VISVESVARAYATECHNOLOGICALUNIVERSITY

BELAGAVI

SchemeofTeachingandExaminations(2026)

M.Tech., in Civil Engineering(Specialization in Computer Aided Structural Engineering) Choice-BasedCreditSystem(CBCS)andOutcome-BasedEducation(OBE)

Specializationin–(Computer AidedStructuralEngineering)													
II SEMESTER													
Sl.No	**Course**	**CourseCode**	**CourseTitle**	**Teaching&LearningScheme**					**Examination**				**Credits**
				CI		**LI**	**TW&SL**	**Total Hours**	**Duration in hours**	**CIEMarks**	**SEEMarks**	**Total Marks**	
				L	**T**	**P**							
1	IPCC	1MCAS201	Computer AidedStructuralStabilityAnalysis	42	0	28	50	120	03	50	50	100	4
2	PCC	1MCAS202	FreeandForcedVibrationsofStructuralElements	42	0	0	48	90	03	50	50	100	3
3	PCC	1MCAS203	Soft Computing Applications in Structural Engineering	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	1MCAS205X	ProfessionalElective–III	42	0	0	48	90	03	50	50	100	3
6	PEC	1MCAS206X	ProfessionalElective–IV	42	0	0	48	90	03	50	50	100	3
7	PCCL	1MCASL207	SoftComputingTechniquesinStructural Engineering Laboratory	0	0	28	02	30	03	50	50	100	1
8	PCC	1MCASS208	Minor Project/Skill DevelopmentProject	0	0	0	60	60	03	50	50	100	2
									Total	**400**	**400**	**800**	**22**

ProfessionalElectiveCourses(PECs)			
PEC-III		PEC-IV	
Code	TitleoftheCourse	Code	TitleoftheCourse
1MCCS205A / 1MCSE205A / 1MCAS205A	FiniteElementMethodsinStructuralAnalysis	1MCSE206E/1MCAS206A	ComputationalStructuralMechanics
1MCAS205B	Computer-AidedStructuralLoadAnalysisandCodalApplications	1MCAS206B/1MCSE206A	ConstructionMaterialsandtheirProperties
1MCSE205B/ 1MCAS205C	AdvancedStructuralAnalysis(NonlinearandStability)	1MCCS206A / 1MCSE206B / 1MCAS206C	Advanced Construction Material Characterization Techniques
1MCAS205D	Computer-AidedAnalysisandDesignofPlatesand Shells	1MCCS206C / 1MCSE206C / 1MCAS206D	DesignofPrecastandCompositeStructures
1MCAS205E	Advanced DesignofStructuralElements	1MCCS206E / 1MCAS206E	Geotechnical Aspects of Foundations and Earth Retaining Structures
1MCCS205F / 1MCSE205F / 1MCAS205F	StructuralReliabilityAnalysisandDesign	1MCCS206F / 1MCSE206F / 1MCAS206F	FiberReinforcedPolymersandMechanicsof Composite Materials

COMPUTERAIDEDSTRUCTURALSTABILITYANALYSIS			
CourseCode	**1MCAS201**	Scheme	2026
TypeofCourse	IntegratedProfessionalCoreCourses (IPCC**)**	Semester	II
TeachingHours/Week(L:T:P)	70(3:0:2)	CIEMarks	50
Total HoursofPedagogyper Semester CI(L /T):LI(P):TW&SL	120(42:0:28:50)	SEEMarks	50
Credits	4	TotalMarks	100
TypeofExamination(IPCC):	Theory-CIE+SEE,andLab-CIEonly.	ExamHours	03

Courseoutcome(CourseSkillSet):

Attheendofthecourse,thestudentwillbeableto:

1. CO1:Explainfundamentalsofstructuralstabilityandbucklingfordeterminateandindeterminatemembers and systems.
2. CO2:Formulatelinearizedstability(eigenvalue)problemsandcomputecriticalloadsforcolumns,framesand plates using analytical and numerical methods.
3. CO3:Modelstabilityproblemsinfiniteelementsoftwareand validateresultsagainst closed-formsolutions.
4. CO4:Performnonlinearbucklingandpost-bucklinganalysis(geometricandmaterialnonlinearity)using commercial FEM packages.
5. CO5:Carryoutimperfectionsensitivity,parametricandstability-baseddesignchecksforcolumns,framesand slender plate/shell elements.
6. CO6:Integratestabilityanalysiswithdesigncodes,producereportsandvisualisationsthatsupportsafe, efficient design decisions.

Module-1

FoundationsofStructuralStability:

Historical overview and significance of stability in structural design; definitions: stability, bifurcation, snap-through, bucklingmodes.Eulercolumntheory forpinned, fixed, andmixed-endconditions; slendernessratio, effectivelength factors, and limitations of Euler theory. Elastic vs. inelastic buckling; tangent modulus approach and introduction to Johnson parabolic curve.

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

Module-2

ElasticStability andBucklingAnalysis:

Cover elastic stability, Euler buckling, effective length of columns, local and global buckling, flexural, torsional and flexural-torsionalbuckling,lateraltorsionalbuckling,IS800:2007stabilityrequirements,eigenvaluebucklinganalysis, mode shapes, imperfections, and interpretation of buckling reports.

LinkedCOs:CO2, CO3. **Numberof Hours:09**

Module-3

GeometricandMaterialNonlinearAnalysis:

Cover nonlinearstructuralbehaviour,P-Deltaand P-δeffects,largedisplacementanalysis,materialnonlinearity,plastic

hinge formation, Newton-Raphson method, incremental load analysis, collapse mechanisms, and nonlinear analysis of RC and steel structures.

LinkedCOs:CO3,CO4. **Numberof Hours: 08**

Module-4

AdvancedComputerApplicationsinStructuralStability:

Address analysis of multistorey buildings, industrial steel buildings, bridges, towers, space frames and shell structures;windandseismic loadingasperIS875andIS1893;responsespectrumanalysis;dynamicstability; construction stage analysis; and engineering reporting.

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

Module-5

DigitalStructuralEngineering andEmergingTechnologies:

Include BIM integration, digital twin concepts, AI and machine learning applications, cloud-based analysis, optimization,reliability-baseddesign,structuralhealthmonitoring,forensicinvestigation,sustainability,ethics,and case studies.

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

PRACTICALCOMPONENTSOFIPCC

LISTOFEXPERIMENTS(LI=28Hrs)

1. Introductiontostructuralanalysissoftwaresuchas STAAD.Pro/ETABS/SAP2000andcreationofbasic structural models.
2. Modellingandanalysis ofdeterminate and indeterminateplanetrusses.
3. Modellingand analysisofportalframesandmulti-storeyframes.
4. Buckling analysisof steelcolumnsusing eigenvalueanalysis.
5. Lateral torsionalbucklinganalysisofsteelbeams.
6. P-Deltaanalysisofreinforcedconcretemulti-storeybuildings.
7. Nonlinearanalysisof steelportalframesconsideringsecond-order effects.
8. Windloadanalysis andstabilityassessmentoftallbuildings asper IS875(Part3).
9. Seismic stabilityanalysis usingResponseSpectrumMethodas per IS1893.
10. Stabilityanalysisofindustrialsteelstructuresandtransmission towers.

SuggestedLearningResources:

TextBooks:

1. MurariLalGambhir,StabilityAnalysisandDesignofStructures,1stEdition,Springer-Verlag,BerlinHeidelberg, 2004.
2. ZdeněkP.BažantandLuigiCedolin,StabilityofStructures:Elastic,Inelastic,FractureandDamageTheories, DoverPublications(unabridgedrepublicationofOxford University Press,1991), Mineola,NewYork,2003.
3. StephenP.TimoshenkoandJamesM.Gere,TheoryofElasticStability,2ndEdition,McGraw-HillBookCompany (Dover reprint, 2009), New York.
4. W.F.ChenandE.M.Lui,StabilityDesignofSteelFrames,CRCPress,BocaRaton,1991.
5. G.J.Simitses, ElasticStabilityofStructures, PrenticeHall,EnglewoodCliffs, NewJersey

ReferenceBooks/Manuals:

1. RelevantIScodesonsteelandconcretedesignandstability,includingIS800:GeneralConstructioninSteel and IS 456: Plain and Reinforced Concrete, and associated design handbooks/manuals issued by BIS.
2. W.F.ChenandE.M.Lui,StructuralStability:TheoryandImplementation,CRCPress,foradvancedtheoretical and implementation aspects of frame stability.

3. DesignmanualsandguidelinesfromAISCandotherinternationalbodiesonframestability,effectivelength factors, and second-order analysis.

WeblinksandVideoLectures (e-Resources)&Softwaretools:

1. **NPTEL–ElasticStabilityofStructures(CourseCode:105105217)**,includingweeklymodulesoncolumns, beam-columns, frames, torsional buckling, plates, and shells.
2. **AnsysInnovationCourses–StructuralInstabilityandBuckling**,basedonNPTELcontent,forvisualization and numerical examples of buckling.
3. NPTEL/SWAYAMvideolectureson*StructuralAnalysis–Advanced*,*SteelStructures*and*FiniteElementMethods* includingmodulesonstabilityandbuckling.
4. Onlineresourcesandlecturenoteson**StructuralStability**fromreputeduniversities(Northwestern University – Bažant&Cedolin materials, METU CE528 course notes

SoftwareTools:

1.0 GeneralStructuralAnalysisand Buckling:

- SAP2000/ETABS(ComputersandStructuresInc.)–eigenvaluebucklingandsecond-order*P*-Δanalysisof frames.
- ANSYSMechanical–linearandnonlinearbuckling analysisofcomponentsandframes.

2.0SpecialisedStabilityandSteelDesign:

- STAAD.Pro–bucklingandstability checks ofsteel frames.
- Designaidsandpluginsaccompanyingmajorsteeldesignpackagesforeffectivelengthandframestability calculations

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(bothCIEandSEE):

TheweightageassignedtoContinuousInternalEvaluation(CIE)andSemesterEndExamination(SEE)shallbe50%each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for a pass in the course.

Astudentshall bedeemedtohavesatisfiedtheacademicrequirementsandearnedthecreditsallottedtoasubject /courseonly ifhe/shesecures notlessthan50%oftheaggregatemarks obtainedinCIEandSEEtakentogether.

ContinuousInternalEvaluation:

(i) Theorycomponent

TheCIEmarksof 25 shallbeearmarkedfortwotests.

Thefirsttestshallbeconductedaftercompletingtwomodulesofthesyllabusandthesecondoneaftercompletingthe rest three modules.

Eachtestshallbeconductedfor25marks.Theaverageofthetwotestsscaleddownto25marksshallconstitutethe test marks for a maximum of 25 marks.

(ii) Laboratorycomponent

Outof25marks,15marksshallbeassignedforassessmentofregularlaboratoryclassworkas pertherubricslistedin Table - ICs/IPCCs1.

Theremaining10marksshallbebasedonthepracticaltestconductedbytwoInternalexaminersappointedbythe HoD.Theallotmentof marks shallbeas perthe rubrics defined forthe practical testas indicated inthe Table – ICs/IPCCs1.
ToqualifyandbecomeeligibletoappearfortheSEEoftheIC/IPCC,astudentshallsecureatleast13marksoutof25in the CIE theory component, and at least 12 marks in the CIE Practical component.

Table–ICs/IPCCs1Distribution ofmarkscorrespondingtolaboratorycomponent		
Component	Description	Marks
Allotmentof marksforregularclasswork		
AbilityinConducting Experiments	Initiative,skill,safetypractices,teamwork,and independenthandlingofequipmentduringregularlab sessions.	5 marks
LaboratoryRecord/ Journal	Regularandneatmaintenance oflab record,accuracyof results,and timelysubmission.	10 marks
Subtotal		15
AllotmentofmarksforCIEpracticaltest		
LaboratoryTest/ Experiment Performance	Abilitytosetupapparatus,followprocedure,take observations,andobtaincorrectresultsin thetest experiment.	5 marks
Viva-Voce	Understandingoftheory,concepts,andexperimental procedure;abilitytoexplainresultsandanswerrelated questions.	5 marks
Subtotal		10
Total		25

Students'activitiesforTW/SLunderNCrF:

As per National credit framework (NCrF) students must spend120hours of study for4 creditcourses,which include Course instructions (CI-70 hour) and Teamwork/Self learning (TW/SL-50 hours). Hence, students must complete minimumoftwoactivitiesaspartofNCrF.Theevaluationactivitieswillbedoneusingsetofrubricsdevelopedforeach activity. The following sample activities are listed below. The course coordinator can also design learning activities basedoncourse outcomes.

Sl.No.	**TermWork(TW)Activity**	**NumberofHours/ Semester**
1	**TW1 – Group Case Project — Stability Assessment &Retrofitof a3-storey Portal Frame:** Evaluate the global and local stability of a 3-storey portal frame, identify causes of instability, and design a retrofit (bracing/section change/strengthening) validated by second-order and eigenvalue analyses. (Maps to CO2–CO6)	25
2	**TW2–ColumnandBeam-ColumnStability DesignPortfolio** Studentsdesignandcheckthestabilityofcompressionmembersand beam-columns using hand calculations plus software verification.	25
SL:SelfLearning,MOOCs,spokentutorials,online educationalresources etc.		
Sl.No.	**Self-Learning(SL)Activity**	**NumberofHours/ Semester**
1	**SL1–IndividualAnalytical+NumericalPortfolio—Rayleigh-Ritz, MATLAB Script, FEM Buckling and Reflective Case Note:**	25

	Build independent capability to derive approximate stability solutions, implement a numerical estimator, run FEM eigenvalue buckling, and reflect on a real case study. (Maps to CO1, CO3–CO5)	
2	**SL2–StabilityFailureCase StudySeminar:** Studentsstudyonerealstructuralfailureandexplainthestabilitymechanism, cause of collapse, and remedial measures.	25

SamplerubricsforTWactivities:

Sl. No.	Criteria	Excellent	Good	Satisfactory	Unsatisfactory
1	Preparation	Complete, well-organized, and technicallycorrect	Minor omissions, mostlycorrect	Basicunderstanding, some gaps	Poor or incomplete
2	Execution	Accurateexecutionwith proper procedure and safety	Minorerrorsin execution	Partiallycorrect execution	Incorrectornot completed
3	Analysis/ Results	Correct analysis, clear interpretation,andvalid conclusions	Mostlycorrect with minor mistakes	Limited interpretation	Noproper analysis
4	CaseStudy/ Application	Strongapplicationtoreal problem, good justification of findings	Adequate application with some justification	Basicapplication only	Nomeaningful application
5	Defence	Clear,confident,and accurate answers	Mostlycorrect answers	Partial understanding	Unableto answer
6	Report Submission	Neat,complete,and submitted on time	Minorissuesin presentation	Acceptablebut incomplete	Missing or poorlyprepared

Suggested rubricsforPracticalcontinuous assessment:

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 the answer but not capable to show in depth knowledge. (2)	Student has not understood the conceptsclearly.(1)
Design Of Experiment(5) (PO2 & PO3)	Student is capable of discussing more than one planning workflow/design for theproblemstatement and selecting the best suitableapproachwith 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)	Student canexplain theplanning/design approach only partly. (1-2)
Implementation(8) (PO3 & PO8)	Student is capable of implementing WBS, schedulelogic,model linkage, resource mapping and issue tracking with an optimalandtraceable workflow.(7-8)	Studentiscapableof implementing the workflow and explaining it with minor gaps. (5-6)	Studentiscapableof implementing the workflow with partial explanation. (3-4)	Student can implement only limitedpartsofthe workflow. (1-2)
Result&Analysis (5)(PO4)	Student is able to run the workflow for various cases and compare4Dsequence, resource,progressand logistics results with properanalysis. (5)	Studentwillbeable toruntheworkflow forall the cases. (4)	Studentwillbeable toruntheworkflow for a few cases and analyze the output. (3)	Studentwillbeable toruntheworkflow but not able to analyze the output. (1-2)
Demonstration(8) (PO9)	The lab record/portfolio is well organized, with clear sections such as brief, method, WBS, schedule, model QA, 4D output, resource sheet,issuelog,results andconclusion.(7-8)	The lab record/portfolio is organized,withclear sections, but some sections are not well-defined.(5-6)	Thelabrecord lacks clearorganizationor structure. Some sections are unclear orincomplete.(3-4)	The lab record is poorly organized, with missing or unclearsections.(1-2)

FREEANDFORCEDVIBRATIONSOFSTRUCTURALELEMENTS			
CourseCode	**1MCAS202**	Scheme	2026
TypeofCourse	**ProfessionalCoreCourses(PCC)**	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:FormulatemathematicalmodelsforSingleDegreeofFreedom(SDOF)andMultiDegreeof Freedom (MDOF) systems.
2. CO2:Analyzefreeandforcedvibrationresponsesofdampedandundampedsystemsunder harmonic and general excitations.
3. CO3:Determinenaturalfrequenciesandmodeshapesofmdofsystemsusinganalyticalandnumerical methods.
4. CO4:Evaluate the dynamicresponseofshearbuildings using normal modesuperposition.
5. CO5:Applyapproximatemethods(Rayleigh's,Dunkerley's,Stodola's)andanalyzecontinuoussystems like beams.

Module-1

Introduction&Dynamics ofSDOFSystems(withComputer-AidedApproach)

- Introductiontodynamicproblemsin CivilEngineering,Conceptofdegreesoffreedom.
- D'Alembert'sprinciple,Principleofvirtualdisplacement,Energyprinciples.
- DynamicsofSDOFsystems:Mathematical modeling.
- Freevibrationresponseofundamped anddampedsystems(under-damped,criticallydamped,over-damped).
- Methodsforevaluationofdamping(Logarithmicdecrement).
- **Computer-AidedApproach:**UsingMATLAB/Pythontosolvefreevibrationproblems.Plottingdisplacement-time responses for different damping conditions. Automated calculation of natural frequency and damping ratio.

Self-study: DevelopaMATLAB/Pythonprogramtoplotfreevibrationresponseforunder-damped,criticallydamped, and over-damped systems.

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

Module-2

ResponseofSDOFSystems toHarmonic&General Loads(withComputer-AidedApproach)

- Responsetoharmonicloading(Magnificationfactor,resonance,bandwidth).
- Support motion(Base excitation).
- VibrationisolationandTransmissibility.
- Numericalmethods appliedtoSDOFsystems–Duhamelintegral(Impulseresponse).
- Principleofvibrationmeasuringinstruments–Seismometer and Accelerometer.
- **Computer-AidedApproach:**UsingMATLAB/Pythontocomputefrequencyresponse.Plottingmagnification factor vs. frequency ratio. Numerical integration using Duhamel integral. Simulation of base excitation problems.

Self-study: Writeaprogramtocomputeandplotthefrequencyresponsecurveforasdofsystemwithdifferent damping ratios.

LinkedCOs:CO2 **NumberofHours:10hrs**

Module-3

DynamicsofMultiDegree ofFreedom(MDOF)Systems(withComputer-AidedApproach)

- MathematicalmodelsofMDOF systems.
- Shearbuildingconcept(2-Storeyand3-Storey).
- Freevibrationofundamped MDOFsystems–DerivationofEigenvalue problem.
- NaturalfrequenciesandModeshapes (EigenvaluesandEigenvectors).
- Orthogonalityofmodes.
- **Computer-AidedApproach:**UsingMATLAB/Pythontosolveeigenvalueproblems.Computingnatural frequencies and mode shapes for multi-storey buildings. Visualizing mode shapes using software.

Self-study: DevelopaMATLAB/Pythonprogramtosolvefornaturalfrequenciesandmodeshapesofa3-storeyshear building

LinkedCOs:CO3 **NumberofHours:8hrs**

Module-4

ForcedVibrationAnalysisofMDOFSystems(withComputer-AidedApproach)

- Responseofshearbuildingstoharmonicloadingwithoutdampingusingnormalmodeapproach(Modal decomposition).
- Responseofshearbuildingstoforcedvibrationforharmonicloadingwithdampingusingnormalmode approach.
- **Computer-Aided Approach:** Using MATLAB/Python for modal decomposition and response analysis. SimulatingresponseofMDOFsystemsunderharmonicloads.Parametricstudyofdampingeffectsusing software.

Self-study: Simulatetheresponseofa2-storeyshearbuildingunderharmonicloadingusingMATLAB/Pythonand compute displacement response

LinkedCOs:CO4 **NumberofHours:8hrs**

Module-5

ApproximateMethods&DynamicsofContinuousSystems(withComputer-AidedApproach)

- **Approximatemethods:**Rayleigh'smethod(Fundamentalfrequency),Dunkerley'smethod,Stodola'smethod (Iterative).
- **DynamicsofContinuoussystems:**Flexuralvibrationofuniformbeamswithdifferentendconditions(Simply supported,Cantilever).
- Derivationofgoverning differentialequation.
- Stiffness matrixandMass matrix(Lumpedand Consistentmass matrices)forbeam elements.
- **Computer-AidedApproach:**UsingMATLAB/PythonforRayleigh'smethodcalculations.FEAsoftwarefor modal analysis of continuous beams. Validation of approximate methods using software results.

Self-study: Determinefundamentalfrequencyofasimplysupportedbeamusing Rayleigh'smethodandvalidate using FEM software.

LinkedCOs:CO5 **NumberofHours:8hrs**

SuggestedLearningResources:

Textbooks:

1. Chopra,A.K.(2020).*DynamicsofStructures:TheoryandApplicationstoEarthquakeEngineering*.Pearson Education.
2. Clough,R.W.,&Penzien,J.(2013).*DynamicsofStructures*.Computers&StructuresInc

ReferenceBooks

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). *Fundamentals ofStructuralDynamics*.Wiley.
4. Biggs,J.M. (1964).*Introductionto StructuralDynamics*. McGraw-Hill.

WeblinksandVideoLectures(e-Resources):

1. NPTELCourse:"StructuralDynamics"byProf.P.Banerjee,IIT Bombay: 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
5. OnlinetutorialsforMATLAB/Pythonfordynamicanalysis.

Teaching-LearningProcess(InnovativeDeliveryMethods):

Thefollowingaresamplestrategies thateducatorsmayadopt to enhancetheeffectivenessoftheteaching-learning processandfacilitatetheachievementofcourseoutcomes.SuggestedInnovativeDeliveryMethodsmayinclude(butare not limited to):

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

AssessmentStructure(bothCIEandSEE)

Theweightageassigned toContinuous InternalEvaluation(CIE)and SemesterEnd Examination(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,Continuous Comprehensive Assessment(CCA) shallbeconductedforatotal of25marks

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	SDOF Vibration Analysis using MATLAB/Python: Write programs to analyze free and forced vibration of SDOF systems. Plot displacement-time and frequency response curves.	24
2	MDOFModalAnalysis:Developa program tocompute naturalfrequenciesand mode shapes of multi-storey buildings using eigenvalue analysis.	24

3	ForcedResponseSimulation:Simulatetheresponseofshearbuildingsunder harmonic loading using modal decomposition method.	24
4	Approximate Methods Implementation: Implement Rayleigh's, Dunkerley's, and Stodola's methods in MATLAB/Python for continuous beams.	24
5	Seminar:Conductatechnicalseminaron"VibrationControlinHigh-Rise Buildings" or "Seismic Base Isolation Techniques".	24
SL:SelfLearning,MOOCs,spokentutorials,online educationalresources etc.		
Sl.No.	**Self-Learning(SL)Activity**	**NumberofHours/ Semester**
1	SDOF Vibration Analysis usingMATLAB/Python: Writeprograms to analyze free and forced vibration of SDOF systems. Plot displacement-time and frequencyresponsecurves.	24
2	MDOFModalAnalysis:Developaprogramtocomputenaturalfrequencies and mode shapes of multi-storey buildings using eigenvalue analysis.	24
3	ForcedResponseSimulation:Simulatethe responseofshearbuildingsunder harmonicloadingusingmodaldecompositionmethod.	24
4	ApproximateMethodsImplementation:ImplementRayleigh's,Dunkerley's, andStodola'smethodsinMATLAB/Pythonforcontinuousbeams.	24
5	Seminar:Conductatechnicalseminaron"VibrationControlinHigh-Rise Buildings"or"SeismicBaseIsolationTechniques".	24

SamplerubricsforTWactivities:

Criteria	4-Excellent	3-Good	2-Satisfactory	1-NeedsImprovement
Problem understanding	Clearproblem framingwithstrong justification.	Mostlyclearwith minorgaps.	Basicattemptwith limited clarity.	Poorlydefined 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.	Relevantwithmin or limitations.	Generic recommendations.	Incompleteor unrealistic.
Presentation	Wellorganizedand professional.	Goodorganizatio n with minor issues.	Acceptablebut uneven.	Poorlypresented.

SOFTCOMPUTING APPLICATIONSINSTRUCTURALENGINEERING			
CourseCode	**1MCAS203**	Scheme	2026
TypeofCourse	ProfessionalCoreCourses(PCC**)**	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 – CIE + SEE, and Lab – CIE only.	ExamHours	03

Courseoutcome(CourseSkillSet):

Atthe endofthecourse,thestudent willbeableto:

1. CO1:Explainthefundamentalsofsoftcomputingtechniquesandtheirrelevancetostructuralengineering problems.
2. CO2:Applyneuralnetworks,fuzzylogic,andgeneticalgorithmsformodelling,prediction,andoptimizationin structural systems.
3. CO3:Developsoftcomputing-basedsolutions forstructuralanalysis,design,andperformanceassessment.
4. CO4:Evaluatethesuitabilityofsoftcomputingtoolsforsolvinguncertain,nonlinear,anddata-driven structural engineering problems.
5. CO5:Implementdatapreprocessing,featureselection,training,validation,andperformanceevaluationfor structural datasets.
6. CO6:Interpretandcomparesoftcomputingoutputsfordecision-makinginstructuralengineering applications.

Module-1

IntroductiontoSoftComputing inStructuralEngineering:

Introduction to soft computing, need for intelligent computing in engineering, deterministic versus data-driven approaches, uncertainty and nonlinearity in structural problems. Overview of neural networks, fuzzy logic, genetic algorithms,swarmintelligence,hybridsystems,andtheirapplicationsinstructuralengineering.Datatypes,structural databases, input-output mapping, training concepts, validation, overfitting, and model generalization.

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

Module-2

ArtificialNeuralNetworksforStructuralApplications:

Basics of perceptron, multilayer feedforward networks, activation functions, backpropagation learning, network architectureselection,errormeasures,andtrainingprocedures.ANNapplicationsinpredictionofconcretestrength,load-carrying capacity, deflection, crack width, and structural response. Data normalization, feature scaling, model validation, sensitivityanalysis,andperformancemetrics.Casestudiesonneuralnetworkmodelsforstructuralengineeringproblems.

LinkedCOs:CO1,CO2,CO5. **Numberof Hours:09**

Module-3

Fuzzy LogicandFuzzy InferenceSystems:

Fuzzy sets,membership functions, fuzzy relations, fuzzy operators, andapproximate reasoning. Fuzzy inferencesystems, rulebasedevelopment,fuzzification,defuzzification,andMamdaniandSugeno models.Applicationsinstructuraldamage assessment,conditionrating,rehabilitationprioritization,andexpertdecisionsupport.Hybridfuzzymodelsforuncertain structuralevaluationandmulti-criteriadecision-makinginstructuralengineering.

LinkedCOs:CO1,CO3,CO4. **NumberofHours: 09**

Module-4

GeneticAlgorithmsandOptimizationTechniques:

Introductiontoevolutionarycomputation,chromosomes,fitnessfunctions,selection,crossover,mutation,andtermination criteria. Single-objective and multi-objective optimization using genetic algorithms. Applications in structural design optimization,sizingandtopologyoptimization,parametercalibration,trussandframeoptimization,andcost-baseddesign selection. Comparison of GA with other metaheuristic approaches for structural engineering problems.

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

Module-5

HybridSoftComputingandCaseStudies:

HybridintelligentsystemscombiningANN,fuzzylogic,andGA; neuro-fuzzysystems; adaptive neuro-fuzzyinference systems (ANFIS); andother compositeapproaches.Applications instructural healthmonitoring,earthquake damage prediction,nonlinearmodelidentification,reliabilityassessment,andconstructionqualityprediction.Casestudieson soft computing-based structural problem solving, interpretation of results, and implementation using available software tools. Emerging trends in explainable AI, digital twins, and intelligent structural decision support.

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

SuggestedLearningResources:

TextBooks:

1. S.N.Sivanandam,S.N.Deepa,andP.Sumathi,IntroductiontoNeuralNetworksUsingMATLAB,McGraw-Hill Education.
2. B.V.Babu, SoftComputingandIntelligentSystems in StructuralEngineering,S.Chand.
3. K.Deb,Optimization for EngineeringDesign:AlgorithmsandExamples,PHILearning.
4. J. S. Jang, C. T. Sun, and E. Mizutani, Neuro-Fuzzy and Soft Computing, Pearson. S. Rajasekaran, G.A. VijayalakshmiPai,"NeuralNetworks,FuzzyLogic,andGeneticAlgorithmsSynthesisandApplications",PHI Learning Pvt. Ltd., 2013.
5. S.N.Sivanandam&S.N.Deepa,"PrinciplesofSoftComputing",WileyIndiaPvtLtd,2007.
6. PratiharD.K.,"SoftComputing",NarosaPublishers,2018.

ReferenceBooks/Manuals:

1. TimothyJ.Ross,FuzzyLogicwithEngineeringApplications,Wiley.
2. DavidE. Goldberg,GeneticAlgorithmsinSearch,OptimizationandMachineLearning,Addison-Wesley.
3. S.Haykin, NeuralNetworksandLearningMachines,Pearson.
4. C.M.Bishop, PatternRecognitionandMachineLearning,Springer.

WeblinksandVideoLectures (e-Resources)& Softwaretools:

1. NPTEL/SWAYAMcoursesonsoftcomputing,AI,andstructuralengineeringapplications.
2. Researcharticlesandcasestudies fromstructuralengineering journals onANN,fuzzylogic, andGAapplications.
3. OpeneducationalresourcesonMATLAB/Python-basedneuralnetworkandoptimizationtoolboxes.

Teaching-LearningProcess(InnovativeDeliveryMethods):

Thefollowingaresamplestrategiesthateducatorsmayadoptto enhancetheeffectivenessofthe teaching-learning processandfacilitatetheachievementofcourseoutcomes.SuggestedInnovativeDeliveryMethodsmayinclude(butare not limited to):

- FlippedClassroom
- Problem-BasedLearning(PBL)
- Case-BasedTeaching
- SimulationandVirtual Labs
- PartialDeliveryofcoursebyIndustry expert/ industrialvisits

- ICT-Enabled Teaching
- RolePlay

Students'activitiesforTW/SLunderNCrF:

As per National credit framework (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-50 hours). Hence, students must complete minimumof two activitiesaspartofNCrF.TheselearningactivitiesshallbeconsideredasCCAcomponentsofCIE.The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listedbelow.Thecoursecoordinatorcanalsodesignlearningactivitiesbasedoncourseoutcomes.

Sl.No.	TermWork(TW)Activity	NumberofHours/ Semester
1	**TW-1:** Structural Data Preparation and Cleaning. Students shall collect andpreprocessstructuraldataforachosencasestudy,including normalization,missingvaluehandling,anddatasetstructuring.	24
2	**TW-2:ANNModelDevelopment**.Studentsshalldevelopandtraina basicneuralnetworkmodelforpredictingastructuralresponse parametersuchasstrength,deflection,orstress.	24
3	**TW-3:Fuzzy DecisionModel**.Students shallprepareafuzzyinference-baseddecisionmodelforstructuralconditionassessmentordamage rating.	24
4	**TW-4: Genetic Algorithm Optimization Exercise.** Students shall formulateandsolveastructuraloptimizationproblemusingGA-based approach	24
SL:SelfLearning,MOOCs,spokentutorials,online educationalresources etc.		
Sl.No.	**Self-Learning(SL)Activity**	**NumberofHours/ Semester**
1	**SL-1:CaseStudy onANNin Structural Prediction.** Studentsshallstudy apublishedstructuralengineeringapplicationandsummarizemodel inputs,outputs,andperformance.	24
2	**SL-2:FuzzyLogicforDamageAssessment.**Studentsshallreviewacase onfuzzy-basedstructuraldecisionmakingandpresenttherulebaseand inferenceprocess.	24
3	**SL-3:GA-BasedStructuralOptimizationReview.**Studentsshallanalyzeastructuraloptimizationcaseandreportobjectivefunction, constraints,andoutcome	24
4	**SL-4:HybridSoftComputingDiscussion.**StudentsshalldiscussANFIS orhybridintelligentmethodsforstructuralhealth monitoringor design.	24

SamplerubricsforTWactivities:

Criteria	Excellent(4)	Good(3)	Satisfactory(2)	NeedsImprovement(1)
Understandingofsoft computing concepts	Correctlyexplains models, assumptions,and relevance to structural	Explainsmost conceptswith minorgaps.	Basic understanding with partial explanation.	Incompleteorincorrect understanding.

Criteria	Excellent(4)	Good(3)	Satisfactory(2)	NeedsImprovement(1)
	engineering.			
Technical implementation	Demonstrates correct workflow and valid computationalsteps.	Minorerrorsin executionor interpretation.	Severalgapsin method or application.	Majorerrorsorweak implementation.
Datahandlingand analysis	Uses data appropriately with clearpreprocessing and evaluation.	Mostly appropriatewith minorissues.	Limitedanalysis and weak justification.	Poorormissinganalysis.
Practicalapplication	Strong linkage to structural engineeringproblem solving.	Goodlinkage with limited depth.	Basicapplication only.	Nomeaningfulpractical linkage.

CONTINUUMMECHANICS			
CourseCode	**1MCCS204 / 1MCSE204 / 1MCAS204**	Scheme	2026
TypeofCourse	**ProfessionalCoreCourse**	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:Explainthefundamentals ofclimatesystem,climatevariability,andclimatechange drivers.
2. CO2:Analyzeclimatedataandidentify trends, extremes, andanomaliesrelevant tohazardassessment.
3. CO3:Developbasicclimatechangemodelsandinterpretsimulationoutputsforengineeringand environmental applications.
4. CO4:Assessvulnerability,exposure,and riskforselectednaturalhazardsusingappropriateframeworks.
5. CO5:Applydisasterriskreductionconcepts,mitigation,adaptation,andresiliencestrategiesinreal-world contexts.
6. CO6:Criticallyevaluateintegratedclimate-riskscenariosandproposesustainable,evidence-based interventions.

Module-1

Basic Concepts ofStressandStrain :

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

Self-studycomponent: Constitutiverelationsforanisotropicmaterialsandfordifferentcasesoforthotropy.

LinkedCOs:CO1 **NumberofHours:8hrs**

Module-2

2DProblemsinRectangularCoordinates:

- Airy'sstressfunctionapproachto2Dproblemsofelasticity.Solutionbypolynomials.Endeffects,Saint-Venant'sprinciple.
- Solutionofsimplebeamproblems includingworkingout ofdisplacementcomponents.

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,wedge andgroove problems

LinkedCOs:CO3 **NumberofHours:8hrs**

Module-4

3DAnalysisofStressandStrain:

- Stressatapointinanyarbitrarydirection.
- Principalstressesandcorresponding directions.
- Determinationof principal stressesandprincipal planes.
- Stressinvariants.
- Determinationofmaximumshearingstress.
- Octahedralstresscomponents.
- Strainatapointinanyarbitrarysection.
- Principalstrainsandcorrespondingdirections.Straininvariants.

Self-studycomponent: Failuretheoriesinageneralstateofstressforductileandbrittlematerials

LinkedCOs:CO4 **NumberofHours:8hrs**

Module-5

TorsionofNon-CircularSections:

- St.Venant'ssemi-inverse methodandPrandtl'sstressfunctionapproach.
- Torsionofstraightprismaticbarsofellipticcrosssection.
- Membraneanalogy.
- Torsionofabarof narrowrectangularcrosssection.
- Torsionofthin-walledopen cross sections.
- Torsionofthin-walledtubes.

Self-studycomponent: Torsionofmulticellproblemsasinmulticellgirdersusedinbridgesandflyovers.**Linked**

LinkedCOs:CO5 **NumberofHours:8hrs**

SuggestedLearningResources:

Textbooks

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

ReferenceBooks

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

WeblinksandVideoLectures(e-Resources)

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

Teaching-LearningProcess(InnovativeDeliveryMethods):

Thefollowingaresamplestrategies thateducatorsmayadopt toenhancetheeffectivenessoftheteaching-learning processandfacilitatetheachievementofcourseoutcomes.SuggestedInnovativeDeliveryMethodsmayinclude(butare not limited to):

- FlippedClassroom
- Problem-BasedLearning(PBL)
- Case-BasedTeaching

- SimulationandVirtualLabs
- PartialDelivery ofcourseby Industryexpert/industrialvisits
- ICT-EnabledTeaching
- Role Play

AssessmentStructure(bothCIEandSEE)

Theweightageassigned toContinuous InternalEvaluation(CIE)and SemesterEnd Examination(SEE)shallbe50% 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,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.Thesampleactivitiesaregivenbelow.Thecoursecoordinatorcanalsogivetheirown TW/SLactivitiesas perthecourseoutcomes.

Sl.No.	TermWork(TW)Activity	NumberofHours/ Semester
1	Assignments: 1. Compatibilityequationsandboundaryconditions(Mod1/CO1)–8h 2. Airy'sstress functionforacantilever beam(Mod2/CO2)–8h 3. TorsionofellipticsectionusingPrandtl'sfunction(Mod5/CO5)–8h	24
2	Seminars: 1. Constitutiverelationsfororthotropicmaterials(Mod1/CO1) – 8h 2. Failuretheoriesforductile andbrittlematerials(Mod4/CO4)–8h 3. Membraneanalogyfortorsion(Mod5/CO5)–8h	24
3	Micro-Project: 1. StressdistributionaroundacircularholeusingPython(Mod3/CO3) –12h 2. Torsionanalysis ofthin-walledopensection(Mod5/CO5)–12h	24

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

Sl.No.	Self-Learning(SL)Activity	NumberofHours/ Semester
1	NPTEL:ContinuumMechanics (IITMadras)	8
2	NPTEL:TheoryofElasticity	8
3	Derivationpractice– Airy'sfunction &polarcoordinates	8

SamplerubricsforTWactivities:

Criteria	4-Excellent	3-Good	2-Satisfactory	1-NeedsImprovement
Problem understanding	Clearproblem framingwithstrong justification.	Mostlyclearwith minorgaps.	Basicattemptwith limited clarity.	Poorlydefined 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.	Relevantwithmin or limitations.	Generic recommendations.	Incompleteor unrealistic.
Presentation	Wellorganizedand professional.	Goodorganizatio n with minor issues.	Acceptablebut uneven.	Poorlypresented.

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

Module-1

BasicConceptsofElasticity,ApproximateMethods&FEMFundamentals:

- Kinematicandstaticvariablesforstructuralproblems.Approximatemethods–Rayleigh-Ritzmethod, Finite difference method.
- Variation methodandminimizationofenergyapproach forelementformulation.
- PrinciplesofFEM–advantages&disadvantages.
- GeneralFEM procedure.
- Finiteelementsfor1D,2D& 3Dproblems–elementaspectratio,meshrefinementvs.higherorder elements, node numbering to minimize bandwidth.

Self-study:CompareRayleigh-RitzandFDM forasimplysupportedbeam..

LinkedCOs:CO1 **NumberofHours:9hrs**

Module-2

DisplacementFunctions,ShapeFunctions&CoordinateSystems

- Nodaldisplacementparameters.Convergencecriterion–completenessandcompatibilityrequirements. Geometric invariance.
- Shapefunctions –polynomialformofdisplacementfunction.Generalizedandnatural coordinates.
- Lagrangianinterpolationfunction–shapefunctionsfor 1D,2D&3D elements

Self-study:Deriveshape functionsfor a3-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: Perform 2x2Gaussianquadratureforaquadrilateralelement.*

LinkedCOs:CO3 **NumberofHours:8hrs**

Module-4

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

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

***Self-study**:AnalyzeaplanetrussusingCSTelementsandverifyresults*

LinkedCOs:CO4 **NumberofHours:8hrs**

Module-5

FEMfor Plates,Shells&IntroductiontoNon-linearAnalysis:

- ApplicationofFEMtoplatesandshells.Choiceofdisplacementfunction–C_0,C_1,andC_2typecontinuity requirements.
- Techniquesfornon-linearstructuralanalysis–geometricnon-linearity,materialnon-linearity,and solution methods (Newton-Raphson, modified Newton-Raphson).

***Self-study**: Comparelinearvsnon-linearanalysisofacantileverbeamunderlargedeflection.*

LinkedCOs:CO5 **NumberofHours:8hrs**

SuggestedLearningResources:

Textbooks

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

ReferenceBooks

1. Rajasekaran,S.–FiniteElement AnalysisinEngineeringDesign, Wheeler Publishing.
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,New York, 1985.

WeblinksandVideoLectures(e-Resources)

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

Teaching-LearningProcess(InnovativeDeliveryMethods):

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

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- ICT-EnabledTeaching
- RolePlay

AssessmentStructure(bothCIE andSEE)

TheweightageassignedtoContinuous InternalEvaluation(CIE) and SemesterEndExamination(SEE)shallbe50% 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.

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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	Assignments: 1. Rayleigh-Ritzsolutionforbeam(Mod1/CO1)–8h 2. Shapefunctionsfor2Delement(Mod2/CO2)–8h 3. CSTanalysis ofplane stress problem(Mod4/CO4)–8h	24
2	Seminars: 1. Isoperimetric formulation (Mod3/CO3) – 8h 2. Non-linear solution methods (Mod5/CO5) – 8h 3. Plates and shellsanalysis(Mod5/CO5)– 8h	24
3	Micro-Project: 1. MATLABprogramfortrussanalysis(Mod4/CO4)–12h 2. FEAofplatewithholeusingANSYS(Mod5/CO5)–12h.	24

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

Sl.No.	Self-Learning(SL)Activity	NumberofHours/Semester
1	NPTEL:FiniteElementAnalysis(IITKharagpur)	8
2	NPTEL:Non-linearFEM (IITMadras)	8
3	FEAsoftwarepractice(ANSYS/ABAQUS)	8

SamplerubricsforTWactivities:

Criteria	4-Excellent	3-Good	2-Satisfactory	1 - Needs Improvement
Problem understanding	Clear problem framingwithstrong justification.	Mostlyclearwith minorgaps.	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.

COMPUTER-AIDEDSTRUCTURALLOADANALYSISANDCODALAPPLICATIONS			
CourseCode	**1MCAS205B**	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:Rememberandunderstandthenature,magnitude,andprobabilisticassessmentofstructural loads (Dead, Live, Wind, Seismic) using computer-aided tools.
2. CO2:ApplytheprovisionsofIS875(Parts1,2,&3),IS1893,andIRC6tocalculatedesignloadsfor buildings and bridges using software.
3. CO3:Analyzeloadpathsforgravityloads(TributaryArea&Stiffnessapproaches)andlateralloads (Floor diaphragm action) in various structural systems using computer models.
4. CO4:Evaluatetheimpactofstructuralforms,materialnonlinearity,andgeometricnonlinearityonthe behavior of tall buildings using analysis software.
5. CO5:Createcomprehensiveprojectreportsincorporatingcodalprovisionsforloadcalculationson buildings and bridges.
6. CO6:Criticallyevaluateandapplyappropriateloadcombinationsfordifferentstructuralsystemsand design scenarios using computer-aided methods.

Module-1

LoadsandLoad Combinations:IS875PART1,2,4,5:

- Sources,NatureandMagnitude,Probabilistic assessment,Characteristicand Designvalues.
- IS875 PART 1and2 codeprovisions.Loadcombination rulesfordesign.
- Loadpathforgravityloads -TributaryAreaandStiffness basedapproaches.
- EstimationofDLandLLonstructuralelementssuchasSlabs,BeamsandColumnsindifferenttypesof structural systems.
- JointLoadson Trusses, Distributedloadonpurlins- Numericalexamples.
- **Computer-AidedApproach:**DevelopingspreadsheettoolsforautomatedDLandLLcalculations.Using structuralanalysissoftware(STAADPro,ETABS)toapplyloadsonstructuralmodelsandverifyloadpaths. Automated load combination generation as per IS 875.

Self-study: Studentsshallprepareaspreadsheet-basedtoolforautomateddeadloadandliveloadcalculationsfor different building configurations. Use software to model a simple building and apply gravity loads.

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

Module-2

WindLoad-IS875PART3:Buildings(IS875:2015revisedversion):

- NatureandMagnitude,Factors influencingwindloads.
- InternalandExternalpressuredistribution,DesignWindSpeedsandPressure.
- Loadpathforwindloads.
- NumericalExamplestocalculateexternalandinternalpressurefordifferenttypesofbuildingsandregions- Flat roofs, Pitched Roofs, Sign boards and Structural glazings.

- **Computer-AidedApproach:**Usingsoftwaretogeneratewindloadpatternsautomatically.Modeling wind pressuredistributiononbuildingsurfacesusinganalysissoftware.Creatingautomatedwindloadcalculators using Excel/VBA. Visualizing wind pressure contours using computational tools.

Self-study: Studentsshallpreparereportonwindloadcalculationforatallbuildingincorporatingallcodal provisions. Create a computer model to apply wind loads and analyze the structural response.

LinkedCOs:CO2, CO3,CO5 **NumberofHours:9hrs**

Module-3

SeismicLoads:IS:1893-2016revisedversion

- NatureandMagnitude,Centreofmass andrigidity.
- CalculationofDesignSeismicForcebyStaticAnalysisMethodand DynamicAnalysisMethod.
- LocationofCentreofMass,LocationofCentreofStiffness,andLateralForceDistributionaspercodalprovisi ons.
- LoadpathforLateralloads-Floordiaphragmaction.
- **Computer-Aided Approach:** Using software (ETABS, STAAD Pro, SAP2000) to performseismic analysis. Automatedcalculationofcenterofmassandcenterofrigidity.Performingresponsespectrumanalysisand time history analysis using software. Comparison of static and dynamic analysis results using computer models.

Self-study: Studentsshallpreparereportforcalculatingseismicforceforvariousseismiczonesincorporatingall codal provisions. Model a building in software and perform seismic analysis.

LinkedCOs:CO2,CO3,CO5 **NumberofHours:9hrs**

Module-4

VehiclesLoadsasperIRC 6-2017onRoadBridges

- Class70 R,ClassAA,ClassA,ClassB,TrackedVehicles, WheeledVehicles.
- LoadCombinations,Impact, Wind,WaterCurrents.
- LongitudinalForces:acceleration,brakingandfrictionalresistance.
- Centrifugalforces,thermal loads,Seismicforces,SnowLoads,CollisionLoads.
- LoadCombinations-SimpleNumericalExamples.
- **Computer-AidedApproach:**Usingbridgeanalysissoftware(MIDASCivil,STAADBridge)toapplyvehicle loadsonbridgemodels.Automatedgenerationofinfluencelinesandmovingloadanalysis.Software-based load combination for bridge structures. Visualizing load effects on bridge components.

Self-study: Studentsshalltakeuparoadbridgeprojectandcalculatethevariousloadcombinationsasper IRC provisions using computer software.

LinkedCOs:CO2,CO6,CO5 **NumberofHours:8hrs**

Module-5

StructuralformsofTallBuildings:IS:16700;2017

- DifferentstructuralformsforTallBuildings.
- LinearandNonlinearbehavior-Materialnonlinearity, Geometricnonlinearity.
- RigidandElasticSupports.
- FirstOrderElasticAnalysis,SecondOrderElasticAnalysis,FirstorderInelasticAnalysis,Secondorder Inelastic Analysis - Concepts and Brief descriptions.
- **Computer-AidedApproach:**Usingadvancedanalysissoftware(ETABS,SAP2000,ANSYS)fortallbuilding analysis.ModelingP-Deltaeffects(geometricnonlinearity).Consideringmaterialnonlinearityinsoftware analysis. Comparing first-order and second-order analysis results using computer models. Visualizing structural behavior under various loading conditions.

Self-study: Studentsshallstudytheinelasticbehaviourofatallbuildingusinganysoftwarepackageandpreparea report comparing linear and nonlinear analysis results.

LinkedCOs:CO4, CO6 **NumberofHours:8hrs**

SuggestedLearningResources:

Textbooks

1. BureauofIndianStandards.(2015).IS875(Part1,2,3,4,5):CodeofPracticeforDesignLoads(Otherthan Earthquake) for Buildings and Structures. New Delhi: BIS.
2. BureauofIndianStandards. (2016).IS1893(Part1):CriteriaforEarthquakeResistantDesignofStructures. New Delhi: BIS.
3. BureauofIndianStandards.(2017).IS16700:CriteriaforStructuralSafetyofTallConcreteBuildings.New Delhi: BIS.
4. IndianRoadsCongress.(2017).IRC6:StandardSpecificationsandCodeofPracticeforRoadBridges,Section II - Loads and Stresses. New Delhi: IRC.

ReferenceBooks:

1. Agarwal,P.,&Shrikhande,M.(2010).EarthquakeResistantDesignofStructures.NewDelhi:PHILearningPvt. Ltd.
2. BungaleS.Taranath.(2016).StructuralAnalysisandDesignofTallBuildings:SteelandComposite Construction. CRC Press.
3. D.L.Schodek,&M.Bechthold.(2014).Structures. PearsonEducation.
4. IS:456-2000.PlainandReinforcedConcrete-CodeofPractice.BIS,NewDelhi.
5. SP:64-2001.ExplanatoryHandbookonIS875(Part1&2).BIS,NewDelhi.

WeblinksandVideoLectures (e-Resources):

1. BureauofIndian Standards(BIS)-www.bis.gov.in
2. NPTEL/SWAYAMcoursesonStructuralDesign,EarthquakeEngineering,andWindEngineering.
3. IndianRoads Congress(IRC) -www.irc.nic.in
4. OnlinetutorialsonIS875,IS1893,andIRC6provisions.
5. Structuralengineeringsoftwaredocumentationandcasestudies(STAADPro,ETABS,SAP2000,MIDAS Civil).

Teaching-LearningProcess(InnovativeDeliveryMethods):

Thefollowingaresamplestrategies thateducatorsmayadopt to enhancetheeffectivenessoftheteaching-learning processandfacilitatetheachievementofcourseoutcomes.SuggestedInnovativeDeliveryMethodsmayinclude(butare not limited to):

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

AssessmentStructure(bothCIEandSEE)

TheweightageassignedtoContinuousInternalEvaluation(CIE)andSemesterEndExamination(SEE)shallbe50% each.Astudent shall securea minimumof50%ofthe maximum marks prescribedforCIE anda minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.

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

ContinuousInternalEvaluation:

ContinuousComprehensiveAssessments(CCA)+InternalAssessmentTest(IA)=ContinuousInternalEvaluation CIE [25+25=50 marks]
AminimumoftwoInternalAssessmentTests(IA)shallbeconducted.Eachtestshallbeconductedforamaximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.
Inaddition,Continuous Comprehensive Assessment(CCA) shallbeconductedforatotal of25marks

Students'activitiesforTW/SLunderNCrF:Samplesonly

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

Sl.No.	TermWork(TW)Activity	NumberofHours/ Semester
1	Computer-Aided Load Analysis: Use structural analysis software (STAAD Pro/ETABS) to model a building, apply gravity loads, and analyze structural response. Compare with manual calculations.	24
2	WindLoadAnalysisusingSoftware:Modelatallbuildingin software, apply wind loads as per IS 875 Part 3, and analyze the structural behavior.	24
3	SeismicAnalysisusingSoftware:Performseismicanalysisofa buildingusingETABS/STAADPro(staticanddynamicmethods). Compareresultsfor differentseismiczones.	24
4	Bridge Load Analysis using Software: Model a road bridge in bridgeanalysissoftware,applyvehicleloadsasperIRC6,and analyzethestructuralresponse.	24
5	TallBuildingNonlinearAnalysis:Studytheinelasticbehaviourof atallbuildingusingsoftware(SAP2000/ETABS)andpreparea report comparing linear and nonlinear analysis results.	24

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

Sl.No.	Self-Learning(SL)Activity	NumberofHours/ Semester
1	Prepare a spreadsheet-basedtoolfor automateddeadload and liveloadcalculationsfordifferentbuildingconfigurations.Use software to model a simple building and apply gravity loads.	16
2	Preparereportonwindloadcalculationforatallbuilding incorporatingallcodalprovisions.Createacomputermodelto apply wind loads and analyze structural response.	16
3	Prepare a report forcalculatingseismicforce forvariousseismic zonesincorporatingallcodalprovisions.Modelabuildingin software and perform seismic analysis.	16
4	Takeupa roadbridgeprojectandcalculatethevariousload combinationsas perIRC provisionsusingcomputersoftware.	16
5	Studythe inelasticbehaviourofatall building usinganysoftware packageandpreparereportcomparinglinearandnonlinear analysis results.	16

SamplerubricsforTWactivities:

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

ADVANCEDSTRUCTURALANALYSIS(NONLINEARANDSTABILITY)			
CourseCode	**1MCSE205B/ 1MCAS205C**	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:Derivedifferentialequationsof beam-columnssubjectedtodifferent loads andendconditions.
2. CO2:Approximatecalculationofcriticalloadsforframesandcontinuousbeamsbyelasticenergy methods
3. CO3:Apply finiteelementmethod tostability analysisofstructuralelements.
4. CO4:Buckling ofrectangularplateswith variousedgeconditions
5. CO5:Bucklingofrectangularplates undercombinedloads.

Module-1

NonlinearAnalysis–Beam-Column:

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

Self-study: Developaprogramfordifferentialequationfordifferentloadingandend conditions.

LinkedCOs:CO1 **NumberofHours:8hrs**

Module-2

NonlinearAnalysis– BucklingofFrames&ContinuousBeams:

- Approximatecalculationofcriticalloadsforacantilever.Exactcriticalloadforhinged-hingedcolumnusing energy approach.
- Bucklingofbar oninelastic foundation.Bucklingofcantilever columnunderdistributedloads.
- Determinationofcritical loadsbysuccessive approximation.Barswithvaryingcrosssection.
- Effectofshearforceoncriticalload.Columnssubjectedtonon-conservative,follower,andpulsatingforces.

Self-study: Preparareportonthe conceptof bucklingofRCstructures.

LinkedCOs:CO2 **NumberofHours:10hrs**

Module-3

StabilityAnalysisbyFiniteElementApproach:

- Derivationofshapefunctionsforatwo-nodedBernoulli-Eulerbeamelement(lateralandtranslational DOF). Element stiffness and element geometric stiffness matrices.
- Assembledstiffnessandgeometricstiffnessmatricesforadiscretisedcolumnwithdifferentboundary conditions.
- Evaluationofcriticalloadsforadiscretised(twoelements)column(bothendsbuilt-in). Algorithmto

generategeometric stiffnessmatrixforfour-noded and eight-nodedisoparametricplateelements.

- Bucklingofpin-jointedframes(maximumoftwoactiveDOF)– symmetricalsinglebayportal frame.

Self-study: Obtainsolutionforthecolumnwithdifferentboundaryconditionsusingreferencematerial.

LinkedCOs:CO3 **NumberofHours:8hrs**

Module-4

BucklingofSimplySupportedRectangularPlates:

- Bucklingofuniformly compressed rectangularplatesimplysupportedalong twoopposite edges perpendiculartothedirectionofcompressionandhavingvariousedgeconditionsalongtheothertwo edges.
- Bucklingofarectangularplatesimplysupportedalongtwooppositesidesanduniformlycompressedinthe direction parallel to those sides.

Self-study: Preparareportonbuckling ofsimplysupportedrectangularplate.

LinkedCOs:CO4 **NumberofHours:8hrs**

Module-5

BucklingofRectangularPlates–CombinedEffects:

- Bucklingofa simplysupportedrectangularplateundercombinedbendingandcompression.
- Bucklingofrectangularplatesundertheactionofshearingstresses.Othercasesofbucklingof rectangularplates.

Self-study: Obtainsolution forothercasesofbuckling ofrectangular plates using referencematerial

LinkedCOs:CO5 **NumberofHours:8hrs**

SuggestedLearningResources

Textbooks

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

ReferenceBooks

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

WeblinksandVideoLectures(e-Resources)

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

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Teaching-LearningProcess(InnovativeDeliveryMethods):

The following are sample strategies thateducators may adopt to enhance the effectiveness of the teaching-learning processandfacilitatetheachievementofcourseoutcomes.SuggestedInnovativeDeliveryMethodsmayinclude(but are not limited to):

- FlippedClassroom
- Problem-BasedLearning(PBL)
- Case-BasedTeaching
- SimulationandVirtualLabs
- PartialDelivery ofcourseby Industryexpert/industrialvisits

- ICT-EnabledTeaching
- Role Play

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)=ContinuousInternalEvaluation CIE [25+25=50 marks]

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

Inaddition,Continuous Comprehensive Assessment(CCA)shallbeconductedforatotal of25marks

Students'activitiesforTW/SLunderNCrF:Samplesonly

AsperNationalcreditformwork(NCrF)studentsmust spend90hoursofstudyfor3creditcourses,whichinclude Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. Theevaluationactivities will be done using setof rubrics developed for eachactivity. Thefollowingsample activities arelistedbelow.Thesampleactivitiesaregivenbelow.Thecoursecoordinatorcanalsogivetheirown TW/SL activitiesasperthecourseoutcomes.

Sl.No.	TermWork(TW)Activity	NumberofHours/ Semester
1	Assignments: 1. Euler'sformulationfor differentend conditions (Mod1/CO1)–8h 2. Energy method criticalloadforhinged-hingedcolumn(Mod2/CO2) –8h 3. FEA critical loadfortwo-elementcolumn(Mod3/CO3)–8h	24
2	Seminars**:** 1. Non-conservativeandfollowerforces(Mod2/CO2) –8h 2. Isoparametricplate elementsforstability(Mod3/CO3)–8h 3. Bucklingofplatesundercombinedloads(Mod5/CO5)– 8h	24
3	Micro-Project**:** 1. MATLABprogramforcolumnbucklingwithvariousBCs(Mod1/CO1)– 12h 2. FEAofportalframebuckling(Mod3/CO3) –12h	24

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

Sl.No.	Self-Learning(SL)Activity	NumberofHours/ Semester
1	NPTEL: StructuralStability(IITMadras)	24
2	NPTEL:AdvancedStructuralStability	24
3	FEAsoftwarepractice(ANSYS/ABAQUS)forbuckling	24

SamplerubricsforTWactivities:

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

COMPUTER-AIDEDANALYSISANDDESIGNOFPLATESAND SHELLS			
CourseCode	**1MCAS205D**	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:Analyzeandclassifydifferenttypesofplatesandshells,applyingappropriatetheoretical frameworks and computer-based methods for their bending and structural analysis
2. CO2:Deriveandsolvedifferentialequationsgoverningthebehaviorofrectangularandcircular plates using both classical and computational approaches.
3. CO3:Implementadvancedanalyticalmethodssuchas Navier'ssolutionandLevy'sapproachusing computer tools for plates with complex boundary conditions.
4. CO4:Applyprinciplesofmembraneandbendingactionintheanalysisofshellstructuresusing computer-aided tools.
5. CO5:Conductcomprehensiveanalysesofadvancedshellformsincludinghyperbolicparaboloidsand cylindrical shells using software tools

Module-1

BendingofPlates– ClassicalTheory&Computer-AidedApproach:

- Classificationofplatesandmethods ofanalysis.
- Slopeandcurvatureofslightly bent plates– curvatureandtwistinanyarbitrarydirection.
- Principalcurvatures.Classical thinplatetheory.
- Relationbetweenbendingmomentsandcurvatures,principalbendingmoments.
- Differentialequationforlaterallyloadedrectangularplates.
- Boundaryconditions.Kirchhoffmodificationof boundaryconditionsat afreeedge.
- Rectangularplatessubjectedtoedgemoments.Cylindricalbendingoflongrectangularplates.
- **Computer-AidedApproach:**Introductiontosoftwaretoolsforplateanalysis(MATLAB,Python,orFEA tools). Using computers to solve plate bending equations.

Self-study: Derivethedifferentialequationforbendingoforthotropicplatesandcomparewithisotropiccaseusing a simple computer program.

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

Module-2

SimplySupportedRectangularPlates–ComputerImplementationofNavier's&Levy'sSolutions:

- Subjectedtoharmonicloading.
- Navier'ssolutionforsimply supportedplates subjectedto:
- Uniformlydistributed load(UDL)
- Hydrostaticpressure
- Patchload,partialUDL,and concentratedload

- Bending ofrectangularplatessubjectedtoUDLbyLevy'sapproach:
- Alledgessimplysupported
- Twoopposite edges simplysupportedandtheothertwoedges clamped
- Bendingofrectangularplatessubjectedtouniformly varyingload(UVL):
- Alledgessimplysupported
- Twoopposite edges simplysupportedandtheothertwoedges clamped
- Methodofsuperpositionforcomplexboundaryconditions.
- **Computer-AidedApproach:**WritingsimpleprogramstoimplementNavierandLevysolutions.Visualizing deflection patterns using software.

Self-study: SolvearectangularplateproblemusingNavier'ssolutionforaconcentratedloadatthecenterusing MATLAB or Python.

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

Module-3

SymmetricalBendingofCircularPlates–SimplifiedComputerAnalysis:

- Differentialequationforsymmetricalbendingoflaterallyloadedcircularplates.
- Roundsimplysupportedplatesubjectedto:
- Uniformlydistributedload(UDL)overtheentiresurface
- Centralconcentratedload
- Constantedgemoment
- Roundclampedplate subjectedto:
- UDLovertheentiresurface
- Centralconcentratedload
- Method ofsuperposition.
- Annularplatesubjected toedge momentsandUDL.
- **Computer-AidedApproach:**Usingsoftwaretoautomatecircularplatecalculations.Plottingdeflectionand stress distributions.

Self-study: Derivethedeflectionexpressionforaclampedcircularplateunder UDLandverifyusingasimple computer program.

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

Module-4

AnalysisofShells–Computer-AidedMembraneAnalysis

- Shapes andformsofshells, geometryofquadric surfaces:
- Generalform,standardequation
- Ellipsoid,hyperboloid,ellipticcone
- Ellipticparaboloid,hyperbolicparaboloid,quadriccylinder
- Classificationsofshells:Membraneactionandbendingaction.
- Membraneanalysisof shellsofrevolution: Domesandconicalshells.
- **Computer-AidedApproach:**Usingsoftwaretomodelshellgeometries.Membraneanalysisusing computational tools.

Self-study: Preparareportondifferentshellformsusedinmodernarchitectureandhowsoftwarehelpsintheir analysis.

LinkedCOs: CO4 **NumberofHours:8hrs**

Module-5

AdvancedShellAnalysis–HyperbolicParaboloid&CylindricalShellsUsingSoftware:

- Membraneanalysisofhyperbolicparaboloidshells.
- Membraneanalysisofcylindricalshells.
- Lundgren'sBeamtheory forbendinganalysisofcylindrical shells.

- **Computer-AidedApproach:**UsingFEAsoftware(ANSYS,ABAQUS,oropen-sourcetools)forshellanalysis. Comparing theoretical and computer-generated results.

Self-study: Analyzeareal-worldcylindrical shellroofusingLundgren's BeamtheoryandverifyusingFEAsoftware.

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

SuggestedLearningResources:

Textbooks

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

ReferenceBooks

1. Cook,R.D.etal.–Conceptsand Applications ofFiniteElementAnalysis,Wiley.
2. Zienkiewicz,O.C. –TheFiniteElementMethod,McGraw-Hill.
3. Reddy,J.N.– TheoryandAnalysis ofElasticPlatesandShells,CRCPress.

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
5. OnlinetutorialsforMATLAB/Python/FEAsoftware

Teaching-LearningProcess(InnovativeDeliveryMethods):

The following are sample strategies thateducators may adopt to enhance the effectiveness of the teaching-learning processandfacilitatetheachievementofcourseoutcomes.SuggestedInnovativeDeliveryMethodsmayinclude(but are not limited to):

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- Case-BasedTeaching
- SimulationandVirtualLabs
- PartialDelivery ofcourseby Industryexpert/industrialvisits
- ICT-EnabledTeaching
- Role Play

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)=ContinuousInternalEvaluation CIE [25+25=50 marks]

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

Inaddition,Continuous ComprehensiveAssessment(CCA) shallbeconductedforatotal of25marks

Students'activitiesforTW/SLunderNCrF:Samples only

AsperNationalcreditformwork(NCrF)studentsmust spend90hoursofstudyfor3creditcourses,whichinclude Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. Theevaluationactivities will be done using set of rubrics developed for eachactivity. Thefollowingsampleactivities arelistedbelow.Thesampleactivitiesaregivenbelow.Thecoursecoordinatorcanalsogivetheirown TW/SL activitiesasperthecourseoutcomes.

Sl.No.	**TermWork(TW)Activity**	**NumberofHours/ Semester**
1	Plate Analysis using MATLAB/Python: Write a program to solve rectangular plate bending problems using Navier's solution and plot deflectioncontours.	24
2	CircularPlateAnalysis:Developaspreadsheetorprogramtoanalyze circular plates under various loading conditions.	24
3	FEAModelingofShellStructures:CreateasimpleFEAmodelofa cylindricalshellordomeusingANSYS/ABAQUSandanalyzeitsbehavior.	24
4	ShellStructureCaseStudy:Preparareportonareal-worldshell structure and its computer-aided analysis and design.	24
5	ComparativeStudy:Compareclassicaltheoreticalresultswithcomputer-generated results for a plate or shell problem.	24
SL:SelfLearning,MOOCs,spokentutorials,online educationalresources etc.		
Sl.No.	**Self-Learning(SL)Activity**	**NumberofHours/ Semester**
1	Derivethedifferentialequationforbendingoforthotropicplatesand comparewithisotropiccaseusingasimplecomputerprogram(asper Module-1 self-study).	24
2	SolvearectangularplateproblemusingNavier'ssolutionfora concentratedloadatthecenterusingMATLABorPython(asper Module-2 self-study).	24
3	Derive thedeflectionexpressionforaclamped circularplateunderUDL andverifyusingasimplecomputerprogram(asperModule-3self-study).	24
4	Preparareportondifferentshellformsusedinmodernarchitecture and howsoftwarehelps intheiranalysis(asperModule-4 self-study).	24
5	Analyzeareal-worldcylindricalshell roofusing Lundgren's Beamtheory andverify usingFEAsoftware(asperModule-5 self-study).	24

SamplerubricsforTWactivities:

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

ADVANCEDDESIGNOFSTRUCTURALELEMENTS			
CourseCode	**1MCAS205E**	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:Understandandapplyprinciplesinthedesignofflatslabs,gridfloors,andcontinuousbeams, incorporating moment redistribution techniques.
2. CO2:Analyzeanddesignreinforcedconcretestructures,includingchimneys,silos,andbunkers,in accordance with relevant codes and standards
3. CO3:Evaluatetheimpactof webopeningsonsteelbeamsanddesignlaterallyrestrainedcastellated beams and Vierendeel girders effectively.
4. CO4:Comprehendthecharacteristics,designtechniques,andlocalbucklingeffectsofcold-formed steel sections, including the relevant IS codes.
5. CO5:Assessfireresistancelevelsofsteelstructures,understandingmaterialbehaviorunder temperature effects and methods of fire protection.

Module-1

Design ofGridFloorsandContinuous Beams withMomentRedistribution(withComputer-AidedApproach):

- Introductiontogridfloorsystems,typesofgridfloors,structuralbehaviorandloaddistribution,analysis methods for grid floors, design considerations, reinforcement detailing, and numerical examples.
- Conceptofmomentredistribution,codalprovisionsasperIS456:2000,plastichingeformation,rotation capacity, redistributionlimits, analysisand design ofcontinuous beams, detailing of reinforcement, and numerical examples.
- **Computer-AidedApproach:**UsingExcelspreadsheetsforautomateddesigncalculations.Structuralanalysis software (STAAD Pro/ETABS) for modeling grid floors and continuous beams. Automated moment redistribution calculations using software. Generation of bending moment and shear force diagrams using computer tools.

Self-study: Develop aspreadsheetfordesignofcontinuousbeamswith momentredistribution as perIS456.

LinkedCOs:CO1 **NumberofHours:8hrs**

Module-2

DesignofFlatSlabsandRCSilos(withComputer-Aided Approach)

- Introduction to flat slab systems, advantages and disadvantages, components of flat slabs (drop panels, column capitals), methods of analysis - Direct Design Method and Equivalent Frame Method, design for flexureandshear,punching shear,reinforcementdetailing,andnumericalexamplesasperIS456:2000.
- Introduction to silos and bunkers, types and structural behavior, loads on silos - Janssen's theory, pressure distribution,designofsilowalls,hoppers,andsupportingstructures,reinforcementdetailing,andnumerical examples.
- **Computer-Aided Approach:** Using software (ETABS/SAFE) for flat slab analysis and design. Automated punchingshearverificationusingspreadsheets.Creatingdesigntemplatesforflatslabs.Usingsoftwarefor silo load calculations and structural analysis.

Self-study: Model a flatslabsysteminETABS/SAFEandcompareresults withmanualcalculations

LinkedCOs:CO2 **NumberofHours:8hrs**

Module-3

YieldLine TheoryofSlabsandDesign ofChimneys(withComputer-AidedApproach)

- Introduction to yield line theory, assumptions and limitations, yield line patterns for various boundary conditions,virtualworkmethod,equilibriummethod,analysisofrectangularandcircularslabs,application in design, and numerical examples.
- Introductiontoreinforcedconcretechimneys,typesandstructuralbehavior,loadsonchimneys-windloads, seismic loads, self-weight, temperature effects, analysis and design of chimney shafts, foundation design, reinforcement detailing, and numerical examples as per relevant codes.
- **Computer-AidedApproach:**Usingsoftwareforyieldlineanalysisandvisualization.Spreadsheet-based designtoolsforchimneysconsideringwindandseismicloads.Automatedloadcombinationcalculations. Structural analysis software for chimney modeling.

Self-study: Preparean ExcelsheetfordesignofRCchimneyconsideringwindand seismicloads

LinkedCOs:CO2 **NumberofHours:8hrs**

Module-4

SteelBeamswith WebOpeningsand CastellatedBeams(with Computer-AidedApproach)

- Typesofwebopenings-circular,rectangular,andelongatedopenings.Practicalguidelinesforlocating openings. Force distribution around openings and failure patterns - Vierendeel mechanism, web-post buckling, and flexural failure.
- Behaviourofbeamswithperforatedwebs,stressconcentrationeffects,analysismethodsforthinandthick webs, design considerations, and numerical examples.
- Introductiontocastellatedbeams,manufacturingprocess,advantages,designforgivensectionalproperties, check for various failure modes - flexural, shear, web-post buckling, and Vierendeel mechanism, and numerical examples as per IS 800:2007.
- IntroductiontoVierendeelgirders,structuralbehaviorandloadtransfermechanism,designforgiven analysis results, member sizing, joint design, and numerical examples.
- **Computer-AidedApproach:** Usingsoftware foranalysisof beamswith web openings.Automated design checksforcastellatedbeamsusingspreadsheets.FEAsoftwareforstressanalysisaroundopenings.Design templates for Vierendeel girders.

Self-study: DevelopanExceltoolforcheckingvariousfailuremodesofcastellatedbeamsasperIS 800

LinkedCOs:CO3 **NumberofHours:9hrs**

Module-5

ColdFormedSteelSectionsandFire Resistance(withComputer-AidedApproach)

- Introductiontocoldformed steelsections,manufacturingtechniques,advantagesoverhot-rolledsections, typicalprofiles(C-sections,Z-sections,channels,angles),stiffenedandunstiffenedelements,localbuckling effects,effective sectionproperties,designof beamsand columnsas perIS 801:2010 and IS811:1987, and numerical examples.
- Introductiontofireresistancelevel(FRL),periodofstructuraladequacy,behaviourofsteelatelevated temperatures, limiting steel temperature, protected and unprotected steel members, methods of fire protection- intumescentcoatings, encasement, and fireproofing materials, fire resistance ratings, and numerical examples as per BS 5950 - Part 8.
- **Computer-AidedApproach:**Usingsoftwareforcoldformedsteeldesign.Spreadsheettoolsforcalculating effective section properties. Automated fire resistance calculations. Software for temperature analysis of steel members.

Self-study: Developaspreadsheet for design ofcoldformedsteelsectionsasper IS80.

LinkedCOs:CO4,CO5 **NumberofHours:9hrs**

SuggestedLearningResources:

Textbooks/ReferenceBooks

1. N.Subramanian,"Design ofSteelStructures", Oxford,IBH.

2. Duggal,S.K.DesignofSteelStructures,TataMcGraw-Hill.
3. IS800:2007,IS801-2010,IS811-1987.
4. BS5950Part-8.
5. INSDAGTeaching ResourceChapter11 to20:www.steel-insdag.org.
6. SP 6(5)-1980.
7. KrishnaRaju. N.,"AdvancedReinforcedConcreteDesign",CBSPublishers&Distributors.

WeblinksandVideoLectures(e-Resources):

1. https://www.youtube.com/watch?v=qJV5zdx7NJs&t=10s
2. https://www.youtube.com/watch?v=aLgdv91U2OQ
3. https://www.youtube.com/watch?v=undsd92MM8w&list=PLbQO4xhI7wEDIYv90NoF7veaJIohpuf0Q

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:Samplesonly

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

Sl.No.	TermWork(TW)Activity	NumberofHours/ Semester
1	Computer-AidedDesignofFlatSlab:Modelanddesignaflatslabsystem using ETABS/SAFE software. Prepare a detailed design report.	24
2	Spreadsheet Tool for Continuous Beams: Develop anExcel spreadsheet foranalysisanddesignofcontinuousbeams withmomentredistribution.	24

3	DesignofCastellatedBeamusingSoftware:Designacastellatedbeam using spreadsheets and verify using structural analysis software.	24
4	ColdFormedSteelDesignTool:DevelopanExceltoolfordesignofcold formed steel sections as per IS 801.	24
5	TechnicalSeminar:Conductionoftechnicalseminarsonrecentresearch activities in structural engineering using computer-aided tools.	24
SL:SelfLearning,MOOCs,spokentutorials,online educationalresources etc.		
Sl.No.	**Self-Learning(SL)Activity**	**NumberofHours/ Semester**
1	Developaspreadsheetfordesignofcontinuousbeamswithmoment redistribution as per IS 456 (as per Module-1 self-study).	24
2	ModelaflatslabsysteminETABS/SAFEandcompareresultswith manual calculations (as per Module-2 self-study).	24
3	Prepare anExcelsheetfordesignofRCchimneyconsideringwindand seismicloads(asperModule-3self-study).	24
4	DevelopanExceltoolforcheckingvariousfailure modesofcastellated beamsasperIS800(asperModule-4self-study).	24
5	Developa spreadsheetfor designofcoldformed steel sections asperIS 801(asperModule-5self-study).	24

SamplerubricsforTWactivities:

Criteria	4-Excellent	3-Good	2-Satisfactory	1 - Needs Improvement
Problem understanding	Clear problem framingwithstrong justification.	Mostlyclearwith minorgaps.	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.	Relevantwithmi nor limitations.	Generic recommendations.	Incompleteor unrealistic.
Presentation	Wellorganizedand professional.	Goodorganizatio n with minor issues.	Acceptablebut uneven.	Poorly presented.

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.	Poorlydefined problem.

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

COMPUTATIONALSTRUCTURALMECHANICS			
CourseCode	**1MCSE206E/ 1MCAS206A**	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:Explainthecomputationalbasisofstructuralmechanics,discretization,andnumericalformulationof engineering problems.
2. CO2:Formulateandsolvestructuralproblemsusingstiffnessmethod,finiteelementconcepts,andmatrix operations.
3. CO3:Analyzetrusses,beams,frames,andplanestress/strainsystemsusingappropriatecomputational procedures.
4. CO4:Evaluatetheeffectsofboundaryconditions,materialbehavior,numericalintegration,andmeshquality on solution accuracy.
5. CO5:Usestructuralanalysissoftwareandverificationcheckstointerpretresultsforrealengineering applications.
6. CO6:Applycomputationalmethodstoindustry-orientedproblemsinvolvingdesignvalidation,retrofit,and performance assessment.

Module-1

FundamentalsofComputationalStructuralMechanics:

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

LinkedCOs:CO1,CO2. **Numberof Hours:08.**

Module-2

StiffnessMethodandMatrixFormulation:

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

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

Module-3

FiniteElementMethodforStructuralProblems:

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

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

Module-4

Two-DimensionalStructuralAnalysis:

Planestress,planestrain,axisymmetric modelling,constantstrain triangle, quadraticelements, isoperimetric formulation,numericalintegration,meshgeneration,andstressrecovery.Introductiontoplateandshellidealization, modelling assumptions, and interpretation of contour plots.

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

Module-5

ComputationalPracticeandIndustryApplications:

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

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

SuggestedLearningResources:

Textbooks/ReferenceBooks

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

WeblinksandVideoLectures(e-Resources)

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

Teaching-LearningProcess(InnovativeDeliveryMethods):

Thefollowingaresamplestrategies thateducatorsmayadopt to enhancetheeffectivenessoftheteaching-learning processandfacilitatetheachievementofcourseoutcomes.SuggestedInnovativeDeliveryMethodsmayinclude(butare not limited to):

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- ICT-EnabledTeaching
- Role Play

AssessmentStructure(bothCIEandSEE)

TheweightageassignedtoContinuousInternalEvaluation(CIE)andSemesterEndExamination(SEE)shallbe50% each.Astudent shall securea minimumof50%ofthe maximum marks prescribedforCIE anda minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.

A studentshall bedeemedtohavesatisfiedtheacademicrequirementsandearnedthe creditsallottedtoa

subject/courseonlyifhe/shesecuresnotlessthan50%oftheaggregatemarksobtainedinCIEandSEEtaken together.

ContinuousInternalEvaluation:

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

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

Inaddition,Continuous Comprehensive Assessment(CCA) shallbeconductedforatotal of25marks

Students'activitiesforTW/SLunderNCrF:Samplesonly

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

Sl.No.	TermWork(TW)Activity	NumberofHours/ Semester
1	**StructuralidealizationandDOFmapping**:Studentsidentifyloadpaths, constraints, and degrees of freedom for a given structural system.	24
2	**Truss/frameanalysisbystiffnessmethod:**Studentsmanuallycompute member forces and compare with software output.	24
3	**Software-basedstructuralvalidationexercise:**Studentsanalyzeastructure using software and verify key outputs using hand calculations.	24

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

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	Clearproblem framingwithstrong justification.	Mostlyclearwith minorgaps.	Basicattemptwith limited clarity.	Poorlydefined problem.
Dataandmethod	Appropriatedata and sound methodology.	Mostly appropriatewith minorissues.	Limiteddataor partialmethod.	Inadequateor incorrectmethod.
Analysis	Robust interpretationand	Generallysound with minor	Partialanalysiswith gaps.	Weakorincorrect analysis.

Criteria	4-Excellent	3-Good	2-Satisfactory	1 - Needs Improvement
	validresults.	errors.		
Recommendations	Strong,feasible,and context-specific.	Relevantwithmin or limitations.	Generic recommendations.	Incompleteor unrealistic.
Presentation	Wellorganizedand professional.	Goodorganizatio n with minor issues.	Acceptablebut uneven.	Poorlypresented.

CONSTRUCTIONMATERIALSANDTHEIRPROPERTIES			
CourseCode	**1MCAS206B/ 1MCSE206A**	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:Analyzematerialpropertiesfrom microstructuretomacro-performancefor designandspecification.
2. CO2:Selectandjustifyadvancedmaterialsforperformance,durability,andsustainabilityincivil applications.
3. CO3:Interpretlaboratoryandnon-destructivetest dataandrelatetoservicebehaviour.
4. CO4:Formulatematerialspecification,mix/designproceduresandqualitycontrolforadvancedconcretes and composites.
5. CO5:Assesslife-cycle,environmentalanddurabilityaspectsandproposeremediationormitigation strategies.

Module-1

FundamentalsandMaterialScience:

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

Learningoutcomes:

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

LinkedCOs:CO1 **NumberofHours:8hrs**

Module-2

TraditionalMaterials:CementitiousSystems,Aggregates, Mortars:

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

Learning outcomes:

- Evaluatecementand SCMselectionfortargetedperformanceanddurability.
- Performmix-design reasoningforspecificstrength/durabilitytargetsandinterpretstandardtestresults.

LinkedCOs:CO2 **NumberofHours:8hrs**

Module-3

AdvancedandHigh-Performance Materials:

- High-performanceconcrete(HPC),high-strengthconcrete(HSC),ultra-highperformanceconcrete(UHPC): constituents, fiber reinforcement, and microstructural tailoring.
- Engineeredcementitiouscomposites(ECC),self-consolidatingconcrete(SCC),geopolymerbindersand alkali-activated materials.
- Cementless/low-carbonbinders,carboncapture/utilizationinbinders,and recycle-basedbinders.
- Fiber-reinforcedpolymers(FRP),FRP-concreteinterfaces,polymer-modifiedmortars,andadvanced adhesives/sealants.

Learningoutcomes:

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

LinkedCOs:CO3 **NumberofHours:9hrs**

Module-4

Durability,Degradation,TestingandNon-DestructiveEvaluation:

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

Learningoutcomes:

- Interpretdurabilitytest dataandpredictservicelife usingappropriatemodels orindices.
- Recommendinspection,monitoringandrehabilitationstrategies basedonNDTfindings.

LinkedCOs:CO2 **NumberofHours:9hrs**

Module-5

Sustainability,Life-Cycle,Standardsand Applications:

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

Learningoutcomes:

- ConductabasicLCAcomparisonandrecommendmaterialchoicestolowerenvironmentalfootprint.
- Criticallyassesspractical constraints,standardscompliance, andqualitycontrolforusingadvanced

materialsinprojects.

LinkedCOs:CO5 **NumberofHours:8hrs**

SuggestedLearningResources:

Textbooks

1. Mamlouk, M.S.andZaniewski,J.P.,MaterialsforCivilandConstructionEngineers,4thEdition,Pearson.
2. Soutsos,M.andDomone, P.,ConstructionMaterials:TheirNature and Behaviour,5thEdition, CRCPress.
3. Claisse, P.A.,CivilEngineeringMaterials:FromTheorytoPractice,1stEdition,Elsevier.
4. Duggal,S.K.,BuildingMaterials,3rdEdition,NewAgeInternationalPublishers.
5. Varghese,P.C.,BuildingMaterials,2ndEdition,Prentice-HallofIndia.

ReferenceBooks

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

WeblinksandVideoLectures(e-Resources):

1. Springer:*MaterialsforConstructionandCivilEngineering*— **Springer Cham**.
2. Taylor& Francis /CRCPress:*ConstructionMaterials:Their Nature andBehaviour*—**CRCPress**.
3. Pearson:*MaterialsforCivilandConstructionEngineers*—**Pearson**.
4. VTUsyllabusportal andcivilengineeringsyllabuspages forformatalignment
5. NPTELanduniversitylecture-noterepositoriesforenrichmentandlab support.

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.

Astudentshallbedeemedtohavesatisfiedtheacademicrequirementsandearnedthecreditsallottedtoa 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	Materialpropertycomparisonchartforconventionaland advancedmaterials.	24
2	Mix-designexercise forconventional concrete, SCC, or geopolymerconcrete.	24
3	Labdatainterpretation worksheetonUPV, rebound hammer, chloride ingress, or sorptivity.	24

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

Sl.No.	Self-Learning(SL)Activity	NumberofHours/ Semester
1	Seminarononeadvanced material:UHPC,ECC,FRP,geopolymer, self-healing concrete, or smart concrete.	24
2	Grouppresentationonsustainabilityandlife-cycleassessmentof construction materials.	24
3	Mini-projectonselectionofmaterialsforamarine,bridge, or high-riseapplication.	24

SamplerubricsforTWactivities:

Criteria	Excellent(4)	Good(3)	Satisfactory(2)	NeedsImprovement (1)
Technicalaccuracy	All concepts correct,precise, and complete.	Minor errors, mostlycorrect.	Some gaps in understanding.	Majorconceptual errors.
Analysis andapplication	Deep analysis, strongapplication to civil problems.	Goodapplication withminor gaps.	Limited application.	Poorornoapplication.
Presentation/format	Clear,well-organized,	Mostlyclearand organized.	Acceptablebut inconsistent.	Poorstructureand readability.

Criteria	Excellent(4)	Good(3)	Satisfactory(2)	NeedsImprovement (1)
	professional format.			
Datainterpretation	Correct interpretationof results and trends.	Mostlycorrect interpretation.	Partial interpretation.	Incorrectorabsent interpretation.
Timelinessand completeness	Submitted on time,complete, and neat.	Minor delay or minoromission.	Severalmissing elements.	Lateorincomplete.

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 calcined clay systems. Chemical admixtures,mineraladmixtures,hydrationmodification,anddurabilityenhancement.Alkali-activatedbinders and geopolymer basics, with emphasis on CO2 reduction and service-life improvement

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

Module-2

SpecialConcretesandComposites:

- High-performance concrete, self-compacting concrete, high-strength concrete, lightweight concrete, fiber reinforcedconcrete,ferrocement,ultra-high-performanceconcrete,androllercompactedconcrete.Mixdesign principles, fresh and hardened properties, applications in buildings, bridges, pavements, and precast systems. Introductionto emerging materials such as 3D-printable concrete and multifunctional cementitious composites.

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

Module-3

SustainableAlternativeMaterials:

- Recycledconcreteaggregate,manufacturedsand,industrialby-products,demolitionwasteutilization,andearth-based/low-carbon materials. Agro-waste and mine-waste-based building products, stabilized blocks, and masonry units. Geosynthetics, stabilization additives, and circular construction concepts for resource efficiency 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, and abrasion. Fresh concrete characterization, rheology, workability, and durability assessment. Introduction to QA/QC protocols and correlation of lab tests with field performance

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

Module-5

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*,McGrawHillEducation,**5thEdition**.
3. **P.K.MehtaandP.J.M.Monteiro**,*Concrete:Microstructure,Properties,andMaterials*,McGrawHillEducation,**4th Edition**.
4. **John NewmanandBanSengChoo**,*Advanced ConcreteTechnology*,CRC Press,**1st Edition**.
5. **K.Ramamurthy**,*MaterialsandEngineeringCharacterization*,relevantuniversity-leveledition/printmaybe 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):

Thefollowingaresamplestrategiesthateducatorsmayadopttoenhancetheeffectivenessoftheteaching-learningprocess andfacilitatetheachievementofcourseoutcomes.SuggestedInnovativeDeliveryMethodsmayinclude(butarenotlimited to):

- FlippedClassroom
- Problem-BasedLearning(PBL)
- Case-BasedTeaching
- SimulationandVirtualLabs
- PartialDelivery ofcoursebyIndustryexpert/industrialvisits
- ICT-EnabledTeaching
- Role Play

AssessmentStructure(both CIEand SEE):

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]

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

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.

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. Transformedstiffnessmatrix foroff-axis FRPlamina(Mod3/CO2)–8h 3. Micromechanicalmoduluspredictionforglass/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.	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.

SOFTCOMPUTING TECHNIQUESINSTRUCTURALENGINEERINGLABORATORY			
Course Code	**1MCASL207**	Scheme	2026
Typeofcourse	ProfessionalCoreCourseLab	Semester	II
TeachingHours/Week(L:T:P)	2(0:0:2)	CIEMarks	50
TotalHoursofPedagogyL:T:P:SL:TW	30(0:0:28:2)	SEEMarks	50
Credits	1	TotalMarks	100
TypeofExamination	**Practical**	ExamHours	3

Courseoutcome (CourseSkillSet):

Attheendofthecourse,thestudentwillbeableto:

1. CO1–L3:Developandimplementsoftcomputing-basedcomputationalmodelsforanalysisofstructural elements using MATLAB/Python.
2. CO2–L4:AnalyzeandinterpretstructuralresponseofRCC,steel,slab,beam,column,andcompositeelements using numerical and soft computing tools.
3. CO3–L5:Evaluateandcomparetheperformanceofstructuralmodelsfordifferentloading,boundary,and material conditions.
4. CO4–L5:Applycomputationalmethodsforstructuraldesignoptimizationanddecisionmakinginengineering applications.
5. CO5–L6:Prepareprofessionaltechnicalreportsandvalidateresultsusingsoftwareoutputsandengineering judgement.

Note:

1. ThelaboratorysyllabusconsistsofPART-AandPART-B.WhilePART-Ahas6-8conventionalexperiments, PART-B has 6 typical open-ended experiments. The maximum marks for the laboratory course are 100.
2. BothPART-AandPART-BareconsideredforCIEandSEE.
3. Studentshaveanswer1(one)questionfromPART-A and1(one)questionfromPART-B.
   a. ThequestionssetforSEEshallbefromamongthe experimentsunderPART-A.Itisevaluatedfor**80marks** outofthemaximum100marks.
   b. Theopen-endedquestionsetforSEEshallbeanyotheropen-endedquestionandnotselectedfromthe experiments under PART-A. It shall be evaluated for **20 marks.**

ForContinuousInternalEvaluation(CIE)duringthesemester,classworkshalltypicallyincludeopen-endedquestions from **Part-B**, along with other similar questions designed to enhance the students' skills.

PART–A

FIXEDEXPERIMENTS

1. DevelopmentofaMATLAB/Pythonmodelfor analysis anddesignofRCCbeamandcolumnelements.(CO1)
2. AnalysisofasimplemultistoreyRCCstructureusinganFEApackageand interpretation ofresults.(CO1,CO2)
3. DevelopmentofMATLAB/Pythonmodelsforanalysisanddesignof RCCslabsfordifferentendconditions. (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/Pythontocomputeruleof mixture parameters and engineering constants. (CO2)

PART–B:OPENENDEDEXPERIMENTS

Open-ended experiments are a type of laboratory activity where the outcome is not predetermined and students are giventhefreedomtoexplore,design,andconducttheexperimentbasedontheproblemstatementsaspertheconcepts 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**

Table2Distributionofmarkscorrespondingto PART-B ofthelaboratorycomponent

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.Theevaluatormayalsoassign intermediate scores depending on the quality of work.

(ii) Ifthetotalscoreresultsinafraction,itshouldberoundedofftothenexthigherinteger.

(iii) Thelistedcriteriaareguidelines;evaluatorsmayalsoconsiderotherauthenticdimensions(e.g.,depthofinsight, critical thinking, and practical awareness, recognition of limitations, or justified compromises.

(iv) Toawardthefull10marksinthe excellentcategory,thestudentmustdemonstratereasonablygood performance acrossallsixcriteria; otherwise,proportionallylowermarksmaybegiven.

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SuggestedrubricsforPracticalcontinuousassessment:

Performance Indicators	Excellent	VeryGood	Good	Satisfactory
Fundamental Knowledge (4)(PO1)	The student has well depth knowledge of the topics related to the course (4)	Studenthasgood knowledge of some of the topics related to course (3)	Studentiscapableof narrating the answer but not capable to showin depthknowledge (2)	Student has not understood the conceptsclearly (1)
Design Of Experiment (5)(PO2& PO3)	Student is capable of discussingmorethanone designforhis/herproblem statementandcapableof provingthebestsuitable designwithproperreason (5)	Student is capable ofdiscussingfew designsforhis/her problemstatement butnot capable of selectingbest(4)	Studentiscapableof discussing single designwithitsmerits andde-merits(3)	Studentiscapableof explainingthedesign (1-2)
Implementation(8) (PO3&PO8)	Student is capable of implementing the design with best suitable algorithm consideringoptimalsolution. (7-8)	Studentiscapable of implementing the design with best suitable algorithmand shouldbecapable ofexplainingit(5-6)	Student is capableof implementing the design with proper explanation. (3-4)	Student is capable of implementing the design. (1-2)
Result &Analysis (5)(PO4)	Student is able to run the program on various cases andcompare theresultwith proper analysis. (5)	Student will be able to run the program for all the cases. (4)	Studentwillbeableto run the code for few casesandanalyzethe output (3)	Student will be able to run the program but not able to analyze the output (1-2)
Demonstration(8) (PO9)	Thelabrecordiswell-organized,withclearsections (e.g.,Introduction,Method, Results, Conclusion). Transitionsbetween sectionsaresmooth.(7-8)	Thelabrecordis organized,with clearsections,but somesectionsare notwell-defined.-6)	Thelabrecordlacks clearorganizationor structure. Some sectionsareunclear orincomplete.(3-4)	Thelabrecordis poorlyorganized, with missing or unclearsections.(1-2)