VISVESVARAYATECHNOLOGICALUNIVERSITY

BELAGAVI

SchemeofTeachingandExaminations(2026)

M.Tech., in Civil Engineering

(SpecializationinComputerAidedDesignofStructures)

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

Specializationin–(ComputerAidedDesignofstructures)													
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	1MCCS201 / 1MCSE201	StructuralDynamics	42	0	28	50	120	03	50	50	100	4
2	PCC	1MCCS202	ActionandResponseofStructuralElements	42	0	0	48	90	03	50	50	100	3
3	PCC	1MCCS203	ComputerAidedMatrixMethodsofStructuralAnalysis	42	0	0	48	90	03	50	50	100	3
4	PCC	1MCCS204 / 1MCSE204 / 1MCAS204	ContinuumMechanics	42	0	0	48	90	03	50	50	100	3
5	PEC	1MCCS205X	ProfessionalElective–III	42	0	0	48	90	03	50	50	100	3
6	PEC	1MCCS206X	ProfessionalElective–IV	42	0	0	48	90	03	50	50	100	3
7	PCCL	1MCCSL207	SoftComputingTechniquesinStructural Engineering Laboratory	0	0	28	02	30	03	50	50	100	1
8	PCC	1MCCSS208	MinorProject/SkillDevelopmentProject	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
1MCCS205A / 1MCSE205A / 1MCAS205A	FiniteElementMethodsinStructuralAnalysis	1MCCS206A / 1MCSE206B / 1MCAS206C	Advanced ConstructionMaterialcharacterizationtechniques
1MCCS205B	StructuralStabilityAnalysis	1MCCS206B	Non-Destructive TestingforCivilEngineering
1MCCS205C / 1MCSE205C	AnalysisandDesignofReinforcedConcreteBridges	1MCCS206C / 1MCSE206C / 1MCAS206D	DesignofPrecastandCompositeStructures
1MCCS205D	GeotechnicalEarthquakeEngineering	1MCCS206D / 1MCSE206D	AnalysisandDesignofPlatesandShells
1MCCS205E / 1MCSE205E	AdvanceddesignofPre-stressedConcreteStructures	1MCCS206E / 1MCAS206E	Geotechnical Aspects of Foundations and Earth Retaining Structures
1MCCS205F / 1MCSE205F / 1MCAS205F	StructuralReliabilityAnalysisandDesign	1MCCS206F / 1MCSE206F / 1MCAS206F	FiberReinforcedPolymersandMechanicsofComposite Materials

STRUCTURALDYNAMICS			
Course Code	**1MCCS201 / 1MCSE201**	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-Determinenaturalfrequenciesandmodeshapesofmdofsystemsusinganalyticalandnumerical methods.
4. CO4L5-Evaluatethedynamicresponseofshearbuildingsusingnormalmodesuperposition.
5. CO5L3-Applyapproximatemethods(Rayleigh's,Dunkerley's,Stodola's)andanalyzecontinuoussystems like beams.

Module-1

Introduction&DynamicsofSDOFSystems

- Introduction to dynamic problems in Civil Engineering, Concept of degrees of freedom, 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).
- PrincipleofvibrationmeasuringinstrumentsSeismometerandAccelerometer.

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).
- 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(Experimentaldeterminationofnaturalfrequenciesand mode shapes using FFT analyzer/sensors).
6. DevelopmentofaMATLAB/Pythonprogramtosolvefornaturalfrequenciesofa3-storeyshearbuilding.
7. Numericalsimulation(usingMATLAB/OpenSees)ofa2-storeyshearbuildingunderharmonicloadingto compute displacement response.
8. ParametricstudyofdampingeffectonMDOFsystemresponseusingsimulation.
9. Determinationoffundamentalfrequencyofasimplysupportedbeamusing Rayleigh'smethod(Manual calculation + validation using FEM software).
10. ModalanalysisofacontinuousbeamusingANSYS/STAADPro(Extractionoffirst3modeshapes).

SuggestedLearningResourcesText

Books

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.

Reference Books/ 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. LaboratorydemonstrationofshakingtableandFFTanalyzerformodeshapes.
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, safety practices, 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	Understandingoftheory,concepts,andexperimental	5

	procedure;abilitytoexplainresultsandanswerrelated questions.	mark s
Subtotal		10
Total		25

Students'activitiesforTW/SLunderNCrF:

AsperNationalcreditframework(NCrF)studentsmustspend120hoursofstudyfor4creditcourses,whichinclude Course instructions (CI-70 hour) and Teamwork/Self learning (TW/SL-50 hours). Hence, students must complete minimum of two activities as part of NCrF. The evaluation activities will be done using set of rubrics developed for eachactivity.Thefollowingsampleactivitiesarelistedbelow.Thecoursecoordinatorcanalsodesignlearning activitiesbasedoncourseoutcomes.

Sl. No.	TermWork(TW)Activity	NumberofHours/Semester
1	**TWActivity1—Experimentalmodalidentificationofan SDOF structure:**Studentsformteams(3–4).BuildoruseanSDOFlabrig (mass-spring-damper or cantilever beam + tip mass), excite by impulseorshaker,recordtime-historyusingaccelerometer/DAQ, compute frequency response and identify natural frequency and damping(logdecrementandcurvefitting).Compareexperimental valuesto analyticalpredictionsand provideashortreportand oral presentation	24
2	**TW Activity 2 — Forced vibration and frequency response function (FRF) measurement of a MDOF frame:** Teams test a small framed model (2-DOF or 3-DOF) on a shaker or with harmonic excitation using a tone generator, record response, compute FRFs, and validate model predictions using modal superposition.Produceatechnicalreportandashort demonstration.	24
3	**TWActivity3-Micro-project:**Designandfabrication ofasmall-scaleTunedMassDamper(TMD)foracantileverbeamtomitigate vibration.	24
4	**TW Activity 4 - Industrial Visit / Expert Lecture:** Visit to a vibration testing laboratory on "Structural Health Monitoring usingDynamicCharacteristics".Reportshouldbesubmittedatthe endalongwithlearningoutcomes.	24
SL:SelfLearning,MOOCs,spokentutorials,onlineeducationalresourcesetc.		
Sl. No.	**Self-Learning(SL)Activity**	**NumberofHours/Semester**
1	NPTELCourse:Enrollin"StructuralDynamics"byProf.P. Banerjee,IITBombay(NPTEL).CompletemodulesonSDOF, MDOF, and earthquake response.	24
2	SWAYAM Course: "DynamicsofStructures" by Prof.Manish Kumar, IITRoorkee. Completecertification.	24
3	OnlineTutorials:Self-pacedlearningofMATLAB/OpenSees fordynamicanalysis(YouTube/edX).Attheendstudents need to demonstrate with a case study	24

SamplerubricsforTW activities:

Criteria	4-Excellent	3-Good	2-Satisfactory	1 - Needs Improvement
Concept understanding	Demonstrates clear understanding of the transport GIS problem, objectives,andworkflow.	Shows good understandingwith minorgaps.	Basicunderstanding with limited clarity.	Understandingis weak or incorrect.
Task completion	Activityiscompletedfully, correctly, and on time.	Activityismostly complete with minoromissions.	Activityispartially complete.	Activity is incompleteor missing.
Technical accuracy	GISlayers,maps,oranalysis are correct, properly processed, and welljustified.	Mostly correct with fewtechnicalerrors.	Containsnoticeable errors but shows partialcorrectness.	Majortechnical errors or no meaningful attempt.
Datahandling andworkflow	Uses data systematically, followsproperworkflow, and maintains good map/database structure.	Workflowisclear with minor gaps.	Workflowis incompleteor inconsistently followed.	Poorworkflow andweak data handling.
Interpretation and analysis	Provides strong interpretationofspatial results and transport implications.	Gives reasonable interpretationwith some analysis.	Interpretationisbrief and descriptive.	Interpretationis minimal or absent.
Presentation and documentation	Work is neat, well structured, and easy to followwithpropermaps, legends, and notes.	Organizedwellwith minorformatting issues.	Acceptable presentationwith several issues.	Poorlyorganized or difficult to read.

SamplerubricsforSelf-Learningactivities:

Criteria	4-Excellent	3-Good	2-Satisfactory	1 - Needs Improvement
Concept understanding	Demonstrates clear and accurateunderstandingof the assigned concept.	Shows good understandingwith minorgaps.	Basicunderstanding with limited detail.	Understanding is weakorincorrect.
Independent learning	Explores beyond the minimumrequirement andshowsinitiativein learning.	Showsgoodinitiative withsomeadditional effort.	Completes the assigned task with limitedexploration.	Relies heavily on guidanceorshows little effort.
Task completion	Activityiscompletedfully, correctly, and on time.	Activity is mostly completewithminor omissions.	Activityispartially complete.	Activity is incompleteor missing.

Criteria	4-Excellent	3-Good	2-Satisfactory	1 - Needs Improvement
Technical accuracy	Workflow,tooluse,or analysisiscorrectand well justified.	Mostly correct with fewtechnicalerrors.	Containsnoticeable errors but shows partialcorrectness.	Majortechnical errors or no meaningful attempt.
Reflectionand analysis	Providesstrongreflection, interpretation, and learning outcomes.	Gives reasonable reflectionwithsome analysis.	Reflectionisbriefand descriptive.	Reflectionis minimalorabsent.
Presentation and organization	Work is neat, well structured,andeasyto follow.	Organizedwellwith minorformatting issues.	Acceptable presentationwith several issues.	Poorly organized ordifficulttoread.

SuggestedrubricsforPracticalcontinuousassessment:

Performance Indicators	Excellent	VeryGood	Good	Satisfactory
Fundamental Knowledge(4) (PO1)	The student has well depth knowledge of constructionplanning, BIM-enabled 4D/5D workflows, project controls and site logistics.(4)	Student has good knowledgeofsome topics related to construction planning and BIM workflows. (3)	Studentiscapableof narrating theanswer but not capable to show in depth knowledge. (2)	Student has not understood the conceptsclearly.(1)
DesignOf Experiment(5) (PO2 & PO3)	Student is capable of discussing more than one planning workflow/designforthe problem statement and selecting the best suitable approach with properreason.(5)	Studentiscapableof discussing a few workflows but not fully capable of selecting the best. (4)	Studentiscapableof discussing a single planning workflow with merits and demerits. (3)	Studentcanexplainthe planning/design approach only partly. (1-2)
Implementation (8)(PO3&PO8)	Student is capable of implementing WBS, schedule logic, model linkage, resource mapping and issue trackingwithanoptimal andtraceableworkflow. (7-8)	Studentiscapableof implementing the workflowand explaining it with minor gaps. (5-6)	Studentiscapableof implementing the workflowwith partial explanation. (3-4)	Student can implement onlylimitedpartsofthe workflow.(1-2)
Result &Analysis(5) (PO4)	Studentisabletorunthe workflow for various cases and compare 4D sequence, resource, progress and logistics results with proper analysis.(5)	Studentwillbeable toruntheworkflow forall the cases. (4)	Studentwillbeable toruntheworkflow for a few cases and analyze the output. (3)	Studentwillbeableto run the workflow but notabletoanalyzethe output. (1-2)

Demonstration (8)(PO9)	Thelabrecord/portfolio is well organized, 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/portfolio is organized, with clear sections, but some sections are notwell-defined.(5-6)	Thelabrecordlacks clearorganization or structure. Some sectionsareunclear orincomplete.(3-4)	Thelabrecordispoorly organized,withmissing or unclear sections. (1-2)

ACTIONANDRESPONSEOFSTRUCTURALELEMENTS			
Course Code	**1MCCS202**	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. Explaintheinternalactionsinstructuralelementsundervariousloadingconditions.
2. Analyzetheresponseofbeams,columns,shafts,andframesunderstaticactions.
3. Determinestresses,strains,deflections,androtationsinstructuralelementsusinganalyticalmethods.
4. Evaluatetheinfluenceofshear,torsion,bending,axialforce,andcombinedloadingonstructuralbehavior.
5. Applyenergymethodsandstabilityconceptstopredictstructuralresponse.
6. Interpretthebehaviorofstructuralelementsfordesignandcomputationalmodellingapplications.

Module-1

BasicsofStructuralActions:

- Introductiontostructuralelementsandloadeffects.
- Externalloadsandinternalactions:axialforce,shearforce,bendingmoment,torque.
- Stressresultantsandequilibriumofstructuralmembers.
- Stressandstraindistributioninprismaticmembers.
- Conceptsofdeformation,compatibility,andconstitutiverelation**s.**

LinkedCOs:CO1,CO4 **NumberofHours:08**

Module-2

ResponseofAxialandFlexuralMembers:

- Responseofbarsunderaxialtensionandcompression.
- Stress,strain,elongation,andthermaleffects.
- Purebendingtheory,flexuralformula,andassumptions.
- Shearforceandbendingmomentdiagrams.
- Deflectionofbeamsbydirectintegrationandmoment-areamethods.

LinkedCOs:CO1,CO2,CO3 **NumberofHours:09**

Module-3

TorsionandShearResponse:

- Shearstressesinbeamsduetotransverseloading.
- Torsionofcircularshafts,powertransmission,andtorsionalrigidity.
- Combinedbendingandtorsion.
- Thin-walledsectionsandshearflow.
- Stresstransformationandprincipalstressesinstructuralmembers**.**

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

Module-4

Frames,ColumnsandStability:

- Analysisofsimpleframesandrigidjointedsystems.
- Axiallyloadedcolumnsandeccentricloading.
- Shortandlongcolumns,slendernessratio.

- Eulerbucklingtheoryandcriticalload.
- Stabilityofstructuralmembersandbasicimperfectioneffects.

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

Module-5

EnergyMethodsandAdvancedResponse:

- Strainenergyandcomplementaryenergy.
- Castigliano'stheoremsfordeflectionandrotation.
- Unitloadmethodfordisplacementanalysis.
- Introductiontoelasticandinelasticresponse.
- Applicationofstructuralresponseconceptsinnumericalandcomputer-aidedanalysis.

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

SuggestedLearningResources:

Textbooks

1. Gere,J.M.,andGoodno,B.J.,MechanicsofMaterials,9thEdition,CengageLearning.
2. Hibbeler,R.C.,MechanicsofMaterials,10thEdition,Pearson.
3. Timoshenko,S.P.,andGoodier,J.N.,TheoryofElasticity,3rdEdition,McGraw-HillEducation.
4. Ugural,A.C.,andFenster,S.K.,AdvancedMechanicsofMaterialsandAppliedElasticity,6thEdition,Pearson.
5. Cook,R.D.,Malkus,D.S.,Plesha,M.E.,andWitt,R.J.,ConceptsandApplicationsofFiniteElementAnalysis,4th Edition, Wiley.

ReferenceBooks

1. Popov,E.P.,EngineeringMechanicsofSolids,2ndEdition,Pearson.
2. Sadd,M.H.,Elasticity:Theory,Applications,andNumerics,3rdEdition,AcademicPress.
3. Logan,D.L.,AFirstCourseintheFiniteElementMethod,6thEdition,CengageLearning.
4. Boresi,A.P.,Schmidt,R.J.,andSidebottom,O.M.,AdvancedMechanicsofMaterials,6thEdition,Wiley.
5. Bathe,K.J.,FiniteElementProcedures,2ndEdition,Klaus-JurgenBathe.

WeblinksandVideo Lectures(e-Resources)

1. NPTELcoursesonSolidMechanics,StructuralMechanics,andFiniteElementMethods.
2. SWAYAMlecturesonmechanicsofsolidsandstructuralanalysis.
3. OpenCourseWarenotesonstructuraloptimizationandcomputationalmechanics.
4. IIT/IIScoursenotesonadvancedsolidmechanicsandmechanicsofstructure.

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.

Astudentshallbedeemedtohavesatisfiedtheacademicrequirementsandearnedthecreditsallottedtoa 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	**TW1:ProblemSheetonStressandDeformation** Studentssolveproblemsonaxialforce,bending,torsion,and stress-strain response of structural members. **Outcomefocus:**CO1,CO2,CO3.	24
2	**TW2:AnalyticalAssignmentonBeamResponse** StudentsderiveSFD,BMD,slope,anddeflectionforagiven beam configuration. **Outcome focus:** CO2, CO3, CO4	24
3	**TW3:MiniReportonStructuralStability** Studentsprepareashortreportonbucklingbehaviorof columns and real structural implications. **Outcomefocus:**CO4,CO6	24
SL:SelfLearning,MOOCs,spokentutorials,onlineeducationalresourcesetc.		
Sl. No.	**Self-Learning(SL)Activity**	**NumberofHours/Semester**
1	**SL1:Software-basedBeamandFrameAnalysis** Students model beams or frames in structural analysis softwareandcompareanalyticalandnumericalresults.	24
2	**SL2:ResponseSimulationunderCombinedLoading** Studentssimulateastructuralmemberundercombined axial,bending,andtorsionalloadsusingasoftwaretool. **Outcomefocus:**CO3,CO5	24
3	**SL3:FEM-basedCaseStudy** Students study one structural element using finite element softwareandcompareth eresponsewithhandcalculations. **Outcomefocus:**CO5,CO6	24

SamplerubricsforTWactivities:

Criteria	4-Excellent	3-Good	2-Satisfactory	1 - Needs Improvement
Problem understanding	Clearproblemframing with strong justification.	Mostlyclearwith minorgaps.	Basicattemptwith limited clarity.	Poorlydefined problem.
Dataandmethod	Appropriatedataand sound methodology.	Mostlyappropriate with minor issues.	Limiteddataorpartial method.	Inadequateor incorrect method.
Analysis	Robustinterpretation and valid results.	Generally sound withminorerrors.	Partialanalysiswith gaps.	Weak or incorrect analysis.
Recommendations	Strong,feasible,and context-specific.	Relevantwith minorlimitations.	Generic recommendations.	Incompleteor unrealistic.
Presentation	Wellorganizedand professional.	Goodorganization withminorissues.	Acceptablebut uneven.	Poorly presented.

COMPUTERAIDEDMATRIXMETHODSOFSTRUCTURALANALYSIS			
Course Code	**1MCCS203**	Scheme	2026
TypeofCourse	**ProfessionalCoreCourse**	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(CourseSkillSet):

Attheendofthecourse,thestudentwillbeableto:

1. Explainthefundamentalconceptsofcomputationalstructuralmechanics,indeterminacy,compatibility, energy principles, and equivalent nodal loads.
2. ApplynumericalmethodssuchasGausselimination,Choleskydecomposition,andGauss-Seidelmethodto solve systems of linear equations in structural analysis.
3. Develop and formulate element flexibility and stiffness matrices for truss, beam, and grid elements, includingtransformationbetweenlocalandglobalcoordinatesystemsandassemblyofglobalmatrices.
4. Analyzestaticallyindeterminatestructuressuchascontinuousbeams,planetrusses,andrigidframesusing flexibility and stiffness methods.
5. Applythedirectstiffnessmethodandimplementbasiccomputationalalgorithms(MATLAB/Python)to analyze trusses, beams, and frames, and interpret structural responses.

Module-1

BasicConcepts&MethodsforSolvingSimultaneousEquations

- Introductiontocomputationalstructuralmechanics,typesofframedstructures –trusses,beams,grids,and frames.
- Staticandkinematicindeterminacy–degreeoffreedom,internalandexternalindeterminacy.Equilibrium equations – force equilibrium at joints and sections.
- Compatibilityconditions–displacementcontinuityatjoints.Principleofsuperposition –applicabilityin linear elastic structures.
- Energyprinciples–strainenergy,complementaryenergy,Castigliano'stheorems,andtheirapplicationsin structural analysis.
- Equivalentjointloads–conversionofdistributedloadsandconcentratedloadstonodalloads.
- Methods for solving linear simultaneous equations: Gauss elimination method – forward elimination and backsubstitution,Choleskymethod–decompositionofsymmetricpositivedefinitematrices,Gauss-Seidel method – iterative approach for large systems. Numerical examples on each method.

Self-study:WriteasmallprograminPython/MATLABtosolveasystemoflinearequationsusingGausselimination method.

LinkedCOs:CO1 **NumberofHours:8hrs**

Module-2

FundamentalsofFlexibilityandStiffnessMethods

- Concepts of stiffness and flexibility – force-displacement relationships, physical interpretation of stiffness and flexibilitycoefficients.Localandglobalcoordinates–transformationofforcesanddisplacementsfromelement level to structure level.
- Developmentofelementflexibilitymatrixfortrusselement(axialdeformation),beamelement(flexural deformation including bending), and grid element (torsion and bending).

- Developmentofelementstiffnessmatrixfortruss,beam,andgridelements.Force-transformationmatrix–transformation of forces from local to global coordinates.
- Developmentofglobalflexibilitymatrixforcontinuousbeams,planetrusses,andrigidplaneframesusing superposition of element flexibilities.
- Displacement-transformationmatrix–transformationofdisplacementsfromlocaltoglobalcoordinates.
- Developmentofglobalstiffnessmatrixforcontinuousbeams,planetrusses,andrigidplaneframes –assembly process,directstiffnessassembly,andboundaryconditionimplementation.Numericalexamplesforeachtype ofstructure.

Self-study:Derivetheelementstiffnessmatrixforabeamelementwithbothtranslationalandrotationaldegreesof freedom.

LinkedCOs:CO1 **NumberofHours:10hrs**

Module-3

AnalysisusingFlexibilityMethod

- Introductiontoflexibilitymethod–selectingredundantforces,writingcompatibilityequationsintermsof unknownredundants.
- Analysisofcontinuousbeams–determinationofreactions,shearforceandbendingmomentdiagramsusing flexibility method.
- Analysisofplanetrusses–redundantmembers,determinationofmemberforcesconsideringcompatibilityof deformations.
- Analysisofrigidplaneframes–internalredundants,momentdistributionusingflexibilityapproach.
- Constructionofflexibilitymatricesforvariousstructures.Applicationofthemethodforstructureswith differentloadingconditions –concentratedloads,uniformlydistributedloads,andtemperatureeffects. Numerical examples covering all cases.

Self-study:Analyzeatwo-spancontinuousbeamusingtheflexibilitymethodandverifyresultswithstandardsoftware.

LinkedCOs:CO2 **NumberofHours:8hrs**

Module-4

AnalysisusingStiffnessMethod

- Introductiontostiffnessmethod–unknowndisplacementsasprimaryunknowns,writingequilibrium equations in terms of unknown displacements.
- Analysisofcontinuousbeams–determinationofjointrotationsandtranslations,computationofendmoments and reactions using stiffness method.
- Analysisofplanetrusses–unknownjointdisplacements,determinationofmemberforcesusingelement stiffness matrices.
- Analysisofrigidplaneframes–unknownjointrotationsandtranslations,includingswayandnon-swayframes. Construction of global stiffness matrices for various structures.
- Applicationofthemethodfordifferentloadingconditions–nodalloads,equivalentjointloadsfromdistributed loads, and thermal effects.
- Numericalexamplescoveringcontinuousbeams,planetrusses,andrigidplaneframes.

Self-study:Analyzeasingle-baysingle-storeyportalframeusingthestiffnessmethodforlateralload.

LinkedCOs:CO2 **NumberofHours:8hrs**

Module-5

DirectStiffnessMethod:

- Introductiontodirectstiffnessmethod–systematicassemblyofglobalstiffnessmatrixwithout transformation of equilibrium equations.
- Stiffnessmatrixfortrusselementinlocalcoordinates(2Daxialelement) –derivationof2x2and4x4 stiffness matrices.
- Transformationoftrusselementstiffnessmatrixfromlocaltoglobalcoordinates –rotationmatrixand transformation rules.
- Analysisofplanetrussesusingdirectstiffnessmethod–assemblyofglobalstiffnessmatrix,applicationof boundary conditions, solution for displacements, and computation of member forces.
- Stiffnessmatrixforbeamelement(2Dbeamwithaxial,shear,andbendingdeformations) –derivationof 6x6 stiffness matrix in local coordinates.
- Analysisofcontinuousbeamsusingdirectstiffnessmethod–assembly,boundaryconditions,andforce computation.
- Analysisoforthogonalframes(noskewmembers)–combiningtrussandbeamelements,assemblyof global stiffness matrix for frames, solution for displacements, and internal force calculations.
- Numerical examples for plane trusses, continuous beams, and orthogonal frames. Introduction to computationalimplementation–algorithmdevelopment,storageschemesforsparsematrices,andpost-processing of results.

Self-study:DevelopaMATLABprogramfordirectstiffnessanalysisofaplanetrussandvalidatewithasolvedexample.

LinkedCOs:CO3 **NumberofHours:8hrs**

SuggestedLearningResources:

Textbooks/ReferenceBooks

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

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	Assignments: 1. SolutionoflinearequationsusingGausseliminationand Cholesky method (Mod1/CO1) – 8h 2. Developmentofglobalflexibilityandstiffnessmatricesfor continuous beam (Mod2/CO1) – 8h 3. Directstiffnessanalysisofaplanetruss(Mod5/CO3)–8h.	24
2	Seminars: 1. ComparisonofGausseliminationvsiterativemethodsforlarge systems (Mod1/CO1) – 8h 2. FlexibilitymethodvsStiffnessmethod–advantagesand limitations (Mod3 & 4/CO2) – 8h 3. Computationalimplementationofdirectstiffnessmethod (Mod5/CO3)– 8h	24
3	Micro-Project: 1. MATLABprogramforanalysisofcontinuousbeamusing stiffness method (Mod4/CO2) – 12h 2. Directstiffnessanalysisofaplanetrusswithvalidation (Mod5/CO3)– 12h	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-Needs Improvement
Problem understanding	Clear problem framing withstrongjustification.	Mostlyclearwith minor gaps.	Basicattemptwith limited clarity.	Poorlydefined problem.
Dataandmethod	Appropriatedataand sound methodology.	Mostlyappropriate with minor issues.	Limiteddataorpartial method.	Inadequateor incorrect method.
Analysis	Robustinterpretation and valid results.	Generally sound withminorerrors.	Partialanalysiswith gaps.	Weak or incorrect analysis.
Recommendations	Strong,feasible,and context-specific.	Relevantwithminor limitations.	Generic recommendations.	Incompleteor unrealistic.
Presentation	Wellorganizedand professional.	Goodorganization withminorissues.	Acceptablebutuneven.	Poorly presented.

CONTINUUMMECHANICS			
Course Code	**1MCCS204 / 1MCSE204 / 1MCAS204**	Scheme	2026
TypeofCourse	**ProfessionalCoreCourse**	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(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 ofstressand strainata point,componentsofstressandstrain ata 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'sprinciple.
- 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,wedgeandgrooveproblems

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.
- Membrane analogy.
- Torsionofabarofnarrowrectangularcrosssection.
- Torsionofthin-walledopencrosssections.
- Torsionof thin-walled tubes.

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.– Theoryof Elasticity,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):

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

AssessmentStructure(bothCIEandSEE)

TheweightageassignedtoContinuousInternalEvaluation(CIE)andSemesterEndExamination(SEE) shallbe50% each.AstudentshallsecureaminimumofSO%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.EachtestshallbeconductedforamaximumofSO marks. The average of the two test marks shall be the marks secured by a student in IA.

Inaddition,ContinuousComprehensiveAssessment(CCA)shallbeconductedforatotalofSO marks

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.ThecoursecoordinatorcanalsogivetheirownTW/SLactivitiesas perthecourseoutcomes.

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. StressdistributionaroundacircularholeusingPython(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	Clear problem framing withstrongjustification.	Mostlyclearwith minor gaps.	Basicattemptwith limited clarity.	Poorlydefined problem.
Dataandmethod	Appropriatedataand sound methodology.	Mostlyappropriate with minor issues.	Limiteddataor partialmethod.	Inadequateor incorrectmethod.
Analysis	Robustinterpretation and valid results.	Generally sound withminorerrors.	Partialanalysiswith gaps.	Weakorincorrect analysis.
Recommendations	Strong,feasible,and context-specific.	Relevantwithminor limitations.	Generic recommendations.	Incompleteor unrealistic.
Presentation	Wellorganizedand professional.	Goodorganization withminorissues.	Acceptablebut uneven.	Poorlypresented.

FINITEELEMENTMETHODSINSTRUCTURALANALYSIS			
Course Code	**1MCCS205A / 1MCSE205A / 1MCAS205A**	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:Applyprinciplesofelasticityandenergymethods(Rayleigh-Ritz,FiniteDifference)toformulate structural problems.
2. CO2:Developshapefunctionsfor1D,2D,and3Delementsusinggeneralized,natural,andLagrangian coordinates ensuring convergence.
3. CO3:Formulateisoparametric,subparametric,andsuper-parametricelementsusingJacobiantransformation and numerical integration.
4. CO4:ExecuteFEMprocedureforbeams,trusses,andplanestress/strainproblemsusingCSTandquadrilateral elements.
5. CO5:Evaluateplates,shells,andselectappropriatetechniquesfornon-linearstructuralanalysis.

Module-1

BasicConceptsofElasticity, ApproximateMethods&FEM Fundamentals:

- Kinematicandstaticvariablesforstructuralproblems.Approximatemethods–Rayleigh-Ritzmethod,Finite difference method.
- Variationmethodandminimizationofenergyapproachforelementformulation.
- PrinciplesofFEM–advantages&disadvantages.
- GeneralFEMprocedure.
- Finiteelementsfor1D,2D&3Dproblems–elementaspectratio,meshrefinementvs.higherorderelements, 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.SerendipityandLagrangianfamilyof elements. Subparametric and super-parametric elements.
- Condensationofinternalnodes.Jacobiantransformationmatrix –strain-displacementmatrixandstiffness matrix. Consistent load vector. Numerical integration – Gaussian quadrature.

Self-study:Perform2x2Gaussianquadratureforaquadrilateralelement.

LinkedCOs:CO3 **NumberofHours:8hrs**

Module-4

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

- ApplicationofFEMforanalysisof1Dand2Dproblems.
- Analysisofsimplebeamsandplanetrusses.Applicationtoplanestress,planestrain,andaxisymmetricproblems 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_2typecontinuity requirements.
- Techniquesfornon-linearstructuralanalysis–geometricnon-linearity,materialnon-linearity,andsolution methods (Newton-Raphson, modified Newton-Raphson).

Self-study:Comparelinearvsnon-linearanalysisofacantileverbeamunderlargedeflection.

LinkedCOs:CO5 **NumberofHours:8hrs**

Suggested Learning Resources

Textbooks

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

ReferenceBooks

1. Rajasekaran,S.–FiniteElementAnalysisinEngineeringDesign,WheelerPublishing.
2. Cook,R.D.,Malkus,D.S.&Plesha,M.E.–ConceptsandApplicationofFiniteElementAnalysis,3rdEdition,John Wiley and Sons, 1989.
3. Shames,I.H.&Dym,C.J.–EnergyandFiniteElementMethodsinStructuralMechanics,McGrawHill,NewYork, 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-learningprocess andfacilitatetheachievementofcourseoutcomes.SuggestedInnovativeDeliveryMethodsmayinclude(butarenotlimited to):

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- 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)=ContinuousInternalEvaluationCIE [25+25=50 marks]

A minimum of two Internal Assessment Tests (IA) shall be conducted.Each testshall beconducted for a maximumof 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 listed below. Thesampleactivitiesaregiven below. Thecoursecoordinator canalsogivetheirown TW/SLactivitiesas perthecourseoutcomes.

Sl. No.	TermWork(TW)Activity	NumberofHours/ Semester
1	Assignments: 1. Rayleigh-Ritz solution for beam (Mod1/CO1) – 8h 2. Shape functions for 2D element (Mod2/CO2) – 8h 3. CSTanalysisofplanestressproblem(Mod4/CO4)–8h	24
2	Seminars: 1. Isoparametric formulation (Mod3/CO3) – 8h 2. Non-linear solution methods (Mod5/CO5) – 8h 3. Platesandshellsanalysis(Mod5/CO5)–8h	24
3	Micro-Project: 1. MATLAB program for truss analysis (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)	24
2	NPTEL:Non-linearFEM(IITMadras)	24
3	FEAsoftwarepractice(ANSYS/ABAQUS)	24

SamplerubricsforTWactivities:

Criteria	4-Excellent	3-Good	2-Satisfactory	1-Needs Improvement
Problem understanding	Clearproblemframing with strong justification.	Mostlyclearwithminor gaps.	Basicattemptwith limited clarity.	Poorlydefined problem.
Dataandmethod	Appropriatedataand sound methodology.	Mostlyappropriatewith minorissues.	Limiteddataor partialmethod.	Inadequateor incorrectmethod.
Analysis	Robustinterpretation and valid results.	Generallysoundwith minor errors.	Partialanalysis with gaps.	Weakorincorrect analysis.
Recommendations	Strong,feasible,and context-specific.	Relevantwithminor limitations.	Generic recommendations.	Incompleteor unrealistic.
Presentation	Wellorganizedand professional.	Goodorganizationwith minorissues.	Acceptablebut uneven.	Poorlypresented.

STRUCTURALSTABILITYANALYSIS			
Course Code	**1MCCS205B**	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. Explainthefundamentalsofstructuralstability,equilibrium,andbucklingbehaviorofstructuralmembersand systems.
2. Analyzestabilityofcolumns,frames,beams,arches,andotherstructuralelementsunderaxial,lateral,and combined loading.
3. Applyenergy,differentialequation,andmatrix-basedmethodsforelasticstabilityanalysisofstructural systems.
4. Evaluatesecond-ordereffects,imperfectionsensitivity,andcriticalloadfactorsinpracticalstructuraldesign situations.
5. Interpretstabilityrequirementsincodesandincorporateappropriateidealizationsinstructuralanalysisand design.
6. Assessthestabilityofstructuralsystemsusinganalyticalandcomputationalapproachesforsafedesign decisions..

Module-1

FundamentalsofStructuralStability:

Introductiontostructuralstability,equilibriumstates,stable,unstable,andneutralequilibrium.Conceptofbuckling, bifurcation,imperfections,andsensitivity.Stabilityofdiscreteandcontinuoussystems.Criticalload,effectivelength,end conditions, and factors influencing stability of structures.

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

Module-2

BucklingofColumns:

Euler buckling of prismatic columns with different end conditions. Derivation of critical load, slenderness ratio, and limitationsofEulertheory.Inelasticbuckling,secantformula,Rankine-Gordonformula,anddesignconsiderationsfor real columns. Buckling under eccentric loading and initial imperfections.

LinkedCOs:CO1,CO2,CO4. **NumberofHours:08**

Module-3

StabilityofFramesandBeam-Columns

Stabilityofpinnedandrigidframes,swayandnon-swayframes.Bucklingofbeam-columnsundercombinedaxialloadand bending. Secondary moments, P-Delta effects, moment magnification, and approximate methods for frame stability. Introductiontocriticalloadanalysisofportalframesandslendermembers.

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

Module-4

EnergyandAnalyticalMethods:

Applicationofstrainenergy,virtualwork,andRayleigh-Ritzmethodsinstabilityanalysis.Differentialequationapproach forcolumnandbeamstability.Stabilityofelasticsystemsusingequilibriumandenergymethods.Introductiontotransfer matrix and stiffness matrix concepts for stability problems.

LinkedCOs:CO1,CO3,CO6. **NumberofHours:08**

Module-5

AdvancedTopicsinStructuralStability:

Stability of arches, plates, and thin-walled members. Local, overall, and lateral-torsional buckling concepts. Influence of geometricimperfections,residualstresses,andmaterialnonlinearity.Second-orderelasticanalysis,code-basedstability provisions, and numerical methods for complex structural systems. Case studies on stability failures in real structures.

Linked COs: CO4, CO5, CO6. **Number of Hours: 10**

LinkedCOs:CO5 **NumberofHours:8hrs**

SuggestedLearningResources:

Textbooks

1. Timoshenko, S.P.andGere,J.M.,TheoryofElasticStability,McGraw-Hill.
2. Ghali,A.,Neville,A.M.andBrown,T.G.,StructuralAnalysis:AUnifiedClassicalandMatrixApproach,CRCPress.
3. Hibbeler,R.C.,StructuralAnalysis,Pearson.
4. Weaver, W. andGere,J.M.,MatrixAnalysisofFramed Structures,Springer

Reference Books

1. Johnson, R.P.,ColumnsandColumn Stability,classicreferencetext.
2. Trahair,N.S.,StabilityofStructures:Elastic,Inelastic,andNonlinearAnalysis,CRCPress.
3. Salmon,C.G.,StructuralStabilityofSteelMembers,Wiley.
4. IScodesandrelevantdesignstandardsforstabilityandslendernesschecks.

WeblinksandVideoLectures(e-Resources)

1. https://archive.nptel.ac.in/courses/105/105/105105217/
2. https://onlinecourses.nptel.ac.in/noc22_ce91/preview
3. https://archive.nptel.ac.in/content/syllabus_pdf/105105217.pdf

Teaching-LearningProcess(InnovativeDeliveryMethods):

Thefollowingaresamplestrategiesthateducatorsmayadopttoenhancetheeffectivenessoftheteaching-learningprocess andfacilitatetheachievementofcourseoutcomes.SuggestedInnovativeDeliveryMethodsmayinclude(butarenotlimited 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)=ContinuousInternalEvaluationCIE [25+25=50 marks]

A minimum of two Internal Assessment Tests (IA) shall be conducted.Each testshall beconducted for a maximumof 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 listed below. Thesampleactivitiesaregiven below. Thecoursecoordinator canalsogivetheirown TW/SLactivitiesas perthecourseoutcomes.

Sl. No.	TermWork(TW)Activity	NumberofHours/Semester
1	**TW-1: Computational Buckling Project— Linked CO2, CO4, CO5** **Task:** Students form groups (3–4) and select a structural component (column,thin-walledsection,frame,orplate)tomodelusinganFE package.Performlineareigenvaluebucklinganalysis,thenintroduce geometricimperfectionandrunnonlinear(arc-lengthorR–R)analysis tocapturepost-bucklingbehaviour.Produceareport(max8pages) withmodelingassumptions,meshstudy,modeshapes,criticalloads, imperfectionsensitivity,anddesignrecommendations.	24
2	**TW-2: Frame Stability and P–Δ Analysis Worksheet (24 hours) — Linked CO3, CO4, CO5** **Task:**Givenamulti-storyframe,studentscomputeapproximatecritical loads using Rayleigh–Ritz or Galerkin method, then perform a refined matrixstiffness(geometricstiffness)approachtocomputeexactlinear bucklingloads.Finally,evaluateP–Δeffectsforgivengravityloadsand recommendstrengtheningorbracingsolutions	24

SL:SelfLearning,MOOCs,spokentutorials,onlineeducationalresourcesetc.

Sl. No.	Self-Learning(SL)Activity	NumberofHours/Semester
1	**SL-1:LiteratureReviewandCaseStudy—LinkedCO1,CO5** **Task:** Individual students perform a focused literature review (5–6 papers) on imperfection sensitivity or shell buckling and prepare a 2-pagecriticalsummarylinkingfindingstodesignpractice. Conducta5-minuteoralsummaryinclass.	24
2	**SL-2:OnlineModuleandQuizonFEBucklingProcedures—Linked CO2, CO5** **Task:**StudentscompletespecifiedNPTELorsoftware-provider tutorialsonbucklinganalysis,runaguidedtutorialmodel,andpass an onlinequiz(providedbyinstructor)andsubmitoutputs.	24

SamplerubricsforTWactivities:

Criteria	4-Excellent	3-Good	2-Satisfactory	1-Needs Improvement
Problem understanding	Clear problem framing withstrongjustification.	Mostlyclearwith minor gaps.	Basicattemptwith limited clarity.	Poorlydefined problem.
Dataandmethod	Appropriatedataand sound methodology.	Mostlyappropriate with minor issues.	Limiteddataorpartial method.	Inadequateor incorrect method.
Analysis	Robustinterpretation and valid results.	Generally, sound withminorerrors.	Partialanalysiswith gaps.	Weak or incorrect analysis.
Recommendations	Strong,feasible,and context-specific.	Relevantwithminor limitations.	Generic recommendations.	Incompleteor unrealistic.
Presentation	Wellorganizedand professional.	Goodorganization withminorissues.	Acceptablebutuneven.	Poorly presented.

ANALYSISANDDESIGNOF REINFORCEDCONCRETE BRIDGES			
Course Code	**1MCCS205C / 1MCSE205C**	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:Selectappropriatebridgesitesanddeterminepreliminarydimensionsforvariousbridgetypesbased on functional requirements.
2. CO2:Analyzeforcesonpiers,abutments,andwingwallsandperformstructuraldesignincludingbridge bearings.
3. CO3:EvaluateworstcaseloadingcombinationsusingIRCstandardsandperformdesignofboxandslab culverts.
4. CO4:Applyclassicalmethods(Courbon,Hendry-Jaeger,Morice-Little)forloaddistributioninT-beambridge girders
5. CO5:Designprestressedconcretebridgecomponentsincludingprestressingforce,cableprofiles,andend blocks

Module-1

BridgeFundamentals,Substructures&Bearings:

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

Self-study:Collectsitedetailsofalocalbridgeandidentifyitstypeandcomponents.

LinkedCOs:CO1 **NumberofHours:9hrs**

Module-2

BoxCulvert&SlabCulvertDesignusingIRCLoading:

- Differentloadingcases–IRCClassAA(trackedandwheeled)andClassAloading.Workingouttheworst combination of loading. Moment distribution method.
- Calculationofbendingmomentandshearforce.Structuraldesignofslabculvertwithreinforcementdetails.

Self-study:CompareIRCClassAAandClassAloadingforagivenspan.

LinkedCOs:CO2 **NumberofHours:8hrs**

Module-3

T-BeamBridge–Slab&CrossGirderDesign:

- Slabdesign:Proportioningofcomponents.Analysisofinteriorslabandcantileverslabusing IRCClassAA tracked, wheeled, and Class A loading. Structural design of slab with reinforcement details.
- Crossgirderdesign:Analysisofcrossgirderfordeadloadandliveloadusing IRCClassAAtracked,wheeled, and Class A loading. Structural design of cross girder with reinforcement details.

Self-study:AnalyzeacantileverslabofaT-beambridgeunderIRCloading.

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

Module-4

T-BeamBridge–MainGirderDesignusingClassicalMethods:

- AnalysisofmaingirderfordeadloadandliveloadusingIRCClassAAtracked,wheeled,andClassAloading using Courbon's method.
- AnalysisofmaingirderusingHendry-JaegerandMorice-LittlemethodforIRCClassAAtrackedvehicleonly. Bendingmomentandshearforcefordifferentloads.Structuraldesignofmaingirderwithreinforcement details.

Self-study:CompareCourbon'smethodwithHendry-Jaegermethodforloaddistribution.

LinkedCOs:CO4 **NumberofHours:9hrs**

Module-5

PrestressedConcrete(PSC)Bridges:

- Introductiontopre-tensioningandpost-tensioning.Proportioningofcomponents.Analysisandstructural design of slab.
- AnalysisofmaingirderusingCourbon'smethodforIRCClassAAtrackedvehicle.Calculationof prestressingforce,cableprofile,andcalculationofstresses.Designofendblockanddetailingofmain girder.

Self-study:Calculateprestressingforceforasimplysupported PSCbridgegirder

LinkedCOs:CO5 **NumberofHours:8hrs**

Suggested Learning Resources

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,New Delhi.
7. IS1343–IndianStandardPrestressedConcreteCodeofPractice,BIS,NewDelhi.

ReferenceBooks

1. Raina,V. K.– ConcreteBridgePractice, Tata McGrawHill.
2. Bakht,B.&Jaeggar–BridgeAnalysisSimplified,McGrawHill.
3. Ponnuswamy, S. –BridgeEngineering,TataMcGrawHill.
4. 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(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	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)	24
2	IRC6&IRC112codeself-study	24
3	CSIBridge/STAADpracticeforbridgemodeling	24

SamplerubricsforTWactivities:

Criteria	4-Excellent	3-Good	2-Satisfactory	1-Needs Improvement
Problem understanding	Clear problem framing withstrongjustification.	Mostlyclearwith minor gaps.	Basicattemptwith limited clarity.	Poorlydefined problem.
Dataandmethod	Appropriatedataand sound methodology.	Mostlyappropriate with minor issues.	Limiteddataorpartial method.	Inadequateor incorrect method.
Analysis	Robustinterpretation and valid results.	Generallysoundwith minor errors.	Partialanalysiswith gaps.	Weak or incorrect analysis.
Recommendations	Strong,feasible,and context-specific.	Relevantwithminor limitations.	Generic recommendations.	Incompleteor unrealistic.
Presentation	Wellorganizedand professional.	Goodorganization withminorissues.	Acceptablebutuneven.	Poorly presented.

GEOTECHNICALEARTHQUAKEENGINEERING			
CourseCode	**1MCCS205D**	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:AchieveKnowledgeofdesignanddevelopmentofproblemsolvingskills..
2. CO2:Understandtheprinciplesofengineeringseismology.
3. CO3:Designanddevelopanalyticalskills.
4. CO4:SummarizetheSeismicevaluationandretrofittingofstructures.
5. CO5:Understandtheconceptsofearthquakeresistanceofreinforcedconcretebuildings.

Module-1

INTRODUCTIONTOGEOTECHNICALEARTHQUAKEENGINEERING:

- Seismichazards–GroundShaking,Structuralhazards,Liquefaction,Landslides,Retainingstructurefailures, Lifeline Hazards, Tsunami and Seiche Hazards; Mitigation of Seismic Hazards, Significant Historical Earthquakes.
- DYNAMICSOILPROPERTIES:RepresentationofStressconditionsbyMohrCircle–Principalstressesandstress path;measurementofdynamicsoilproperties:Fieldtest,labtests,interpretationofobservedgroundresponse.

Self-study: Studentsshallpreparereportonsignificanthistoricalearthquakesandtheirimpactongeotechnical structures

LinkedCOs:CO1,CO2 **NumberofHours:9hrs**

Module-2

LIQUEFACTION:

- Liquefactionrelatedphenomenon–flowliquefaction,CyclicMobility;Evaluationofliquefactionhazards; liquefactionSusceptibilityhistoricalcriteria.Geologiccriteria.Compositionalcriteria.Statecriteria:initiation of liquefaction- flow liquefaction surface, Influence of excess pore pressure. Evaluation of Initiation of liquefaction–effectsofliquefaction.
- **Self-study:**Studentsshallprepareacasestudyonliquefaction-inducedfailuresfrompastearthquakes.

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

Module-3

SOIL IMPROVEMENT FORREMEDIATIONOFSEISMICHAZARDS:

- Densification techniques - Vibro techniques. Dynamic compaction, Blasting. Compaction grouting, Arial extent ofDensification;Reinforcementtechniques–stonecolumns.Compactionpiles.Drilledinclusions;groutingand mixing techniques-drainage techniques.
- Verificationofsoilimprovement–labtestingtechniques;In-situtestingtechniques,Geophysicaltesting techniques; Other considerations.

Self-study: Studentsshalldevelopacomparativestudyreportonvarioussoilimprovementtechniquesforseismic hazard mitigation

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

Module-4

GENERALPRINCIPLEOFMACHINEFOUNDATION DESIGN:

- Typesofmachineandfoundation,Generalrequirementsofmachinefoundations;permissibleamplitude, Allowable soil pressure. Permissible stresses of concrete and steel. Permissible stresses of timber.
- FOUNDATIONOFRECIPROCATINGMACHINE;Modesofvibrationofarigidfoundationblock.Methodsof analysis, Linear elastic weight less spring method, Elastic half space method.
- Effectoffootingshapeonvibratoryresponse,Dynamicresponseofembeddedblockfoundation.
- Soilmassparticipatinginvibrations,Designprocedureforablockfoundation.

Self-study: Studentsshallsolvenumericalproblemsondesignofblockfoundationforreciprocatingmachines.

LinkedCOs:CO3,CO5 **NumberofHours:9hrs**

Module-5

FOUNDATIONOFIMPACTTYPEMACHINE:

- Dynamicanalysis.Designprocedureforahammerfoundation.
- FOUNDATIONOFROTARYMACHINES:Specialconsiderations.Designcriteria.LoadsonaT.G.Foundations, Method of analysis and design, Resonance method. Amplitude method, Combined method.

Self-study: Studentsshallpreparedesigncalculationsforhammerfoundationandrotarymachinefoundation.

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

Suggested Learning Resources

Textbooks

1. StevenLKramer–GeotechnicalEarthquakeEngineering,PHIseries.
2. SwamiSaran–SoilDynamicsandMachineFoundations,GalgotiaPublicationsPvt.Ltd.
3. AnilK.Chopra,DynamicsofStructures–TheoryandApplicationtoEarthquakeEngineering,2nded.,Pearson Education.

ReferenceBooks

4. EarthquakeResistantDesignofBuildingStructures,VinodHosur,WILEY(India).
5. EarthquakeResistantDesignofStructures,Duggal,OxfordUniversityPress.
6. Earthquakeresistantdesignofstructures-PankajAgarwal,ManishShrikande,PHIIndia.
7. IS–1893(PartI):2002,IS–13920:1993,IS–4326:1993,IS-13828:1993.
8. DesignofEarthquakeResistantBuildings,MinoruWakabayashi,McGrawHillPub.
9. SeismicDesignofReinforcedConcreteandMasonryBuildings,TPaulayandMJNPriestley,JohnWileyand Sons.

WeblinksandVideoLectures(e-Resources)

1. https://www.youtube.com/watch?v=q-kHDw37XOM&list=PLbMVogVj5nJRNzx4KtSTVj7qr9OxwY3IF
2. NPTELcoursesonGeotechnicalEarthquakeEngineering.
3. ISCodesandBISstandardsforearthquakeresistantdesign.
4. EERI(EarthquakeEngineeringResearchInstitute)publicationsandcasestudies.

Teaching-LearningProcess(InnovativeDeliveryMethods):

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

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- ICT-EnabledTeaching
- RolePlay

AssessmentStructure(bothCIEandSEE)

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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	Seismic Hazard Assessment: Prepare a comprehensive report on seismic hazards for a selected region including ground shaking, liquefaction, and landslide potential.	24
2	Liquefaction Evaluation: Conduct liquefaction susceptibility assessmentforagivensoilprofileusingstandardpenetrationtest (SPT)data.	24
3	SoilImprovementTechnique:Designasoilimprovementstrategy for a liquefiable site using appropriate densification or reinforcementtechniques.	24
4	MachineFoundationDesign:Designablockfoundationfora reciprocating machineconsidering dynamicsoilproperties.	24
5	TechnicalSeminar:Conductionoftechnicalseminarsonrecent research activities in geotechnical earthquake engineering.	24

SL:SelfLearning,MOOCs,spokentutorials,onlineeducationalresourcesetc.

Sl. No.	Self-Learning(SL)Activity	NumberofHours/Semester
1	Preparereportonsignificanthistoricalearthquakesandtheir impactongeotechnicalstructures(asperModule-1self-study).	16
2	Prepareacasestudyonliquefaction-inducedfailuresfrompast earthquakes (as per Module-2 self-study).	16
3	Developacomparativestudyreportonvarioussoilimprovement techniquesforseismichazardmitigation(asperModule-3self-study).	16
4	Solvenumericalproblemsondesignofblockfoundationfor reciprocatingmachines(asperModule-4self-study).	16
5	Preparedesigncalculationsforhammerfoundationandrotary	16

	machinefoundation(asperModule-5self-study).	

SamplerubricsforTWactivities:

Criteria	4-Excellent	3-Good	2-Satisfactory	1-Needs Improvement
Problem understanding	Clear problem framing withstrongjustification.	Mostlyclearwith minor gaps.	Basicattemptwith limited clarity.	Poorlydefined problem.
Dataandmethod	Appropriatedataand sound methodology.	Mostlyappropriate with minor issues.	Limiteddataorpartial method.	Inadequateor incorrect method.
Analysis	Robustinterpretation and valid results.	Generally sound withminorerrors.	Partialanalysiswith gaps.	Weak or incorrect analysis.
Recommendations	Strong,feasible,and context-specific.	Relevantwithminor limitations.	Generic recommendations.	Incompleteor unrealistic.
Presentation	Wellorganizedand professional.	Goodorganization withminorissues.	Acceptablebutuneven.	Poorly presented.

ADVANCEDDESIGNOFPRE-STRESSEDCONCRETESTRUCTURES			
Course Code	**1MCCS205E / 1MCSE205E**	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,analysisofbehavior.
- AnalysisofMembers Under Flexure:Introduction,analysisatserviceloads –basedonstressconcept,based on force concept, based on load balancing concept, cracking moment, kern point, pressure line, variation of stressinsteel,condition atultimate limitstate,analysisofrectangularsections,analysisofflangedsections, analysisofpartiallyprestressedsections,analysisofun-bondedpost-tensionedbeams,analysisofbehavior. 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,componentsofshearresistance, modes of failure, effect of prestressing force.
- Design for shear: Limit state of collapse for shear, maximum permissible shear stress, design of transverse reinforcement,detailingrequirementforshear,generalcomments,designsteps,designofstirrupsforflange.
- Analysisfortorsion:Introduction,stressesinanuncrackedbeam,crackpatternunderpuretorsion,components of resistance for pure torsion, modes of failure, effect of prestressing force.
- Designfortorsion:Limitstateofcollapsefortorsion,designoflongitudinalreinforcement,designoftransverse

reinforcement,detailingrequirements,generalcomments,designsteps.Numericalproblems.

Self-study:CompareshearandtorsiondesignprovisionsbetweenIS1343andACIcodes.

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

Module-4

AdvancedCalculationsofDeflection,CrackWidth&TransmissionofPrestress

- Calculationofdeflection:Deflectionduetogravityloads,deflectionduetoprestressingforce,totaldeflection, limits of deflection, determination of moment of inertia, limits of span-to-effective depth ratio.
- Calculationofcrackwidth:Methodofcalculation,limitsofcrackwidth.
- Transmissionofprestress:Introduction,pre-tensionedmembers,transmissionlength,developmentlength,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.
- Continuous beams: Introduction, analysis, incorporation of moment due to reactions, pressure line due to prestressingforce,concordantcableprofile,cableprofiles,partiallycontinuousbeams,analysisatultimate 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

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

WeblinksandVideo Lectures(e-Resources)

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

Teaching-LearningProcess(InnovativeDeliveryMethods):

Thefollowingaresamplestrategiesthateducators mayadopt toenhancethe effectivenessof theteaching-learning process andfacilitatetheachievementofcourseoutcomes.SuggestedInnovativeDeliveryMethodsmayinclude(butarenotlimited 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)=ContinuousInternalEvaluationCIE [25+25=50 marks]

A minimum of two Internal Assessment Tests (IA) shallbe conducted. Each test shall be conducted fora 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 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 listed below. Thesampleactivitiesaregiven below. The coursecoordinator canalsogivetheirown TW/SLactivitiesas perthecourseoutcomes.

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

SamplerubricsforTWactivities:

Criteria	4-Excellent	3-Good	2-Satisfactory	1 - Needs Improvement
Problem understanding	Clear problem framing withstrongjustification.	Mostlyclearwith minorgaps.	Basicattemptwith limited clarity.	Poorlydefined problem.
Dataandmethod	Appropriatedataand sound methodology.	Mostlyappropriate with minor issues.	Limiteddataor partialmethod.	Inadequate or incorrectmethod.
Analysis	Robustinterpretation and valid results.	Generally sound withminorerrors.	Partialanalysiswith gaps.	Weakorincorrect analysis.
Recommendations	Strong,feasible,and context-specific.	Relevantwithminor limitations.	Generic recommendations.	Incompleteor unrealistic.
Presentation	Wellorganizedand professional.	Goodorganization withminorissues.	Acceptablebut uneven.	Poorlypresented.

STRUCTURALRELIABILITYANALYSISANDDESIGN			
CourseCode	**1MCCS205F / 1MCSE205F / 1MCAS205F**	Scheme	2026
TypeofCourse	**ProfessionalElectiveCourse**	Semester	II
TeachingHours/Week(L:T:P)	42(3:0:0)	CIEMarks	50
TotalHoursofPedagogyper Semester CI(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,andstructuralresistanceforengineering applications.
3. CO3:Applyreliabilitymethodsfor safetyassessment anddesignofstructuralcomponentsand systems.
4. CO4:Analyzefailureprobability,reliabilityindex,andriskmeasuresforstructuralperformanceevaluation.
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 propertiesofconcrete,steel,timber,andotherstructuralmaterials.Resistancemodelling,biasfactors,andcoefficient of variation. Data fitting, estimation of parameters, and interpretation of probabilistic input variables. Load and resistance uncertainty in structural design**.**

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

Module-3

Reliability MethodsandFailureProbability:

First-order and second-order reliability concepts, safety index, probability of failure, and reliability index. Analytical andnumericalmethodsforreliabilityevaluation.Meanvalueapproach,levelI,levelII,andlevelIIImethods.FORMand 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-BasedDesignof StructuralElements:

Reliability-basedlimitstatedesign,ultimateandserviceabilitylimitstates,partialsafetyfactors,targetreliability,and calibrationconcepts.Reliabilityanalysisofbeams,columns,slabs,andconnections.Loadcombinations,resistancefactors, and designcheckunderuncertainty.Applicationofreliabilityconcepts to reinforcedconcrete andsteelstructures.

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

Module-5

System Reliability,Risk, andDecisionMaking:

Systemreliability ofstructural assemblies,seriesandparallel systems,redundancy,andcomponentinteraction. Deterioration,ageing,fatigue,corrosion,andtime-dependentreliability. Risk,consequenceoffailure,inspection planning,maintenance,andlife-cycleperformance.Reliabilityupdating,Bayesianconcepts,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,3rd Edition, 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,StatisticsandReliabilityfor Engineers,McGraw-HillEducation.

ReferenceBooks

1. Nowak,A.S.andCollins,K.R.,ReliabilityofStructures,2ndEdition,CRCPress.
2. Benjamin,J.R.andCornell,C. A.,Probability,Statistics, andDecisionfor CivilEngineers,DoverPublications.
3. Ditlevsen,O.andMadsen,H.O.,Structural ReliabilityMethods,Wiley.
4. ISO2394,GeneralPrinciplesonReliabilityfor Structures,LatestEdition.

WeblinksandVideoLectures(e-Resources)

1. NPTEL/SWAYAMcourses on probabilisticmethodsandstructuralreliability.
2. Professionallectures onreliability-baseddesignandstructuralsafetyassessment.
3. Referencematerialsonprobabilisticstructuraldesignandlife-cycleassessment.

Teaching-LearningProcess(InnovativeDeliveryMethods):

The followingare sample strategies thateducators mayadopt toenhance the effectiveness ofthe teaching-learning processandfacilitatetheachievementofcourseoutcomes.SuggestedInnovativeDeliveryMethodsmayinclude(butare not limited to):

- FlippedClassroom
- Problem-BasedLearning (PBL)
- Case-BasedTeaching
- SimulationandVirtualLabs
- PartialDelivery of coursebyIndustryexpert/industrialvisits
- ICT-EnabledTeaching
- RolePlay

AssessmentStructure(bothCIE andSEE)

The weightage assignedtoContinuous Internal Evaluation(CIE) andSemesterEndExamination (SEE)shall be50% each.Astudentshallsecureaminimumof50%ofthemaximummarksprescribedforCIEanda minimumof40% 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)shallbe conducted.Eachtestshallbeconductedfora maximum of 25marks.Theaverageofthetwotestmarksshallbethemarkssecuredbyastudentin IA.

Inaddition,ContinuousComprehensiveAssessment(CCA)shallbeconductedforatotalof25marks

Students'activitiesforTW/SLunderNCrF:Samples only

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	**TW-1:ProbabilityDistribution Exercise:**Studentsshallanalyzesampledata for load or material strength and fit an appropriate probability distribution. They shall compute mean, variance, standard deviation, and comment on the suitabilityofthefittedmodel.	24
2	**TW-2:ReliabilityIndexCalculation:**Studentsshall evaluatereliabilityindex andprobabilityoffailureforasimplestructuralelementusinggivenloadand resistance data.	24
3	**TW-3: FORM-Based StructuralCheck**:Studentsshallperformabasic FORM-basedreliabilityassessmentforastructuralmemberandinterpretthedesign point and sensitivity factors.	24
4	**TW-4:Reliability-BasedDesignComparison:**Studentsshallcompare deterministicdesignandreliability-baseddesignforachosenstructural componentandpresentdesignimplications.	24

SL:SelfLearning,MOOCs,spokentutorials,online educationalresources etc.

Sl.No.	Self-Learning(SL)Activity	NumberofHours/ Semester
1	**SL-1:CaseStudyonStructuralFailure:**Studentsshallstudyastructural failurecaseandidentifytheroleofuncertainty,modellingerror,material variation,anddesignassumptions.	24
2	**SL-2:ReliabilityofStructuralSystems:**Studentsshallpreparareportson seriesandparallelsystemreliabilitywithexamplesfrombuildings,bridges,or frames.	24
3	**SL-3:MaintenanceandInspectionPlanning:**Studentsshallproposean inspectionandmaintenanceplanforadeterioratingstructureusingreliability concepts.	24
3	**SL-4:Software/SpreadsheetImplementation:**Studentsshalldevelopa spreadsheet orsimple computational model to estimate reliability index fora structural element.	24

SamplerubricsforTWactivities:

Criteria	4-Excellent	3-Good	2-Satisfactory	1-NeedsImprovement
Problem understanding	Clear problem framingwithstrong justification.	Mostly clear withminorgaps.	Basicattemptwith limited clarity.	Poorly defined problem.
Dataandmethod	Appropriatedata and sound methodology.	Mostly appropriatewith minorissues.	Limiteddataor partialmethod.	Inadequateorincorrect method.
Analysis	Robust interpretationand valid results.	Generallysound with minor errors.	Partialanalysiswith gaps.	Weakorincorrect analysis.
Recommendations	Strong,feasible,and context-specific.	Relevantwith minor limitations.	Generic recommendations.	Incompleteor unrealistic.
Presentation	Wellorganizedand professional.	Goodorganizatio n with minor issues.	Acceptablebut uneven.	Poorly presented.

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

Courseoutcome(CourseSkillSet):

Atthe endofthecourse,thestudent willbeableto:

1. CO1:Selectadvanced constructionmaterialsforspecificcivilengineeringapplications.
2. CO2:Explainthebehavior,properties,andperformanceofspecialconcretesandalternativematerials.
3. CO3:Applyappropriatelaboratoryandfieldcharacterizationtechniques forconstructionmaterials.
4. CO4:Interprettestresultsto assessdurability, quality,andservice-lifeperformance.
5. CO5:Recommendsustainableandindustry-relevantmaterialsolutionsformodernconstruction.

Module-1

AdvancedCementitiousMaterials:

- Overview of advanced construction materials, performance requirements, and industry drivers. Blended cements, silica fume, GGBS, fly ash, metakaolin, rice husk ash, and limestone calcinedclay systems. 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 reinforced concrete, ferrocement, ultra-high-performance concrete, and roller compacted concrete. Mix designprinciples,freshandhardenedproperties,applicationsinbuildings,bridges,pavements,andprecast systems.
  Introductiontoemergingmaterialssuchas3D-printableconcreteandmultifunctionalcementitiouscomposites.

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

Module-3

SustainableAlternativeMaterials:

- Recycled concrete aggregate, manufactured sand, industrial by-products, demolition waste utilization, 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:

- Sampling and specimen preparation for cement, concrete, aggregates, and composite materials. Mechanical and physical tests: compressive strength, split tensile strength, flexural strength, modulus of elasticity, sorptivity, permeability,RCPT,shrinkage,andabrasion.Freshconcretecharacterization,rheology,workability,anddurability assessment. Introduction to QA/QC protocols and correlation of lab tests with field performance

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

Module-5

CharacterizationTechniquesII:

- Optical microscopy, SEM, TEM, and image analysis for microstructure study. XRD for phase identification, XRF/EDS/FTIR for chemical characterization, TGA/DTA/DSC for thermal behavior, and pore structure interpretation.NDTandin-situmethodssuchasreboundhammer,UPV,covermeter,GPR,half-cellpotential, carbonation depth, and corrosion assessment. Selection of techniques based on the material problem and industry application.

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

SuggestedLearningResources:

Textbooks

1. **A.M.Neville**,*PropertiesofConcrete*,Pearson,**5th Edition**.
2. **M.L.Gambhir**,*ConcreteTechnology:TheoryandPractice*,McGraw Hill Education,**5thEdition**.
3. **P.K.MehtaandP.J.M.Monteiro**,*Concrete:Microstructure,Properties,andMaterials*,McGrawHillEducation, **4thEdition**.
4. **John NewmanandBanSengChoo**,*Advanced ConcreteTechnology*,CRC Press,**1st Edition**.
5. **K.Ramamurthy**,*MaterialsandEngineeringCharacterization*,relevantuniversity-leveledition/printmay be used where available.

ReferenceBooks

1. **R.Dayal**,*SpecialConcreteandSustainabilityinConstruction*,NewAgeInternational,**latestedition**.
2. **N.KrishnaRaju**,*AdvancedReinforcedConcrete Design*,CBS Publishers,**latestedition**.
3. **J.FrancisYoungandS. Mindess**,*Concrete*,PrenticeHall, **latestedition**.
4. **M.S.Shetty**,*ConcreteTechnology:TheoryandPractice*,S.Chand, **latestedition**.
5. **B.S. NarayananandP.Azhagusundaram**,*TestingofMaterialsandStructures*,**latest edition**.

WeblinksandVideoLectures(e-Resources)

1. VTUConsortiume-resourcesforaccesstoIEEE,ScienceDirect,Springer,Taylor&Francis,Emerald, EBSCO, and other scholarly content.
2. NPTEL/SWAYAMmodulesonconcretetechnology,materialcharacterization,anddurabilityassessment.
3. IScodesandASTMstandardsfortesting ofcement,concrete,aggregates,durability,andNDTmethods.

Teaching-LearningProcess(InnovativeDeliveryMethods):

The following are sample strategies that educatorsmay adopt to enhance the effectiveness of the teaching-learning processand facilitate the achievement ofcourse outcomes. Suggested Innovative Delivery Methods may include (but are notlimitedto):

- FlippedClassroom
- Problem-BasedLearning(PBL)
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- SimulationandVirtualLabs
- PartialDelivery ofcourseby Industryexpert/industrialvisits
- ICT-EnabledTeaching
- Role Play

AssessmentStructure(both CIEandSEE):

The weightage assigned to Continuous Internal Evaluation(CIE) and Semester End Examination(SEE) shall be 50% each.Astudentshallsecureaminimumof50%ofthemaximummarks prescribedforCIE anda minimumof40%of the maximum marks prescribed for SEE to be eligible for passing.

Astudentshallbedeemedtohavesatisfiedtheacademicrequirementsandearnedthecreditsallottedtoa subject/courseonlyifhe/shesecuresnotlessthan50%oftheaggregatemarksobtainedinCIEandSEEtaken together.

ContinuousInternalEvaluation:

ContinuousComprehensiveAssessments(CCA)+InternalAssessmentTest(IA)=ContinuousInternalEvaluationCIE [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,Continuous ComprehensiveAssessment(CCA) shall beconductedforatotal of25marks

Students'activitiesforTW/SLunderNCrF:Samples only

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. The sample activities aregivenbelow.The course coordinator canalsogivetheirownTW/SL activities as perthecourseoutcomes.

Sl.No.	**TermWork(TW)Activity**	**NumberofHours/ Semester**
1	MixdesignexerciseforHPC,SCC,andgeopolymerconcreteusing given material data.	24
2	Characterizationdata interpretation from XRD, SEM,UPV,and RCPT test reports.	24
3	**Durability-based design worksheet** comparing conventional and sustainable mixes.	24
4	Labrecordanalysisofstrengthanddurabilityperformanceof alternate materials.	24

SL:SelfLearning,MOOCs,spokentutorials,online educationalresources etc.

Sl.No.	**Self-Learning(SL)Activity**	**NumberofHours/ Semester**
1	Reviewoneresearchpaperson**geopolymerorUHPC**and prepare a summary report	24
2	YouTubeplaylistonXRDandSEManalysis	24
3	MIPdata analysispractice usingopendatasets	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	Inappropriate method
Analysis andinterpretation	Clear,logical,and insightful	Adequate interpretation	Basic interpretation	Weakorabsent
Presentation	Neat,structured,and professional	Mostlyneat	Acceptable	Poorlyorganized
Timeliness	Submittedontime	Minordelay	Latesubmissio n	Notsubmitted

NON-DESTRUCTIVETESTINGFORCIVILENGINEERING			
Course Code	**1MCCS206B**	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:Understandtherole,nature,purpose,andmanagementofNDTactivitiesinmaterialscienceandcivil engineering.
2. CO2:ApplysurfaceNDTmethodsincludingVisualTesting,PenetrantTesting,MagneticTesting,andEddy Current Testing for defect detection.
3. CO3:AnalyzeinternalinspectionmethodssuchasRadiography,UltrasonicTesting,Thermography,and Acoustic Emission techniques.
4. CO4:EvaluateNDTapplicationsforinspectionofbridgesanddamsincludingfailurecausesandpreventive measures.
5. CO5:Applydisasterriskreductionconcepts,mitigation,adaptation,andresiliencestrategiesinreal-world contexts.
6. CO6:AssessconcretestructuresusingNDTmethodsandinterpretresultsforresiduallifeassessment.

Module-1

IntroductionandManagementofNDTActivities:

- RoleofNDTinmaterialscience,Nature,Definition,PurposeandImportanceAdvantagesandlimitationsofNDT.
- VariousNDTMethods-PrinciplesandapplicationsandlimitationsofManagementofNDTProcesses.

Self-study: Studentsshallpreparereportontheroleof NDTinqualitycontrolandqualityassuranceinconstruction projects.

LinkedCOs:CO1 **NumberofHours:9hrs**

Module-2

SurfaceNDTMethods:

- **VisualTesting:**Requirements,Equipment,forlabinsituandRemoteVisualTesting,Visualinspectionofwelds, and visual acceptance standards.
- **PenetrantTesting:**types,procedures,testequipment,sensitivityindicators,flawevaluation,ASMEAcceptance standards, Advantages and limitation. Studying the working principles of Rebound Hammer.
- **MagneticTesting:**Types,procedurestestequipmentASMEAcceptanceStandards.Advantagesandlimitations ofapplications.
- **EddycurrentTesting:**PrinciplesTypesequipmentadvantagesandlimitations.

Self-study: Studentsshallprepareacomparativeanalysisofsurface NDTmethodsandtheirsuitabilityfordifferent applications.

LinkedCOs:CO2 **NumberofHours:9hrs**

Module-3

NDTMethodsforInternalInspection;

- **RadiographyTesting:**PrinciplesTechniquesSensitivityanalysis,EquipmentRadiationsources-XraysGamma raysandneutrons,DetectorsXrayfilmsImagingplates,ImageprocessingInterpretationanddefectevaluation. Computed Tomography its advantages and disadvantages.

- **UltrasonicTesting:**Principlesitsadvantagesanddisadvantages.EquipmentTechniquesProbes,AB&CScan methods, Phased array Ultrasonic testing Advantages and Limitations. Studying the working principles of UltrasonicPulseVelocityMeter,Profometer.
- **Thermography:**Principlesequipmentapplicationsadvantages,limitationsandapplications.
- **AcousticEmission:**Principles,TypesequipmentAdvantageslimitationsandapplications.

Self-study: StudentsshallpreparereportontheprinciplesandapplicationsofadvancedNDTtechniquesincivil engineering

LinkedCOs:CO3 **NumberofHours:8hrs**

Module-4

NDTofBridgesandDams:

- TypesofBridgesandtheirmainissues&failurecausesandpreventivemeasures.DifferentNDTmethodsand applications concerning the Inspection of important bridge elements.
- TypesofDamsandtheirmainissues&failurecausesandpreventivemeasures.DifferentNDTmethodsand applications concerning the Inspection of important dam elements.

Self-study: StudentsshallprepareacasestudyonNDTinspectionofamajorbridgeordamstructureinIndia.

LinkedCOs:CO4 **NumberofHours:8hrs**

Module-5

NDTofConcreteStructures:

- ImportantCasestudieslikeCasestudyofDhruvaReactorbuilding.Residuallifeassessmentmethodsincivil engineering. Study of NDT of Concrete Structures in India.
- Studying the working principles of Scanning Electron Microscopy (SEM) and XRD testing methods.

Self-study: StudentsshallpreparereportonresiduallifeassessmentmethodologiesforconcretestructuresLinked COs: CO5 Number of Hours: 8 hrs

SuggestedLearningResources:

Textbooks

1. JPrasad,CGKrishnadasNairandTRangachari"NondestructiveTestingofmaterials"Vol1,2and3.
2. NondestructiveTestinghandbookVol10NondestructiveTestingOverviewAmericansocietyfornon-destructive testing.
3. NDTofBridgesbyIndianRailwayInstituteofCivilEngineering

ReferenceBooks

1. NonDestructiveEvaluationofConcretestructuresCasestudyDhruvaRai,SateeshandDrVerdeBARC.
2. MethodsforPredictingRemainingLifeofConcreteinStructuresNISTIR4954JCliftonandPommersheim Building and Fire Research Laboratory Gaithersburg, Maryland 20899.
3. ResidualLifeAssessmentofConcreteStructures-AReviewNeethuUrs,MantheshBS,HarishJayaram,Dr.MN Hegde.

WeblinksandVideoLectures(e-Resources)

1. NPTELcoursesonNon-DestructiveTestingofMaterials.
2. IS13311(Part1&2):MethodsofNon-destructivetestingofconcrete.
3. ASTMstandardsforNDTmethods.
4. ASNT(AmericanSocietyforNondestructiveTesting)resources.

Teaching-LearningProcess(InnovativeDeliveryMethods):

Thefollowingaresamplestrategiesthateducatorsmayadopttoenhancetheeffectivenessoftheteaching-learningprocess andfacilitatetheachievementofcourseoutcomes.SuggestedInnovativeDeliveryMethodsmayinclude(butarenotlimited 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)=ContinuousInternalEvaluationCIE [25+25=50 marks]

A minimum of two Internal Assessment Tests (IA) shall be conducted.Each testshall beconducted for a maximumof 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 listed below. Thesampleactivitiesaregiven below. The coursecoordinator canalsogivetheirown TW/SLactivitiesas perthecourseoutcomes.

Sl. No.	TermWork(TW)Activity	NumberofHours/Semester
1	Identifyingmaterialpropertieslikecompressivestrength, corrosion,andmicrostructuraldefects using NDTmethods.	24
2	DocumentationofthefindingsfromNDTtechniquesin detailed reports, including data analysis and recommendationsforfurtheractions.	24
3	Data Interpretation and Diagnosis: Develop skills in interpreting NDT results, such as reading ultrasonic wave signals,analyzingthermalimages,anddetectingvoidsor cracks.	24
4	ConductacasestudyonNDTinspectionofabridgeordam structure and prepare a comprehensive report.	24
5	Performresiduallifeassessmentofaconcretestructure using NDT data and prepare a detailed analysis report.	24

SL:SelfLearning,MOOCs,spokentutorials,onlineeducationalresourcesetc.

Sl. No.	Self-Learning(SL)Activity	NumberofHours/Semester
1	Prepare a report on the role of NDT in quality control and qualityassuranceinconstructionprojects(asperModule-1 self-study).	16
2	PrepareacomparativeanalysisofsurfaceNDTmethods and their suitability for different applications (as per Module-2self-study).	16

3	Preparareportontheprinciplesandapplicationsof advancedNDTtechniquesincivilengineering(asper Module-3self-study).	16
4	PrepareacasestudyonNDTinspectionofamajorbridge ordamstructureinIndia(asperModule-4self-study).	16
5	Preparareportonresiduallifeassessmentmethodologies forconcretestructures(asperModule-5self-study).	16

SamplerubricsforTWactivities:

Criteria	4-Excellent	3-Good	2-Satisfactory	1-Needs Improvement
Problem understanding	Clear problem framing withstrongjustification.	Mostlyclearwith minor gaps.	Basicattemptwith limited clarity.	Poorlydefined problem.
Dataandmethod	Appropriatedataand sound methodology.	Mostlyappropriate with minor issues.	Limiteddataorpartial method.	Inadequateor incorrect method.
Analysis	Robustinterpretation and valid results.	Generallysoundwith minor errors.	Partialanalysiswith gaps.	Weak or incorrect analysis.
Recommendations	Strong,feasible,and context-specific.	Relevantwithminor limitations.	Generic recommendations.	Incompleteor unrealistic.
Presentation	Wellorganizedand professional.	Goodorganization withminorissues.	Acceptablebutuneven.	Poorlypresented.

DESIGNOFPRECAST and COMPOSITESTRUCTURES			
CourseCode	**1MCCS206C / 1MCSE206C / 1MCAS206D**	Scheme	2026
TypeofCourse	**ProfessionalElectiveCourse**	Semester	II
TeachingHours/Week(L:T:P)	42(3:0:0)	CIEMarks	50
Total HoursofPedagogyper Semester CI(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. Analyze and designcompositebeams, slabs, andfloorsystems fordifferent loadingconditions.
4. Evaluatejointbehavior, diaphragmaction,and stabilityrequirementsinprecastand compositebuildings.
5. Preparedesignanddetailingrequirementsforpracticalprecastandcompositeconstructionsystems.

Module-1

Fundamentalsofprecastconstruction:

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

LinkedCOs:CO1,CO5 **Numberof Hours:08**

Module-2

Precaststructuralelementsand connections:

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

Design ofcompositebeamsandslabs:

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

Precast-compositebuildingsystems anddetailing:

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.,Precast ConcreteStructures,2nd Edition,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–McGraw Hill;1989.
6. R.P.Johnson:CompositeStructureofSteelandConcrete(Volume1),BlackwellScientificPublication(Second Edition), U.K., 1994.

ReferenceBooks

1. Elliott,K.S.,Precast ConcreteStructures,2nd Edition,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, CodeofPracticefor CompositeConstructioninStructuralSteeland Concrete.
7. INSDAGTeaching ResourceChapter21 to27:www.steel-insdag.org.

WeblinksandVideoLectures(e-Resources)

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

Teaching-LearningProcess(InnovativeDeliveryMethods):

The followingare sample strategies thateducators mayadopt toenhance the effectiveness ofthe teaching-learning processandfacilitatetheachievementofcourseoutcomes.SuggestedInnovativeDeliveryMethodsmayinclude(butare not limited to):

- FlippedClassroom
- Problem-BasedLearning(PBL)
- Case-BasedTeaching
- SimulationandVirtualLabs
- PartialDelivery of coursebyIndustryexpert/industrialvisits
- ICT-EnabledTeaching
- RolePlay

AssessmentStructure(bothCIE andSEE)

The weightage assignedtoContinuous Internal Evaluation(CIE) andSemesterEndExamination (SEE)shall be50% each.Astudentshallsecureaminimumof50%ofthemaximummarksprescribedforCIEanda minimumof40% 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:Designahollowcoreslabsystemwith composite topping for a given floor plan.	24
2	DesignofPrecastBeam:Designaprecastpre-stressedbeamforagivenspan 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,online educationalresources etc.

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	Preparedesigncalculations forprecastcolumnswithcorbelsfordifferent loadingconditions(asper Module-3self-study).	24
4	Preparareportonprogressivecollapsemechanismsanddesignstrategiesfor prevention(asperModule-4self-study).	24
5	Solvedesignexamplesofcomposite beamsandcompositefloors asper	24

	IS:11384(asperModule-5self-study).	

SamplerubricsforTWactivities:

Criteria	4-Excellent	3-Good	2-Satisfactory	1 - Needs Improvement
Problem understanding	Clear problem framingwithstrong justification.	Mostly clear withminorgaps.	Basicattemptwith limited clarity.	Poorlydefined problem.
Dataandmethod	Appropriatedata and sound methodology.	Mostly appropriatewith minorissues.	Limiteddataor partialmethod.	Inadequate or incorrectmethod.
Analysis	Robust interpretationand valid results.	Generallysound with minor errors.	Partialanalysiswith gaps.	Weakorincorrect analysis.
Recommendations	Strong,feasible,and context-specific.	Relevantwith minor limitations.	Generic recommendations.	Incompleteor unrealistic.
Presentation	Wellorganizedand professional.	Goodorganizatio n with minor issues.	Acceptablebut uneven.	Poorly presented.

ANALYSISANDDESIGNOFPLATESANDSHELLS			
Course Code	**1MCCS206D / 1MCSE206D**	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(CourseSkillSet):

Attheendofthecourse,thestudentwillbeableto:

1. CO1:Analyzeandclassifydifferenttypesofplatesandshells,applyingappropriatetheoreticalframeworks and methods for their bending and structural analysis.
2. CO2Deriveandsolvedifferentialequationsgoverningthebehaviorofbothrectangularandcircularplates under various loading conditions, including uniform and concentrated loads
3. CO3:Implementadvancedanalyticalmethods,suchasNavier'ssolutionandLevy'sapproach,toeffectively 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:

- Classificationofplatesandmethodsofanalysis.Slopeandcurvatureofslightlybentplates –curvatureand twist in any arbitrary direction.
- Principalcurvatures.Classicalthinplatetheory.Relationbetweenbendingmomentsandcurvatures, principal bending moments.
- Differentialequationforlaterallyloadedrectangularplates.Boundaryconditions.Kirchhoffmodificationof boundary conditions at a free edge.
- Differentialequationforthebendingoforthotropicplates.Rectangularplatessubjectedtoedgemoments.
- Cylindricalbendingoflongrectangularplates.Structuraleffectsduetobendingofplates.

Self-study:Derivethedifferentialequationforbendingoforthotropicplatesandcomparewithisotropiccase.

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

Module-2

SimplySupportedRectangularPlates–Navier's&Levy'sSolutions

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

Self-study:SolvearectangularplateproblemusingNavier'ssolutionforaconcentratedloadatthecenter.

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

Module-3

SymmetricalBendingofCircularPlates:

- Differential equationfor symmetrical bending oflaterally loaded circularplates. A round simply supported platesubjectedtouniformlydistributedload(UDL)overtheentiresurface,acentralconcentratedload,and

constantedgemoment.

- AroundclampedplatesubjectedtoUDLovertheentiresurfaceandacentralconcentratedload.
- MethodofsuperpositionAnnularplatesubjectedtoedgemomentsandUDLovertheentiresurface.

Self-study:Derivethedeflectionexpressionforaclampedcircularplateunder UDL

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

Module-4

AnalysisofShells–Shapes,Classification&MembraneAnalysis :

- Shapesandformsofshells,geometryofquadricsurfaces;generalform,standardequation,ellipsoid, hyperboloid,ellipticcone,ellipticparaboloid,hyperbolicparaboloid,quadriccylinder,etc.;classificationsof 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**

Suggested Learning Resources

Textbooks / Reference Books

1. Timoshenko,S.&Woinowsky-Krieger,W.–TheoryofPlatesandShells,2ndEdition,McGraw-HillCo.,NewYork, 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(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

AsperNationalcreditformwork(NCrF)studentsmustspend90hoursofstudyfor3creditcourses,whichinclude Courseinstructions(CI-42hour)andTeamwork/Selflearning(TW/Sl-48hours).Hence,studentsmust complete minimumoftwoactivesaspartofNCrF.Theselearningactivitiesshallbeconsideredas CCAcomponentsofCIE. Theevaluationactivitieswillbedoneusingsetofrubricsdevelopedforeachactivity.Thefollowingsampleactivities arelistedbelow.Thesampleactivitiesaregivenbelow.Thecoursecoordinatorcanalsogivetheirown TW/SL activitiesasperthecourseoutcomes.

Sl. No.	TermWork(TW)Activity	NumberofHours/Semester
1	Assignments: 1.Derivationofplatedifferentialequationandboundary conditions(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'ssolutionofrectangular plate(Mod2/CO3)–12h 2.FEAanalysisofcylindricalshellusingLundgren'sBeam theory(Mod5/CO5)–12h	24
SL:SelfLearning,MOOCs,spokentutorials,onlineeducationalresourcesetc.		
Sl. No.	**Self-Learning(SL)Activity**	**NumberofHours/Semester**
1	NPTEL:TheoryofPlatesandShells(IITMadras)	24
2	YouTubeplaylist onplatebending solutions	24
3	FEAsoftwarepracticeforshellanalysis	24

SamplerubricsforTWactivities:

Criteria	4-Excellent	3-Good	2-Satisfactory	1-Needs Improvement
Problem understanding	Clear problem framing withstrongjustification.	Mostlyclearwith minor gaps.	Basicattemptwith limited clarity.	Poorlydefined problem.
Dataandmethod	Appropriatedataand sound methodology.	Mostlyappropriate with minor issues.	Limiteddataorpartial method.	Inadequateor incorrectmethod.
Analysis	Robustinterpretation and valid results.	Generallysoundwith minor errors.	Partialanalysiswith gaps.	Weakorincorrect analysis.
Recommendations	Strong,feasible,and context-specific.	Relevantwithminor limitations.	Generic recommendations.	Incompleteor unrealistic.
Presentation	Wellorganizedand professional.	Goodorganization withminorissues.	Acceptablebutuneven.	Poorlypresented.

GEOTECHNICALASPECTS OFFOUNDATIONSANDEARTHRETAININGSTRUCTURES			
CourseCode	**1MCCS206E / 1MCAS206E**	Scheme	2026
TypeofCourse	**ProfessionalElectiveCourse**	Semester	II
TeachingHours/Week(L:T:P)	42(3:0:0)	CIEMarks	50
Total HoursofPedagogyper Semester CI(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. Explaingeotechnicalprinciplesgoverningfoundation performanceandretainingstructurebehavior.
2. Analyzesoil-structureinteraction,bearingcapacity,settlement,andearthpressureconditionsfordesign decisions.
3. Designandevaluateshallowand deep foundationsfordifferent groundand loadingconditions.
4. Designandcheckearthretainingstructuresforstability,serviceability,andconstructability.
5. Applyindustrytools,fielddata,and code-basedprovisionstofoundationandretainingwallproblems.
6. Assessgeotechnical risks,investigationoutputs,remediationoptions,andsafeconstructionpractices.

Module-1

SoilBehaviorand SiteInvestigation:

- Introductiontogeotechnical designphilosophy,soilclassification, index properties,andengineering behavior of soils relevant to foundations and retaining structures. Site investigation planning, boreholes, sampling, in-situtests,groundwaterassessment,andinterpretationofgeotechnicalinvestigationreports.Soilstratification, design parameters, and uncertainty in soil data.

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

Module-2

ShallowFoundations;

- Bearing capacity theories, settlement analysis, allowable bearing pressure, and factors affecting foundation choice.Designofisolated,strip,combined,andraftfoundationsunderaxialandeccentricloading.Construction issues, ground improvement options, and remedial measures for weak subgrades.

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

Module-3

DeepFoundationsandSpecialFoundations:

- Pilefoundations,piletypes,loadtransfermechanisms,pilecapacityestimation,pilegroupaction,settlement of piles, and negative skin friction. Under-reamed piles, well foundations, caissons, and foundations in expansive or problematic soils. Foundation selection for heavy structures, bridges, retaining systems, and industrial facilities.

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

Module-4

Earth PressureandRetainingStructures:

- Lateralearthpressuretheories,active,passive,andat-restpressure,surchargeeffects,waterpressure,and drainageconsiderations.Designand stability ofgravity walls,cantileverretaining walls,counterfort walls, anchored walls, and sheet pile systems. Checks for sliding, overturning, bearing pressure, and overall stability.

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

Module-5

ConstructionPractice,Monitoring,and Risk:

- Construction sequencing for foundations and retaining structures, dewatering, excavation support, instrumentation, monitoring, and quality control. Geo-hazards, adjacent structure protection, settlement control, excavation safety, and temporary works. Case studies on foundation failures, retaining wall distress, andmitigationmeasures;introductiontoBIM-enabledgeotechnicalinformationmanagementandsustainable ground engineering practice.

LinkedCOs:CO1,CO4,CO6 **NumberofHours:08**

SuggestedLearningResources

Textbooks

1. Das,B.M.andSobhan,K.,*Principles ofGeotechnicalEngineering*,9thEdition,CengageLearning.
2. Bowles, J.E.,*FoundationAnalysisandDesign*,5thEdition,McGraw-HillEducation.
3. Varghese, P.C.,*FoundationEngineering*,2nd Edition,PHILearning.
4. Sharma,H. D.,*GeotechnicalEngineering*,3rd Edition,TataMcGraw-HillEducation.

ReferenceBooks

1. Terzaghi,K.,Peck,R.B.andMesri,G.,Soil MechanicsinEngineeringPractice,3rdEdition, Wiley.
2. Tomlinson,M.andWoodward,J.,Pile DesignandConstructionPractice,6thEdition,CRC Press.
3. Coduto,D.P., Foundation Design:Principles andPractices,2ndEdition,Pearson.
4. Das,A.and Sivakugan,N.,PrinciplesofFoundationEngineering,8thEdition,CengageLearning.

StandardsandCodes

5. IS1904,Codeofpracticefordesignandconstructionoffoundationsinsoils.
6. IS2911,Codeofpracticefordesignandconstructionofpilefoundations.
7. IS2950,Codeofpracticefordesignandconstructionofraftfoundations.
8. IS14458,Codeofpracticeforretainingwallswhereapplicable.

WeblinksandVideoLectures(e-Resources)

1. https://www.youtube.com/watch?v=lsYFtwwlHIw&list=PLbRMhDVUMngeiZjKPTPEFl1CByXmYX3Kv
2. https://www.youtube.com/watch?v=LIAAhaeeA8Q
3. NPTEL coursesonFoundation EngineeringandSoilDynamics.
4. ISCodes:IS2974(PartsItoIV),IS2911(PartsItoIV),IS6403.

Teaching-LearningProcess(InnovativeDeliveryMethods):

The followingare sample strategies thateducators mayadopt toenhance the effectiveness ofthe teaching-learning processandfacilitatetheachievementofcourseoutcomes.SuggestedInnovativeDeliveryMethodsmayinclude(butare not limited to):

- FlippedClassroom
- Problem-BasedLearning (PBL)
- Case-BasedTeaching
- SimulationandVirtualLabs
- PartialDelivery of coursebyIndustryexpert/industrialvisits
- ICT-EnabledTeaching
- RolePlay

AssessmentStructure(bothCIE andSEE)

TheweightageassignedtoContinuousInternalEvaluation(CIE)andSemesterEndExamination(SEE)shallbe50% each.

A studentshall secure a minimum of 50%ofthe maximum marks prescribed forCIE 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)=ContinuousInternalEvaluation CIE [25+25=50 marks]

AminimumoftwoInternal AssessmentTests(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:Samples only

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.Theselearningactivitiesshallbeconsidered asCCAcomponentsofCIE.The evaluationactivitieswillbedoneusingsetofrubricsdevelopedforeachactivity.Thefollowingsampleactivitiesare listedbelow.Thesampleactivitiesaregivenbelow. The coursecoordinatorcanalsogivetheirownTW/SLactivities asperthecourseoutcomes.

Sl.No.	TermWork(TW)Activity	NumberofHours/ Semester
1	BearingCapacityandSettlementAnalysis:Determinetheallowablebearing pressure for a given soil profile using different field tests.	24
2	FoundationDesignforExpansiveSoils:Prepareadesignreportforashallow foundation on expansive soil with appropriate remedial measures.	24
3	PileFoundationDesign:Designapilefoundationforamulti-storeybuilding including single pile and pile group analysis.	24
4	RetainingStructureDesign:DesignaMechanicallyStabilizedEarth(MSE)wall or sheet pile wall for a given site condition.	24
5	MachineFoundationDesign:Designablockfoundationforareciprocating machine as per IS 2974.	24

SL:SelfLearning,MOOCs,spokentutorials,online educationalresources etc.

Sl.No.	Self-Learning(SL)Activity	NumberofHours/ Semester
1	**CaseStudyonFoundationFailure:**Studentsstudyafoundationdistresscase, identify causes, and propose remedial measures.	24
2	**RetainingStructureFieldReview**:Studentsobserveanexistingretainingwall orbasementsupportsystemanddocumentstructuralanddrainageobservations.	24
3	**SoilDataInterpretationandSelection.**Studentsinterpretborelogand SPT/CPTdataandrecommendfoundationtypeanddesignparameters.	24
4	**DigitalGeotechnicalDocumentation:**Studentsprepareacompactdigital reportwithsketches, calculationsheets,andstructuredsiteobservations.	24

SamplerubricsforTWactivities:

Criteria	Excellent4	Good3	Satisfactory2	NeedsImprovement 1
Understandingofsoil and foundation concepts	Correctlyinterprets geotechnical data and applies conceptsaccurately.	Minoromissions ininterpretation orapplication.	Basic understanding with partial application.	Incorrect or incomplete understanding.
Technicalaccuracy	Calculations,checks, and decisions are accurate and well justified.	Smallcalculation orjustification errors.	Severalerrorsbut basic method visible.	Major errors or missingmethod.
Designqualityand feasibility	Solutionispractical, code-aware, and constructable.	Mostlypractical with minor issues.	Limitedpractical justification.	Unrealisticorunsafe design.
Documentation quality	Clear, complete, professional,and well organized.	Mostlyclearand complete.	Adequatebut inconsistent.	Poorlyorganizedor incomplete.

FIBERREINFORCEDPOLYMERSAND MECHANICSOFCOMPOSITEMATERIALS			
CourseCode	**1MCCS206F / 1MCSE206F / 1MCAS206F**	Scheme	2026
TypeofCourse	**ProfessionalElectiveCourse**	Semester	II
TeachingHours/Week(L:T:P)	42(3:0:0)	CIEMarks	50
Total HoursofPedagogyper Semester CI(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:DeriveengineeringconstantsofFRPcompositesusingmacro andmicro mechanicalapproaches
4. CO4:Selectappropriatefibers(glass,carbon,aramid,natural)andmatrixmaterialsforFRPcomposite manufacture
5. CO5:ApplyclassicallaminationtheoryandfailurecriteriaforFRPcompositelaminates.

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.
- Selectionofmaterials based onapplicationrequirements.
- ManufacturingtechniquesforFRPcomposites–handlayupmethod,compressionmouldingmethod, filament winding, pultrusion, and vacuum bagging.
- Basics offiberreinforcedpolymercomposites (syntheticFRPandnatural FRPcomposites).
- Advantages andlimitationsofFRPcompositesover conventionalmaterials.
- ApplicationsofFRP instructuralretrofitting,bridgestrengthening, andnewconstruction.

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

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

Module-2

Macro-mechanical Behavior of FRPLamina– 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 engineering constants for orthotropic materials (positive definiteness of stiffness matrix).
- PhysicalsignificanceofengineeringconstantsforFRPcomposites.
- Numericalproblemsoncomputationofstiffnessandcompliancematrices.

Self-study:Derivetherelationshipbetweenengineeringconstantsandcompliancematrixforanorthotropic FRP lamina.

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

Module-3

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

- Stress-strainrelationsforplanestressinanorthotropicFRPlamina–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/compressivestrength(Y_1,Yc),in-planeshearstrength(S).
- ThermalandmechanicalstressanalysisinFRPlaminatesduetotemperaturechangesandmoisture absorption.
- Numericalproblemsontransformed stiffnessand stresscomputation.

Self-study:Computetransformedreducedstiffnessmatrix foraFRPlaminaorientedat30°,45°,and60°.

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

Module-4

Micro-mechanicalBehavior of FRP Lamina–StiffnessPrediction :

- Introductiontomicro-mechanicsofFRPcomposites.Mechanicsofmaterialsapproachtostiffness prediction – assumptions of perfect bonding, uniform strain/stress fields.
- Determination oflongitudinal modulus (E_1)using rule of mixtures and modified rule ofmixtures. Determinationoftransversemodulus(E_2)usingseriesmodel(Reussmodel),Halpin-Tsaiequations,and elasticity approach.
- Determination ofmajorPoisson's ratio(ν_{12}) usingrule ofmixtures.
- Determinationofin-planeshearmodulus(G_{12})usingHalpin-Tsaiand elasticity solutions.
- Comparisonofmicromechanicspredictionswithexperimentalresults.Limitationsofmechanicsof materials approach – semi-empirical methods.
- Numerical problemsonestimationofallfourengineeringconstantsfromfiberandmatrixproperties.

Self-study:CompareE_2 predictionsusingseriesmodelvsHalpin-Tsaiequationsfordifferentfibervolumefractions.

LinkedCOs:CO3 **NumberofHours:8hrs**

Module-5

Classical LaminationTheory &Failure CriteriaforFRPLaminates:

- 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.
- Mechanical coupling in laminates – extension-extension (A), bending-extension (B), and bending-bending(D)couplingmatrices.Analysisofsimplelaminatedstructuralelements–plystressandstrain calculation under axial, bending, and thermal loads.
- FailuretheoriesforFRPcomposites:MaximumStressFailureCriterion,MaximumStrainFailure

Criterion,Tsai-HillFailure Criterion,Tsai-WuTensor Failure Criterion(conceptonly).

- Firstplyfailure(FPF)andlastplyfailure(LPF)concepts.Numericalproblemsonlaminateanalysisand failure prediction.

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

LinkedCOs:CO5 **NumberofHours:8hrs**

SuggestedLearningResources:

Textbooks

1. Mukhopadhyay,M. –MechanicsofCompositeMaterialsandStructures,UniversitiesPress,2009.
2. Jones,R.M.–Mechanics ofCompositeMaterials, 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:Mechanics ofCompositeMaterials–IIT Kharagpur
3. NPTEL:FiberReinforcedPolymerComposites– IITMadras

Teaching-LearningProcess(InnovativeDeliveryMethods):

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

- FlippedClassroom
- Problem-BasedLearning (PBL)
- Case-BasedTeaching
- SimulationandVirtualLabs
- PartialDelivery of coursebyIndustryexpert/industrialvisits
- ICT-EnabledTeaching
- RolePlay

AssessmentStructure(bothCIE andSEE)

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:Samples only

AsperNationalcreditformwork(NCrF)studentsmustspend90hoursofstudyfor3creditcourses,whichinclude Courseinstructions(CI-42hour)andTeamwork/Selflearning(TW/Sl-48hours).Hence,studentsmustcomplete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE.

Theevaluationactivitieswillbedoneusingsetofrubrics developedforeach activity.Thefollowingsampleactivities arelistedbelow.Thesampleactivitiesaregivenbelow.Thecoursecoordinatorcanalsogivetheirown TW/SL activities as per the course outcomes.		
Sl.No.	**TermWork(TW)Activity**	**NumberofHours/ Semester**
1	Assignments**:** 1. EngineeringconstantsfororthotropicFRP lamina (Mod2/CO2)–8h 2. Transformedstiffnessmatrixforoff-axisFRPlamina (Mod3/CO2)–8h 3. Micromechanicalmodulus predictionforglass/epoxy(Mod4/CO3)–8h	24
2	Seminars: 1. FRPmanufacturingtechniques–handlayupvspultrusion (Mod1/CO4) – 8h 2. Thermal andmoisturestress analysis inFRP(Mod3/CO2)– 8h 3. ComparisonoffailurecriteriaforFRPlaminates(Mod5/CO5)–8h	24
3	Micro-Project**:** 1. MATLABprogramformicro-mechanicalstiffnesspredictionofFRP (Mod4/CO3) – 12h 2. CLTanalysisand failurepredictionofacross-plyFRPlaminate (Mod5/CO5)–12h	24
SL:SelfLearning,MOOCs,spokentutorials,online educationalresources etc.		
Sl.No.	**Self-Learning(SL)Activity**	**NumberofHours/ Semester**
1	NPTEL:MechanicsofComposite Materials(IITKharagpur)	24
2	NPTEL:FiberReinforced PolymerComposites(IITMadras)	24
3	FRPdesignsoftware practice(e.g.,ESAComp,CADEC)	24

SamplerubricsforTWactivities:

Criteria	4-Excellent	3-Good	2-Satisfactory	1 - Needs Improvement
Problemunderstanding	Clear problem framingwithstrong justification.	Mostly clear withminorgaps.	Basicattemptwith limited clarity.	Poorly defined problem.
Dataandmethod	Appropriatedata and sound methodology.	Mostly appropriatewith minorissues.	Limiteddataor partialmethod.	Inadequate or incorrectmethod.
Analysis	Robust interpretationand valid results.	Generallysound with minor errors.	Partialanalysiswith gaps.	Weakorincorrect analysis.
Recommendations	Strong,feasible,and context-specific.	Relevantwith minor limitations.	Generic recommendations.	Incompleteor unrealistic.
Presentation	Wellorganizedand professional.	Goodorganizatio n with minor issues.	Acceptablebut uneven.	Poorly presented.

SOFTCOMPUTING TECHNIQUESINSTRUCTURALENGINEERINGLABORATORY			
Course Code	**1MCCSL207**	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-basedcomputationalmodelsforanalysisof structural elements using MATLAB/Python.
2. CO2–L4:AnalyzeandinterpretstructuralresponseofRCC,steel,slab,beam,column,andcomposite elements using numerical and soft computing tools.
3. CO3–L5:Evaluateandcomparetheperformanceofstructuralmodelsfordifferentloading,boundary, andmaterial conditions.
4. CO4–L5:Applycomputationalmethodsforstructuraldesignoptimizationanddecisionmakingin engineering applications.
5. CO5– L6:Prepare professional technicalreportsandvalidateresultsusingsoftware outputsand engineering judgement.

Note:

1. The laboratory syllabus consists of PART-A and PART-B. While PART-A has 6-8 conventional experiments,PART-Bhas6typicalopen-endedexperiments.Themaximummarksforthelaboratory course are 100.
2. BothPART-AandPART-BareconsideredforCIEandSEE.
3. Studentshaveanswer1(one)questionfromPART-A and1(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/Pythonmodelfor analysis anddesignofRCCbeamandcolumnelements.(CO1)
2. AnalysisofasimplemultistoreyRCCstructureusinganFEApackageandinterpretationofresults.(CO1, CO2)
3. DevelopmentofMATLAB/Pythonmodelsforanalysisanddesignof RCCslabsfordifferentend conditions. (CO2)
4. Structural analysisof2Dbeamswithdifferentloadingand supportconditionsusingMATLAB/Python.(CO2)
5. Analysisofsteelbeamelementsusing MATLAB/Python.(CO2)
6. AnalysisofsteelcolumnelementsusingMATLAB/Python.(CO2)
7. Analysisofcold-formedsteelsections for differentloadconditionsusingMATLAB/Python.(CO1)
8. Analysisofunidirectionalfibre-reinforcedcompositematerialsusingMATLAB/Pythontocompute rule of mixture parameters and engineering constants. (CO2)

PART–B:OPENENDEDEXPERIMENTS

Open-endedexperimentsareatypeoflaboratoryactivitywheretheoutcomeisnot predeterminedandstudentsare giventhe freedom toexplore,design,andconduct the experiment basedonthe problemstatements as perthe concepts definedbythecoursecoordinator.Itencouragescreativity,criticalthinking,andinquiry-basedlearning.

1. Analysisofunidirectionalfibre-reinforcedcompositematerialsusingMATLAB/Pythontocompute compliance matrix, stiffness matrix, and related parameters. (CO1, CO2)
2. Analysisofunidirectionalfibre-reinforcedcompositematerialsusingMATLAB/PythontocomputeA-B-D matrix. (CO1, CO2)
3. DevelopmentofasoftcomputingmodeltopredictstructuralresponseofRCCbeamsundervariedloading conditions. CO3, CO4
4. OptimizationofsteelbeamdimensionsusingMATLAB/Pythonforminimumweightandadequatestrength. CO3,CO4
5. Predictionofslabresponsefordifferentendconditionsusingacomputationalmodelandcomparisonwith analytical results. CO4, CO5
6. Developmentofacomparativestudy ofstructuralresponseusingnumerical, analytical,and softcomputing approaches.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,andcold-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:Theory andProgramming, McGraw-HillEducation, 2ndEdition.
6. R.C. Hibbeler,StructuralAnalysis,Pearson, 10thEdition.
7. M.K.JainandS.R.K.Iyengar,NumericalMethodsforScientificandEngineeringComputation,NewAge International, 6th Edition.
8. RelevantBIScodes,softwaremanuals,andjournalpapersasapplicable.

Reference books/Manuals:

1. FiniteElementProcedures–Klaus-JürgenBathe,PrenticeHall.Comprehensivereferenceforfiniteelement 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. MATLAB forEngineers–Holly Moore,Pearson.UsefulfordevelopingMATLAB-basedprogramsforstructural analysis anddesign.

SoftwareTools:

1. MATLAB/GNUOctave
   - RCCbeam,slab,and columndesign
   - Steelmemberdesign
   - Structuralanalysisofbeamsandframes
   - Structuraldynamics andvibration studies
2. Python(NumPy,SciPy,Matplotlib)
   - Structuralanalysisanddesigncomputations
   - Composite materialanalysis
   - Datavisualizationandparametricstudies
3. ETABS
   - Multi-storeybuildinganalysisanddesign

- Seismicand dynamicanalysis
- Structuraldetailinganddrawings

4. SAP2000
   - Chimneys,silos, bunkers,domes,andspecialstructures
   - Staticanddynamicanalysis
5. AutoCAD
   - Structuraldrawingsand detailing

AssessmentStructure(bothCIE andSEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each.Astudentshallsecureaminimumof50%ofthemaximummarksprescribedforCIEandaminimumof40%ofthe maximum marks prescribed for SEE to be eligible for a pass in the course.

Astudentshallbedeemedtohavesatisfiedtheacademicrequirementsandearnedthecreditsallottedtoasubject /courseonlyifhe/shesecuresnotlessthan50%oftheaggregatemarksobtainedinCIEandSEEtakentogether.

ContinuousInternalEvaluation(CIE):

Forthe ProfessionalCoreCourseLaboratory,the maximummarksprescribedare 100. Out ofthese,50 marksareallotted for Continuous Internal Evaluation (CIE) and 100 marks for the Semester End Examination (SEE). The SEE marks obtained out of 100 shall be proportionately scaled down to 50 marks. The final result shall be declared based on the aggregate of the CIE marks (50) and the scaled-down SEE marks (50), totalling 100 marks."

Outof50 marks, 40marks shall be assigned forassessment ofregularlaboratoryPART -A classwork, and10marks for Part – B. (Table 1)

Outof40marks, 25marksshallbebased onthe regularclassworkandallotment of marksshallbeas perrubricslisted in Table 1.

Theremaining15marksshallbebasedonthepracticaltestconductedbytwoInternalexaminersappointedbytheHoD. The allotment of marks shall be as per the rubrics defined for the practical test as indicated in the Table 1.

Theopen-endedquestionsetforCIEshallbeanyotheropen-endedquestionandnotselectedfromtheexperiments underPART-A.Itshallbeevaluatedfor10marks.Theallotmentofmarksshallbeasperrubricslistedin Table2.

Table–1Distribution ofmarkscorrespondingtolaboratorycomponent

Component	Description	Marks
Allotment ofmarks forregularclasswork		
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,andobtaincorrectresultsinthetestexperiment.	5marks

Viva-Voce	Understandingoftheory,concepts,andexperimental procedure;abilitytoexplainresultsandanswerrelated questions.	10marks
	Subtotal	**15**
	Total	**40**

Table2DistributionofmarkscorrespondingtoPART-Bofthelaboratorycomponent

EvaluationRubricsforcontinuous internalevaluationCIE).Maximummarks:10

CriteriaandGuidingfactors	**Students'Level andRubrics** **Excellent:E,Good:G,Fair:F** **NeedsImprovements:NI**			
	E	**G**	**F**	**NI**
(1) ProblemUnderstanding **Criteria:**Istheproblemunderstoodcorrectlyandframed appropriately? (i)Clarity in interpreting the given problem. (ii)Identificationofrelevantconceptsandconstraints. (iii)Abilitytorephraseormodeltheproblemlogically.	2.0	1.5	1.0	0.5
(2) ConceptualKnowledge **Criteria**:Arethechosenmethodsorconceptsvalidforthis type of problem? (i) Applicationof appropriatetheories,principles,orlaws. (ii) Integrationofmultipleconceptswherenecessary. (iii)Accuracyinstatingrelevantequationsormodels.	2.0	1.5	1.0	0.5
(3) ApproachandStrategy **Criteria**:Istheapproachwellthoughtoutandmethodical? (i) Logical structure andprogression. (ii) Use of diagrams, sketches, or flowcharts if applicable. (iii)Identificationofassumptionsandboundaryconditions.	2.0	1.5	1.0	0.5
(4) Executionand Accuracy **Criteria**:Arethecalculationscorrect?Isthefinalsolution reasonable? (i) Correct application of formulas/methods. (ii)Accuracyofcalculationsorsimulations(ifany). (iii)Unitconsistencyandresultverification.	2.0	1.5	1.0	0.5
(5) Innovation orDepth **Criteria**:Hasthestudentshownoriginalthinkingor alternative methods? (i)Novel or efficient solutions. (ii)Consideration of alternate approaches. (iii)Interdisciplinaryintegrationorpracticalextensions.	1	0.75	0.5	0.25
(6) Presentationand Clarity **Criteria**:Istheanswereasytofollowandprofessionally written? (i) Organizationandneatness. (ii) Clarityofexplanation,labelling,and steps. (iii) Useofproper technicalterminology.	1	0.75	0.5	0.25

Total	10	7.5	5.0	2.5

Note:

(i) ThemarksshownforExcellent,Good,Fair,NeedsImprovementareindicative.Theevaluatormayalso assign 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) Toawardthefull10marksintheexcellentcategory,thestudentmustdemonstratereasonablygoodperformance across all six criteria; otherwise, proportionally lower marks may be given.

SuggestedrubricsforPracticalcontinuous Assessment:

Performance Indicators	Excellent	VeryGood	Good	Satisfactory
Fundamental Knowledge (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 onedesignforhis/her problem statement andcapableofproving the best suitable designwithproper reason(5)	Studentiscapableof discussingfew designsforhis/her problemstatement butnot capableof selecting best (4)	Student is capable of discussing single designwithitsmerits and de-merits (3)	Student is capable of explainingthedesign (1-2)
Implementation(8) (PO3&PO8)	Student is capable of implementing the design with best suitable algorithm considering optimal solution. (7-8)	Student is capable of implementing the designwithbest suitable algorithmandshould be capable of explaining it (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)	Studentisabletorun the program on various cases and compare the result withproperanalysis. (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 abletoanalyzethe output (1-2)
Demonstration(8) (PO9)	Thelabrecordiswell-organized, with clear sections (e.g., Introduction, Method, Results, Conclusion). Transitions between sectionsare smooth.(7-8)	The lab record is organized,withclear sections, but some sectionsarenotwell-defined. - 6)	The lab record lacks clearorganizationor structure. Some sections are unclear orincomplete.(3-4)	The lab record is poorlyorganized, with missing or unclearsections. (1-2)

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