunderNCrF:Samplesonly

As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listedbelow.Thesampleactivitiesaregivenbelow.Thecoursecoordinatorcanalsogivetheirown TW/SLactivitiesas perthecourseoutcomes.

Sl. No.	TermWork(TW)Activity	NumberofHours/ Semester
1	DesignofPrecastFloorSystem:Designahollowcoreslabsystemwithcomposite topping for a given floor plan.	24
2	Design of Precast Beam: Design a precast pre-stressed beam for a given span and loading condition.	24
3	DesignofPrecastColumnwithCorbels:Designabracedcolumnwithcorbelsfor a multi-storey precast structure.	24
4	DesignofPrecastConnections:Designbeam-columnconnectionsand structural ties for a precast building.	24
5	DesignofCompositeFloorandBeam:Designaprofiledsteelsheetcomposite floor and a simply supported composite beam.	24

SL:SelfLearning,MOOCs,spokentutorials,onlineeducationalresourcesetc.

Sl. No.	Self-Learning(SL)Activity	NumberofHours/ Semester
1	Preparareportonmodularcoordinationprinciplesanditsimportancein precast construction (as per Module-1 self-study).	24
2	Solvenumericalproblemsondesignofprecastbeamsunderproppedand unpropped conditions (as per Module-2 self-study).	24
3	Preparedesigncalculationsforprecastcolumnswithcorbelsfordifferent loadingconditions(asperModule-3self-study).	24
4	Preparareportonprogressivecollapsemechanismsanddesignstrategiesfor prevention(asperModule-4self-study).	24
5	Solvedesignexamplesofcompositebeamsandcompositefloorsasper IS:11384(asperModule-5self-study).	24

SamplerubricsforTWactivities:

Criteria	4-Excellent	3-Good	2-Satisfactory	1-NeedsImprovement
Problem understanding	Clearproblem framing with strong justification.	Mostlyclear with minor gaps.	Basicattemptwith limited clarity.	Poorlydefined problem.
Dataandmethod	Appropriatedata	Mostly	Limiteddataor	Inadequateorincorrect

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Criteria	4-Excellent	3-Good	2-Satisfactory	1-NeedsImprovement
	and sound methodology.	appropriate with minor issues.	partialmethod.	method.
Analysis	Robust interpretationand validresults.	Generallysound with minor errors.	Partialanalysiswith gaps.	Weakorincorrect analysis.
Recommendations	Strong,feasible, and context-specific.	Relevantwith minor limitations.	Generic recommendations.	Incompleteor unrealistic.
Presentation	Well organized andprofessional.	Good organization with minor issues.	Acceptablebut uneven.	Poorlypresented.

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ANALYSISANDDESIGNOFPLATESANDSHELLS			
Course Code	**1MCSE206D / 1MCCS206D**	Scheme	2026
TypeofCourse	**ProfessionalElectiveCourse**	Semester	II
TeachingHours/Week(L:T:P)	42(3:0:0)	CIEMarks	50
TotalHoursofPedagogyper SemesterCI(L/T):LI(P):TW&SL	90(42:0:0:48)	SEEMarks	50
Credits	3	TotalMarks	100
TypeofExamination(IPCC):	Theory	ExamHours	03

Courseoutcome (CourseSkillSet):

Attheendofthecourse,thestudentwillbeableto:

1. CO1:Analyzeandclassifydifferenttypesofplatesandshells,applyingappropriatetheoretical frameworks and methods for their bending and structural analysis.
2. CO2Deriveandsolvedifferentialequationsgoverningthebehaviorofbothrectangularandcircular plates under various loading conditions, including uniform and concentrated loads
3. CO3:Implementadvancedanalyticalmethods,suchasNavier'ssolutionandLevy'sapproach,to effectively analyze simply supported plates with complex boundary conditions.
4. CO4:Applyprinciplesofmembraneandbendingactionintheanalysisofshellstructures, understanding their geometric properties and structural behavior.
5. CO5:Conductcomprehensiveanalysesofadvancedshellforms,includinghyperbolicparaboloidsand cylindrical shells, integrating practical applications and theoretical knowledge.

Module-1

BendingofPlates–ClassicalTheory&DifferentialEquations:

- Classificationofplatesand methodsofanalysis.Slopeandcurvatureofslightlybentplates –curvature and twist in any arbitrary direction.
- Principalcurvatures.Classicalthinplatetheory.Relationbetweenbendingmomentsandcurvatures, principal bending moments.
- Differentialequationforlaterallyloadedrectangularplates.Boundaryconditions.Kirchhoff modification of boundary conditions at a free edge.
- Differentialequationforthebendingoforthotropicplates.Rectangularplatessubjectedtoedge moments.
- Cylindricalbendingoflongrectangularplates.Structuraleffectsduetobendingofplates.

Self-study:Derivethedifferentialequationforbendingoforthotropicplatesandcomparewithisotropiccase.

LinkedCOs:CO1,CO2 **NumberofHours:8hrs**

Module-2

SimplySupportedRectangularPlates–Navier's&Levy'sSolutions

- Subjectedtoharmonicloading,Navier'ssolutionforsimplysupportedplatessubjectedtouniformly distributed load (UDL), hydrostatic pressure, patch load, partial UDL, and concentrated load, etc.
- Bendingofrectangularplatessubjectedto UDLbyLevy'sapproach:(i)alledgessimplysupported,(ii) two opposite edges simply supported and the other two edges clamped.
- Bendingofrectangularplatessubjectedtouniformlyvaryingload(UVL):(i)alledgessimplysupported, (ii)twooppositeedgessimplysupportedandtheothertwoedgesclamped.
- Methodofsuperpositionfortheanalysisofrectangularplateswithcomplexboundaryconditions.

Self-study:SolvearectangularplateproblemusingNavier'ssolutionforaconcentratedloadatthecenter.

LinkedCOs:CO2,CO3 **NumberofHours:10hrs**

Module-3

SymmetricalBendingofCircularPlates:

- Differentialequationforsymmetricalbendingoflaterallyloadedcircularplates.Aroundsimply supported plate subjectedto uniformly distributedload (UDL)overthe entire surface,a central concentratedload,andconstantedgemoment.

- AroundclampedplatesubjectedtoUDLovertheentiresurfaceandacentralconcentratedload.
- MethodofsuperpositionAnnularplatesubjectedtoedgemomentsandUDLovertheentiresurface.

Self-study:Derivethedeflectionexpressionforaclampedcircularplateunder UDL

LinkedCOs:CO2,CO3 **NumberofHours:8hrs**

Module-4

AnalysisofShells–Shapes,Classification&MembraneAnalysis:

- Shapes and forms of shells, geometry of quadric surfaces; general form, standard equation, ellipsoid, hyperboloid,ellipticcone,ellipticparaboloid,hyperbolicparaboloid,quadriccylinder,etc.;classifications of shells, membrane action, and bending action.
- Membraneanalysisofshellsofrevolution:domesandconicalshells.

Self-study:Preparareportondifferentshellformsusedinmodernarchitecture.

LinkedCOs: CO4 **NumberofHours:8hrs**

Module-5

AdvancedShellAnalysis–HyperbolicParaboloid&CylindricalShells :

- Membraneanalysisofhyperbolicparaboloidshellsandmembraneanalysisofcylindricalshells.
- Lundgren'sBeamtheoryforbendinganalysisofcylindricalshells.

Self-study:Analyzeareal-worldcylindricalshellroofusingLundgren'sBeamtheory.

LinkedCOs:CO4,CO5 **NumberofHours:8hrs**

SuggestedLearningResources

Textbooks / Reference Books

1. Timoshenko,S.&Woinowsky-Krieger,W.– TheoryofPlatesandShells,2ndEdition,McGraw-HillCo.,New York, 1959.
2. Ramaswamy,G.S.–DesignandConstructionofConcreteShellRoofs,CBSPublishersandDistributors, New Delhi, 1986.
3. Ugural,A.C.–StressesinPlatesandShells,2ndEdition,McGraw-Hill,1999.
4. Szilard,R.–TheoryandAnalysisofPlates:ClassicalandNumericalMethods,PrenticeHall,1994.
5. Chatterjee,B.K.–TheoryandDesignofConcreteShells,Chapman&Hall,NewYork,3rdEdition,1988.

WeblinksandVideoLectures(e-Resources)

1. https://www.youtube.com/watch?v=tA_LGwTvre4&list=PLwdnzlV3ogoXQR59FK4dNDzxb5I65IIuu
2. https://www.youtube.com/watch?v=CkolEAtY6jY
3. NPTEL:TheoryofPlatesandShells–IITMadras
4. NPTEL:AdvancedStructuralAnalysis–PlatesandShells.

Teaching-LearningProcess(InnovativeDeliveryMethods):

Thefollowingaresamplestrategiesthateducatorsmayadopttoenhancetheeffectivenessoftheteaching-learning processandfacilitatetheachievementofcourseoutcomes.SuggestedInnovativeDeliveryMethodsmayinclude(but are not limited to):

- FlippedClassroom
- Problem-BasedLearning(PBL)
- Case-BasedTeaching
- SimulationandVirtualLabs
- PartialDeliveryofcoursebyIndustryexpert/industrialvisits
- ICT-EnabledTeaching
- RolePlay

AssessmentStructure(bothCIEandSEE)

The weightage assigned to Continuous Internal Evaluation(CIE) and SemesterEnd Examination (SEE) shall be 50%each.Astudentshallsecureaminimumof50%ofthemaximummarksprescribedforCIEandaminimum

of40%ofthemaximummarksprescribedforSEEtobeeligibleforpassing.
A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/courseonlyifhe/shesecuresnotlessthan50% oftheaggregatemarksobtainedinCIEandSEEtaken together.

ContinuousInternalEvaluation:

ContinuousComprehensiveAssessments(CCA)+InternalAssessmentTest(IA)=ContinuousInternal Evaluation
CIE [25+25=50 marks]
AminimumoftwoInternalAssessmentTests(IA)shallbeconducted.Eachtestshallbeconductedfora maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.
Inaddition,ContinuousComprehensiveAssessment(CCA)shallbeconductedforatotalof25marks

Students'activitiesforTW/SLunderNCrF:Samplesonly

AsperNationalcreditformwork(NCrF)studentsmustspend90hoursofstudyfor3creditcourses,whichinclude Courseinstructions(CI-42hour)andTeamwork/Selflearning(TW/Sl-48hours).Hence,studentsmustcomplete minimumoftwoactivesaspartof NCrF.Theselearningactivitiesshallbeconsidered asCCAcomponentsofCIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activitiesarelistedbelow.Thesampleactivitiesaregivenbelow.The coursecoordinatorcanalsogivetheirown TW/SLactivitiesasperthecourseoutcomes.

Sl. No.	TermWork(TW)Activity	NumberofHours/ Semester
1	Assignments: 1. Derivationofplatedifferentialequationandboundaryconditions (Mod1/CO1, CO2) – 8h 2. Navier'ssolutionforUDLonsimplysupportedplate(Mod2/CO3)–8h 3. CircularplatedeflectionunderUDL(Mod3/CO2)–8h	24
2	Seminars: 1. Kirchhoff'smodificationofboundaryconditions(Mod1/CO1)–8h 2. Levy'sapproachforclampedplates(Mod2/CO3)–8h 3. Membraneanalysisofdomesandconicalshells(Mod4/CO4)–8h	24
3	Micro-Project: 1. MATLABprogramforNavier'ssolutionofrectangularplate (Mod2/CO3) – 12h 2. FEAanalysisofcylindricalshellusingLundgren'sBeamtheory (Mod5/CO5)– 12h	24

SL:SelfLearning,MOOCs,spokentutorials,onlineeducationalresourcesetc.

Sl. No.	Self-Learning(SL)Activity	NumberofHours/ Semester
1	NPTEL:TheoryofPlatesandShells(IITMadras)	8
2	YouTubeplaylist onplatebending solutions	8
3	FEAsoftwarepracticeforshellanalysis	8

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SamplerubricsforTWactivities:

Criteria	4-Excellent	3-Good	2-Satisfactory	1 - Needs Improvement
Problem understanding	Clearproblem framing with strong justification.	Mostlyclear with minor gaps.	Basicattemptwith limited clarity.	Poorlydefined problem.
Dataandmethod	Appropriatedata and sound methodology.	Mostly appropriate with minor issues.	Limiteddataor partialmethod.	Inadequate or incorrectmethod.
Analysis	Robust interpretationand validresults.	Generally sound with minorerrors.	Partialanalysiswith gaps.	Weakorincorrect analysis.
Recommendations	Strong,feasible, and context-specific.	Relevantwith minor limitations.	Generic recommendations.	Incompleteor unrealistic.
Presentation	Well organized andprofessional.	Good organization with minor issues.	Acceptablebut uneven.	Poorlypresented.

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COMPUTATIONALSTRUCTURALMECHANICS			
Course Code	**1MCSE206E / 1MCAS206A**	Scheme	2026
TypeofCourse	**ProfessionalElectiveCourse**	Semester	II
TeachingHours/Week(L:T:P)	42(3:0:0)	CIEMarks	50
TotalHoursofPedagogyper SemesterCI(L/T):LI(P):TW&SL	90(42:0:0:48)	SEEMarks	50
Credits	3	TotalMarks	100
TypeofExamination(IPCC):	Theory	ExamHours	03

Courseoutcome(CourseSkillSet):

Attheendofthecourse,thestudentwillbeableto:

1. CO1:Explainthecomputationalbasisofstructuralmechanics,discretization,andnumericalformulationof engineering problems.
2. CO2:Formulateandsolvestructuralproblemsusingstiffnessmethod,finiteelementconcepts,andmatrix operations.
3. CO3:Analyzetrusses,beams,frames,andplanestress/strainsystemsusingappropriatecomputational procedures.
4. CO4:Evaluatetheeffectsofboundaryconditions,materialbehavior,numericalintegration,andmeshquality on solution accuracy.
5. CO5:Usestructuralanalysissoftwareandverificationcheckstointerpretresultsforrealengineering applications.
6. CO6:Applycomputationalmethodstoindustry-orientedproblemsinvolvingdesignvalidation,retrofit,and performance assessment.

Module-1

FundamentalsofComputationalStructuralMechanics:

- Introduction to computational mechanics, role of numerical methods in structural engineering, mathematical idealization of structures, continuum and discrete models, degrees of freedom, nodal variables,stiffnessandflexibilityconcepts,andoverviewofstructuralanalysisworkflows.Introductionto matrix algebra for structural systems, coordinate systems, and transformation of variables.

LinkedCOs:CO1,CO2. **NumberofHours:08.**

Module-2

StiffnessMethodandMatrixFormulation:

- Directstiffnessmethodforstructuralanalysis,elementstiffnessmatrices,assemblyofglobalstiffnessmatrix, load vectors, boundary conditions, and solution of simultaneous equations. Analysis of spring, bar, truss, beam,andplaneframeelements.Introductiontocomputerimplementation,sparsity,andsolutionstrategies.

LinkedCOs:CO2,CO3,CO5. **NumberofHours:09.**

Module-3

FiniteElementMethodforStructuralProblems:

- Finite element formulation, weak form, weighted residual approach, principle of virtual work, interpolation functions, shape functions, convergence requirements, compatibility, and completeness. One-dimensional structural elements, bar and beam elements, consistent and equivalent nodal loads, and post-processing of elementresults.

LinkedCOs:CO1,CO2,CO3. **NumberofHours:08.**

Module-4

Two-DimensionalStructuralAnalysis:

Plane stress, plane strain, axisymmetricmodelling, constant strain triangle, quadratic elements, isoperimetric formulation,numerical integration, mesh generation, and stress recovery. Introduction to plate and shell idealization, modelling assumptions, and interpretation of contour plots.

LinkedCOs:CO3,CO4,CO5. **NumberofHours:08**

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Module-5

ComputationalPracticeandIndustryApplications:

Useofstructuralanalysissoftwareformodelsetup,loadcases,combinations,supportconditions,verification,and result interpretation. Model validation, sensitivity checks, common errors in FE modelling, and application to industrial structures such as buildings, bridges, industrial frames, towers, and retrofit assessments. Introduction to nonlinear and dynamic response, with emphasis on practical engineering decision-making.

LinkedCOs:CO4,CO5,CO6. **NumberofHours:09.**

SuggestedLearningResources:

Textbooks/ReferenceBooks

1. Chandrupatla,T.R.andBelegundu,A.D.,*IntroductiontoFiniteElementsinEngineering*,**4thEdition**,Pearson.
2. Weaver,W.&Gere,J.M.–MatrixAnalysisofFramedStructures,CBSPublishersandDistributorsPvt.Ltd., 2004.
3. Rajasekaran,S.&Sankarasubramanian,G.–ComputationalStructuralMechanics,PHI,NewDelhi,2001.
4. Martin,H.C.–IntroductiontoMatrixMethodsofStructuralAnalysis,McGraw-Hill,NewYork,1966.
5. Rubinstein,M.F.–MatrixComputerAnalysisofStructures,Prentice-Hall,EnglewoodCliffs,NewJersey,1966.
6. Beaufait,F.W.,Rowan,W.H.,Jr.,Hoadely,P.G.&Hackett,R.M.–ComputerMethodsofStructuralAnalysis, Prentice-Hall, Englewood Cliffs, New Jersey, 1970.
7. Kardestuncer,H.–ElementaryMatrixAnalysisofStructures,McGraw-Hill,NewYork,1974.

WeblinksandVideoLectures(e-Resources)

1. https://www.youtube.com/watch?v=Wa9ZSWlrpnk&list=PLbRMhDVUMngeZatm4MIOKG4sHxXuB_yri
2. https://www.youtube.com/watch?v=oMSoFeCZL5k&list=PL8pjaLEv3XhmeAp8aEWfp7t2bf2Nh2dYy
3. NPTEL:MatrixMethodsofStructuralAnalysis–IITKharagpur
4. NPTEL:ComputationalStructuralMechanics–IITMadras
5. McGuire,W.,Gallagher,R.H.,andZiemian,R.D.,MatrixStructuralAnalysis,latestedition.
6. Hutton,D.V.,Fundamentalsof FiniteElement Analysis,

Teaching-LearningProcess(InnovativeDeliveryMethods):

Thefollowingaresamplestrategiesthateducatorsmayadopttoenhancetheeffectivenessoftheteaching-learning processandfacilitatetheachievementofcourseoutcomes.SuggestedInnovativeDeliveryMethodsmayinclude(butare not limited to):

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- PartialDeliveryofcoursebyIndustryexpert/industrialvisits
- ICT-EnabledTeaching
- RolePlay

AssessmentStructure(bothCIEandSEE)

TheweightageassignedtoContinuousInternalEvaluation(CIE)andSemesterEndExamination(SEE)shallbe50% each.Astudent shallsecure aminimum of 50% of themaximum marksprescribed forCIE and aminimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/courseonlyifhe/shesecuresnotlessthan50%oftheaggregatemarksobtainedinCIEandSEEtaken together.

ContinuousInternalEvaluation:

ContinuousComprehensiveAssessments(CCA)+InternalAssessmentTest(IA)=ContinuousInternalEvaluation CIE [25+25=50 marks]

AminimumoftwoInternalAssessmentTests(IA)shallbeconducted.Eachtestshallbeconductedforamaximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.

Inaddition,ContinuousComprehensiveAssessment(CCA)shallbeconductedforatotalof25marks

Students'activitiesforTW/SLunderNCrF:Samplesonly

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As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimumoftwoactivesaspartofNCrF.TheselearningactivitiesshallbeconsideredasCCAcomponentsofCIE.The evaluationactivitieswillbedoneusingsetofrubricsdevelopedforeachactivity.Thefollowingsampleactivitiesare listedbelow.Thesampleactivitiesaregivenbelow.The coursecoordinatorcanalsogivetheirownTW/SLactivities asperthecourseoutcomes.

Sl. No.	TermWork(TW)Activity	NumberofHours/ Semester
1	**StructuralidealizationandDOFmapping**:Studentsidentifyloadpaths, constraints, and degrees of freedom for a given structural system.	24
2	**Truss/frameanalysisbystiffnessmethod:**Studentsmanuallycompute member forces and compare with software output.	24
3	**Software-basedstructuralvalidationexercise:** Studentsanalyzeastructure using software and verify key outputs using hand calculations.	24
SL:SelfLearning,MOOCs,spokentutorials,onlineeducationalresourcesetc.		
Sl. No.	**Self-Learning(SL)Activity**	**NumberofHours/ Semester**
1	NPTEL:MatrixMethodsofStructuralAnalysis(IITKharagpur)	24
2	NPTEL:ComputationalStructuralMechanics(IITMadras)	24
3	MATLABprogrammingpracticeformatrixstructuralanalysis	24

SamplerubricsforTWactivities:

Criteria	4-Excellent	3-Good	2-Satisfactory	1-NeedsImprovement
Problem understanding	Clearproblem framing with strong justification.	Mostlyclear with minor gaps.	Basicattemptwith limited clarity.	Poorlydefinedproblem.
Dataandmethod	Appropriatedata and sound methodology.	Mostly appropriate with minor issues.	Limiteddataor partialmethod.	Inadequateorincorrect method.
Analysis	Robust interpretationand validresults.	Generallysound with minor errors.	Partialanalysiswith gaps.	Weakorincorrect analysis.
Recommendations	Strong,feasible, and context-specific.	Relevantwith minor limitations.	Generic recommendations.	Incompleteor unrealistic.
Presentation	Well organized andprofessional.	Good organization with minor issues.	Acceptablebut uneven.	Poorlypresented.

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FIBERREINFORCEDPOLYMERSANDMECHANICSOFCOMPOSITEMATERIALS			
Course Code	**1MCSE206F / 1MCAS206F / 1MCCS206F**	Scheme	2026
TypeofCourse	**ProfessionalElectiveCourse**	Semester	II
TeachingHours/Week(L:T:P)	42(3:0:0)	CIEMarks	50
TotalHoursofPedagogyper SemesterCI(L/T):LI(P):TW&SL	90(42:0:0:48)	SEEMarks	50
Credits	3	TotalMarks	100
TypeofExamination(IPCC):	Theory	ExamHours	03

Courseoutcome (CourseSkillSet):

Attheendofthecourse,thestudentwillbeableto:

1. CO1:DefineandclassifyFRPcompositesandtheirconstituentsforstructuralengineeringapplications
2. CO2Analyzemacro-mechanicalbehaviorofFRPlaminatesincludingstress-strainrelationsand engineering constants
3. CO3:DeriveengineeringconstantsofFRPcompositesusingmacroandmicromechanicalapproaches
4. CO4:Selectappropriatefibers(glass,carbon,aramid,natural)andmatrixmaterialsforFRPcomposite manufacture
5. CO5:Applyclassicallaminationtheoryandfailurecriteriaor FRPcompositelaminates.

Module-1

IntroductiontoFRPComposites–Constituents,Manufacturing&Applications:

- Introductiontocompositematerials,classifications(thermosetandthermoplastic)andcivil/structural engineering applications.
- FiberReinforcedPolymers(FRP)–typesoffibers(glass,carbon,aramid,naturalfibers),typesof polymer matrices (epoxy, polyester, vinyl ester).
- Constituentmaterialsofcomposites–reinforcementsandmatrix.Ruleofmixturefordensityand volume fraction.
- Selectionofmaterialsbasedonapplicationrequirements.
- ManufacturingtechniquesforFRPcomposites–handlayupmethod,compressionmouldingmethod, filament winding, pultrusion, and vacuum bagging.
- Basicsoffiberreinforcedpolymercomposites(syntheticFRPandnaturalFRPcomposites).
- AdvantagesandlimitationsofFRPcompositesoverconventionalmaterials.
- ApplicationsofFRPinstructuralretrofitting,bridgestrengthening,andnewconstruction.

Self-study:CollectcasestudiesofFRPapplicationsinstructuralrehabilitation(e.g.,bridgegirderstrengthening, column wrapping).

LinkedCOs:CO1,CO4 **NumberofHours:8hrs**

Module-2

Macro-mechanicalBehaviorofFRPLamina–Anisotropic&OrthotropicMaterials:

- Introductiontomacro-mechanicsofFRPlamina.Stress-strainrelationsforanisotropicmaterials –3D generalized Hooke's law.
- Stiffnessmatrix[C]andcompliancematrix[S]foranisotropic,monoclinic,orthotropic,transversely isotropic, and isotropic materials.
- Engineeringconstantsfororthotropicmaterials–E_1,E_2,E_3,G_{12},G_{13},G_{23},ν_{12},ν_{13},ν_{23}.Restrictionson engineeringconstantsfororthotropicmaterials(positivedefinitenessofstiffnessmatrix).
- PhysicalsignificanceofengineeringconstantsforFRPcomposites.
- Numericalproblemsoncomputationofstiffnessandcompliancematrices.

Self-study:Derivetherelationshipbetweenengineeringconstantsandcompliancematrixforanorthotropic FRP lamina.

LinkedCOs:CO2,CO3 **NumberofHours:8hrs**

Module-3

Macro-mechanicalBehaviorofFRPLamina(Continued)–PlaneStress,Invariants&Strength:

- Stress-strainrelationsforplanestressinanorthotropic FRPlamina –reducedstiffnessmatrix[Q]and reduced compliance matrix [S].
- Stress-strainrelationsforaFRPlaminaofarbitraryfiberorientation –transformationofstressesand strains from material axes (1-2) to global axes (x-y).
- Transformationequationsforstiffnessmatrices –$[\bar{Q}]=[T]^{-1}[Q][T]^{-T}$.Invariantpropertiesofan orthotropic lamina – U_1, U_2, U_3, U_4, U_5 invariants.
- StrengthsofanorthotropicFRPlamina–longitudinaltensile/compressivestrength(X_1,Xc),transverse tensile/compressive strength (Y_1, Yc), in-plane shear strength (S).
- ThermalandmechanicalstressanalysisinFRPlaminatesduetotemperaturechangesandmoisture absorption.
- Numericalproblemsontransformedstiffnessandstresscomputation.

Self-study:Computetransformedreducedstiffnessmatrixfor aFRPlaminaorientedat30°,45°,and60°.

LinkedCOs:CO2,CO3 **NumberofHours:8hrs**

Module-4

Micro-mechanicalBehaviorofFRPLamina–StiffnessPrediction:

- Introductiontomicro-mechanicsofFRPcomposites.Mechanicsofmaterialsapproachtostiffness prediction – assumptions of perfect bonding, uniform strain/stress fields.
- Determinationoflongitudinalmodulus(E_1)usingruleofmixturesandmodifiedruleofmixtures. Determinationoftransversemodulus(E_2)usingseriesmodel(Reussmodel),Halpin-Tsaiequations,and elasticity approach.
- DeterminationofmajorPoisson'sratio(ν_{12})usingruleofmixtures.
- Determinationofin-planeshearmodulus(G_{12})usingHalpin-Tsaiandelasticitysolutions.
- Comparisonofmicromechanicspredictionswithexperimentalresults.Limitationsofmechanicsof materials approach – semi-empirical methods.
- Numericalproblemsonestimationofallfourengineeringconstantsfromfiberandmatrixproperties.

Self-study:CompareE_2predictionsusingseriesmodelvsHalpin-Tsaiequationsfordifferentfibervolumefractions.

LinkedCOs: CO3 **NumberofHours:8hrs**

Module-5

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ClassicalLaminationTheory&FailureCriteriaforFRPLaminates:

- Classicalcompositelaminationtheory(CLT)–assumptions,strain-displacementrelations,forceand moment resultants. Cross-ply laminates ($[0/90]_s$, $[0/90/90/0]$), angle-ply laminates ($[\pm\theta]_s$, $[\pm\theta]_{2s}$), symmetric, anti-symmetric, and general symmetric laminates.
- Mechanicalcouplinginlaminates–extension-extension(A),bending-extension(B),andbending-bending (D) coupling matrices. Analysis of simple laminated structural elements – ply stress and strain calculation under axial, bending, and thermal loads.
- FailuretheoriesforFRPcomposites:MaximumStressFailureCriterion,MaximumStrainFailure Criterion, Tsai-Hill Failure Criterion, Tsai-Wu Tensor Failure Criterion (concept only).
- Firstplyfailure(FPF)andlastplyfailure(LPF)concepts.Numericalproblemsonlaminateanalysis and failure prediction.

Self-study:CompareTsai-HillandTsai-Wufailurecriteriafora$[0/90]_s$FRPlaminateunderuniaxialtension.

LinkedCOs: CO5 **NumberofHours:8hrs**

SuggestedLearningResources:

Textbooks

1. Mukhopadhyay,M.–MechanicsofCompositeMaterialsandStructures,UniversitiesPress,2009.
2. Jones,R.M.–MechanicsofCompositeMaterials,McGrawHillPublishingCo.
3. Agarwal,B.D.&Broutman,L.J.–AnalysisandPerformanceofFiberComposites,JohnWileyandSons.
4. Kaw,A.K.–MechanicsofCompositeMaterials,SecondEdition,CRCPress,2006.

ReferenceBooks

1. .Daniel,I.M.&Ishai,O.–EngineeringMechanicsofCompositeMaterials,OxfordUniversityPress.
2. Hyer,M.W.–StressAnalysisofFiberReinforcedCompositeMaterials,McGrawHill.
3. Mallick,P.K.–FiberReinforcedComposites:Materials,Manufacturing,andDesign,CRCPress.

WeblinksandVideoLectures(e-Resources)

1. https://www.youtube.com/watch?v=0kB0G6WKhKE&list=PLSGws_74K01-bdEEUElQ9-obrujIKGEhg
2. NPTEL:MechanicsofCompositeMaterials–IITKharagpur
3. NPTEL:FiberReinforcedPolymerComposites–IITMadras

Teaching-LearningProcess(InnovativeDeliveryMethods):

Thefollowingaresamplestrategiesthateducatorsmayadopttoenhancetheeffectivenessoftheteaching-learning processandfacilitatetheachievementofcourseoutcomes.SuggestedInnovativeDeliveryMethodsmayinclude(but are not limited to):

- FlippedClassroom
- Problem-BasedLearning(PBL)
- Case-BasedTeaching
- SimulationandVirtualLabs
- PartialDeliveryofcoursebyIndustryexpert/industrialvisits
- ICT-EnabledTeaching
- RolePlay

AssessmentStructure(bothCIEandSEE)

The weightage assigned to Continuous Internal Evaluation(CIE) and SemesterEnd Examination (SEE) shall be 50%each.Astudentshallsecureaminimumof50%ofthemaximummarksprescribedforCIEandaminimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/courseonlyifhe/shesecuresnotlessthan50% oftheaggregatemarksobtainedinCIEandSEEtaken together.

ContinuousInternalEvaluation:

ContinuousComprehensiveAssessments(CCA)+InternalAssessmentTest(IA)=ContinuousInternal Evaluation CIE [25+25=50 marks]

AminimumoftwoInternalAssessmentTests(IA)shallbeconducted.Eachtestshallbeconductedfora maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.

Inaddition,ContinuousComprehensiveAssessment(CCA)shallbeconductedforatotalof25marks

Students'activitiesforTW/SLunderNCrF:Samplesonly

As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which includeCourseinstructions(CI-42hour)andTeamwork/Selflearning(TW/Sl-48hours).Hence,studentsmust complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can alsogivetheirownTW/SLactivitiesasperthecourseoutcomes.

Sl. No.	TermWork(TW)Activity	NumberofHours /Semester
1	Assignments: 1. EngineeringconstantsfororthotropicFRPlamina(Mod2/CO2)–8h 2. TransformedstiffnessmatrixforoffaxisFRPlamina(Mod3/CO2)–8h 3. Micromechanicalmoduluspredictionforglass/epoxy(Mod4/CO3)–8h	24
2	Seminars: 1. FRPmanufacturingtechniques–handlayupvspultrusion(Mod1/CO4)– 8h 2. ThermalandmoisturestressanalysisinFRP(Mod3/CO2)–8h 3. ComparisonoffailurecriteriaforFRPlaminates(Mod5/CO5)–8h	24
3	Micro-Project: 1. MATLABprogramformicro-mechanicalstiffnesspredictionofFRP (Mod4/CO3) – 12h 2. CLTanalysisandfailurepredictionofacross-plyFRPlaminate (Mod5/CO5)–12h	24

SL:SelfLearning,MOOCs,spokentutorials,onlineeducationalresourcesetc.

Sl. No.	Self-Learning(SL)Activity	NumberofHours /Semester
1	NPTEL:MechanicsofCompositeMaterials(IITKharagpur)	24
2	NPTEL:FiberReinforcedPolymerComposites(IITMadras)	24
3	FRPdesignsoftwarepractice(e.g.,ESAComp,CADEC)	24

SamplerubricsforTWactivities:

Criteria	4-Excellent	3-Good	2-Satisfactory	1-NeedsImprovement

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Problem understanding	Clearproblem framing with strong justification.	Mostlyclear with minor gaps.	Basicattemptwith limited clarity.	Poorlydefined problem.
Dataandmethod	Appropriatedata and sound methodology.	Mostly appropriate with minor issues.	Limiteddataor partialmethod.	Inadequate or incorrectmethod.
Analysis	Robust interpretationand validresults.	Generally sound with minorerrors.	Partialanalysiswith gaps.	Weakorincorrect analysis.
Recommendations	Strong,feasible, and context-specific.	Relevantwith minor limitations.	Generic recommendations.	Incompleteor unrealistic.
Presentation	Well organized andprofessional.	Good organization with minor issues.	Acceptablebut uneven.	Poorlypresented.

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SOFTCOMPUTINGTECHNIQUESINSTRUCTURALENGINEERINGLABORATORY			
CourseCode	**1MCSEL207**	Scheme	2026
Typeofcourse	ProfessionalCoreCourseLab	Semester	II
TeachingHours/Week(L:T:P)	2(0:0:2)	CIEMarks	50
TotalHoursofPedagogyL:T:P:SL:TW	30(0:0:28:2)	SEEMarks	50
Credits	1	TotalMarks	100
TypeofExamination	**Practical**	ExamHours	3

Courseoutcome(CourseSkillSet):

Attheendofthecourse,thestudentwillbeableto:

1. CO1–L3:Developandimplementsoftcomputing-basedcomputationalmodelsforanalysisofstructural elements using MATLAB/Python.
2. CO2 – L4: Analyze and interpret structural response of RCC, steel, slab, beam, column, and compositeelements using numerical and soft computing tools.
3. CO3 – L5: Evaluate and compare the performance of structural models for different loading, boundary, and material conditions.
4. CO4–L5:Applycomputationalmethodsforstructuraldesignoptimizationanddecisionmakingin engineering applications.
5. CO5–L6:Prepareprofessionaltechnicalreportsandvalidateresultsusingsoftwareoutputsand engineeringjudgement.

Note:

1. The laboratory syllabus consists of PART-A and PART-B. While PART-A has 6-8 conventional experiments, PART-B has 6 typical open-ended experiments. The maximum marks for the laboratory course are 100.
2. BothPART-AandPART-BareconsideredforCIEand SEE.
3. Studentshaveanswer1(one)questionfromPART-Aand1(one)questionfromPART-B.
   a. ThequestionssetforSEEshallbefromamongtheexperimentsunderPART-A.Itisevaluatedfor**80 marks** out of the maximum 100 marks.
   b. Theopen-endedquestionsetforSEEshallbeanyotheropen-endedquestionandnotselectedfrom the experiments under PART-A. It shall be evaluated for **20 marks.**

ForContinuousInternalEvaluation(CIE)duringthesemester,classworkshalltypicallyincludeopen-ended questionsfrom**Part-B**,alongwithothersimilarquestionsdesignedtoenhancethestudents'skills.

PART–A

FIXEDEXPERIMENTS

1. DevelopmentofaMATLAB/Pythonmodelforanalysisanddesignof RCCbeamandcolumnelements. (CO1)
2. AnalysisofasimplemultistoreyRCCstructureusinganFEApackageandinterpretationofresults.(CO1, CO2)
3. DevelopmentofMATLAB/Pythonmodelsforanalysisanddesignof RCCslabsfordifferentend conditions. (CO2)
4. Structuralanalysisof2Dbeamswithdifferentloadingandsupportconditionsusing MATLAB/Python. (CO2)
5. AnalysisofsteelbeamelementsusingMATLAB/Python.(CO2)
6. AnalysisofsteelcolumnelementsusingMATLAB/Python.(CO2)
7. Analysisofcold-formedsteelsectionsfordifferentloadconditionsusingMATLAB/Python.(CO1)
8. Analysisofunidirectionalfibre-reinforcedcompositematerialsusingMATLAB/Pythontocomputerule of mixture parameters and engineering constants. (CO2)

PART–B:OPENENDEDEXPERIMENTS

Open-endedexperimentsareatypeoflaboratoryactivitywheretheoutcomeisnotpredeterminedandstudents aregiventhefreedomtoexplore,design,andconducttheexperimentbasedontheproblemstatementsasperthe conceptsdefinedbythecoursecoordinator.Itencouragescreativity,criticalthinking,andinquiry-basedlearning.

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1. Analysisofunidirectionalfibre-reinforcedcompositematerialsusingMATLAB/Pythontocompute compliance matrix, stiffness matrix, and related parameters. (CO1, CO2)
2. Analysisofunidirectionalfibre-reinforcedcompositematerialsusingMATLAB/PythontocomputeA-B-D matrix. (CO1, CO2)
3. DevelopmentofasoftcomputingmodeltopredictstructuralresponseofRCCbeamsundervaried loading conditions. CO3, CO4
4. OptimizationofsteelbeamdimensionsusingMATLAB/Pythonforminimumweightandadequate strength. CO3, CO4
5. Predictionofslabresponsefordifferentendconditionsusingacomputationalmodelandcomparison with analytical results. CO4, CO5
6. Developmentofacomparativestudyofstructuralresponseusingnumerical,analytical,andsoft computingapproaches.CO4,CO5

SuggestedLearningResources:

Textbooks:

1. MatrixAnalysisofStructures–AslamKassimali,CengageLearning.Coversmatrixmethods,structural analysis, stiffness method, and computational implementation.
2. DesignofReinforcedConcrete–JackC.McCormacandRussellH.Brown,Wiley.UsefulforRCCbeams, slabs, and columns.
3. DesignofSteelStructures–N.Subramanian,OxfordUniversityPress.Coverssteelbeams,columns,and cold-formed steel sections.
4. MechanicsofCompositeMaterials–RobertM.Jones,CRCPress.Coversruleofmixtures,engineering constants, compliance and stiffness matrices, and laminate theory (A-B-D matrix).
5. C.S.KrishnaMurthy,FiniteElementAnalysis:TheoryandProgramming,McGraw-HillEducation,2nd Edition.
6. R.C.Hibbeler,StructuralAnalysis,Pearson,10thEdition.
7. M.K.JainandS.R.K.Iyengar,NumericalMethodsforScientificandEngineeringComputation,NewAge International, 6th Edition.
8. RelevantBIScodes,softwaremanuals,andjournalpapersasapplicable.

Referencebooks/Manuals:

1. FiniteElementProcedures–Klaus-JürgenBathe,PrenticeHall.Comprehensivereferenceforfinite element analysis of structural systems.
2. StructuralAnalysis–R.C.Hibbeler,PearsonEducation.Usefulforunderstandingstructuralbehavior, beams, frames, and classical analysis methods.
3. EngineeringMechanicsofCompositeMaterials –IsaacM.DanielandOriIshai,OxfordUniversityPress. Advanced treatment of composite material behavior and laminate analysis.
4. MATLABforEngineers–HollyMoore,Pearson.UsefulfordevelopingMATLAB-basedprogramsfor structuralanalysisanddesign.

SoftwareTools:

1. MATLAB/GNUOctave
   - RCCbeam,slab,andcolumndesign
   - Steelmemberdesign
   - Structuralanalysisofbeamsandframes
   - Structuraldynamicsandvibrationstudies
2. Python(NumPy,SciPy,Matplotlib)
   - Structuralanalysisanddesigncomputations
   - Compositematerialanalysis
   - Datavisualizationandparametricstudies
3. ETABS
   - Multi-storeybuildinganalysisanddesign
   - Seismicanddynamicanalysis
   - Structuraldetailinganddrawings
4. SAP2000

- Chimneys,silos,bunkers,domes,andspecialstructures
- Staticanddynamicanalysis

5.AutoCAD

- Structuraldrawingsanddetailing

AssessmentStructure(bothCIEandSEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for a pass in the course.

Astudentshallbedeemedtohave satisfiedtheacademicrequirements andearnedthe credits allottedtoasubject /courseonlyifhe/shesecuresnotlessthan50%oftheaggregatemarksobtainedinCIEandSEEtakentogether.

ContinuousInternalEvaluation(CIE):

ForttheProfessionalCoreCourseLaboratory,themaximummarksprescribedare100.Outofthese,50marksare allotted for Continuous Internal Evaluation (CIE) and 100 marks for the Semester End Examination (SEE). The SEEmarksobtainedoutof100shallbeproportionatelyscaleddownto50marks.Thefinalresultshallbedeclared based on the aggregate of the CIE marks (50) and the scaled-down SEE marks (50), totalling 100 marks."

Out of 50 marks, 40 marks shall be assigned for assessment of regular laboratory PART -A classwork, and 10 marks for Part – B. (Table 1)

Outof40marks,25marksshallbebasedonthe regularclassworkandallotmentofmarksshallbeasperrubrics listed in Table 1.

The remaining 15 marks shall be based on the practical test conducted by two Internal examiners appointed by theHoD.The allotmentofmarksshallbeasperthe rubricsdefinedforthe practicaltestasindicatedinthe Table 1.

The open-ended question set for CIE shall be any other open-ended question and not selected from the experimentsunderPART-A.Itshallbeevaluatedfor10marks.Theallotmentofmarksshallbeasperrubrics listedinTable2.

Table–1Distributionofmarkscorrespondingtolaboratorycomponent

Component	Description	Marks
Allotmentofmarksforregularclasswork		
AbilityinConducting Experiments	Initiative, skill, safety practices, teamwork, and independenthandlingofequipmentduringregularlab sessions.	10 marks
LaboratoryRecord/ Journal	Regularandneatmaintenanceoflabrecord,accuracyof results,andtimelysubmission.	15marks
	Subtotal	**25**
AllotmentofmarksforCIEpracticaltest		
Laboratory Test / ExperimentPerformance	Abilitytosetupapparatus,followprocedure,take observations,andobtaincorrectresultsinthetest experiment.	5marks
Viva-Voce	Understandingoftheory,concepts,andexperimental procedure;abilitytoexplainresultsandanswerrelated questions.	10marks
	Subtotal	**15**
	Total	**40**

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Table2DistributionofmarkscorrespondingtoPART-Bofthelaboratorycomponent EvaluationRubricsforcontinuousinternalevaluationCIE).Maximummarks:10				
CriteriaandGuidingfactors	**Students'LevelandRubrics** **Excellent:E,Good:G,Fair:F** **NeedsImprovements:NI**			
	E	**G**	**F**	**NI**
(1) ProblemUnderstanding **Criteria:**Istheproblemunderstoodcorrectlyandframed appropriately? (i) Clarityininterpretingthegivenproblem. (ii) Identificationofrelevantconceptsandconstraints. (iii) Abilitytorephraseormodeltheproblemlogically.	2.0	1.5	1.0	0.5
(2) ConceptualKnowledge **Criteria**:Arethechosenmethodsorconceptsvalidforthis type of problem? (i) Applicationofappropriatetheories,principles,orlaws. (ii) Integrationofmultipleconceptswherenecessary. (iii)Accuracyinstatingrelevantequationsormodels.	2.0	1.5	1.0	0.5
(3) ApproachandStrategy **Criteria**:Istheapproachwellthoughtoutandmethodical? (i) Logicalstructureandprogression. (ii) Use of diagrams, sketches, or flowcharts if applicable. (iii)Identificationofassumptionsandboundaryconditions.	2.0	1.5	1.0	0.5
(4) ExecutionandAccuracy **Criteria**:Arethecalculationscorrect?Isthefinalsolution reasonable? (i) Correctapplicationofformulas/methods. (ii) Accuracyofcalculationsorsimulations(ifany). (iii)Unit consistency and result verification.	2.0	1.5	1.0	0.5
(5) InnovationorDepth **Criteria**:Hasthestudentshownoriginalthinkingor alternative methods? (i)Novel or efficient solutions. (ii)Considerationofalternateapproaches. (iii)Interdisciplinaryintegrationorpracticalextensions.	1	0.75	0.5	0.25
(6) PresentationandClarity **Criteria**:Istheanswereasytofollowandprofessionally written? (i) Organizationandneatness. (ii) Clarityofexplanation,labelling,andsteps. (iii) Useofpropertechnicalterminology.	1	0.75	0.5	0.25
Total	10	7.5	5.0	2.5

Note:
(i) ThemarksshownforExcellent,Good,Fair,NeedsImprovement areindicative.The evaluatormayalsoassign intermediate scores depending on the quality of work.
(ii) Ifthetotalscoreresultsinafraction,itshouldberoundedofftothenexthigherinteger.
(iii) Thelistedcriteriaareguidelines;evaluatorsmayalsoconsiderotherauthenticdimensions(e.g.,depthof insight, critical thinking, and practical awareness, recognition of limitations, or justified compromises.(iv)To award the full10 marks in the excellent category, the student must demonstrate reasonably good performanceacrossallsixcriteria;otherwise,proportionallylowermarksmaybegiven.

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Suggested rubricsforPracticalcontinuousassessment:

Performance Indicators	Excellent	VeryGood	Good	Satisfactory
Fundamenta lKnowledge (4)(PO1)	The student has well depth knowledge of the topics related to the course (4)	Student has good knowledge of some of the topics related to course (3)	Student is capable of narrating the answer but not capable to showin depth knowledge (2)	Student has not understood the concepts clearly (1)
Design Of Experiment (5)(PO2&PO3)	Student is capable of discussing more than one design for his/her problem statement and capable of proving the best suitable design with proper reason (5)	Studentiscapable ofdiscussingfew designsforhis/her problemstatement butnot capable of selecting best (4)	Student is capable of discussing single designwithitsmerits and de-merits (3)	Student is capable of explaining the design(1-2)
Implementatio n(8) (PO3&PO8)	Student is capable of implementing the design with best suitable algorithm consideringoptimalsolution. (7-8)	Studentiscapable of implementing the design with best suitable algorithm and shouldbecapable ofexplainingit(5-6)	Student is capableof implementing the design with proper explanation. (3-4)	Student is capable of implementing the design. (1-2)
Result &Analysis (5)(PO4)	Student is able to run the program on various cases andcompare theresultwith proper analysis. (5)	Student will be able to run the program for all the cases. (4)	Studentwillbeableto run the code for few casesandanalyzethe output (3)	Student will be able to run the program but not able to analyze the output (1-2)
Demonstration(8) (PO9)	The lab record is well-organized,withclearsections (e.g., Introduction, Method, Results, Conclusion). Transitions between sectionsaresmooth. (7-8)	The lab record is organized,with clearsections,but somesectionsare notwell-defined.-6)	The lab record lacks clearorganizationor structure. Some sectionsareunclear or incomplete. (3-4)	The lab record is poorlyorganized, with missing or unclear sections. (1-2)