Course Title	**DESIGN OF CONCRETE BRIDGES**	Semester	III
Course Code	MVJ19CSE31	**CIE**	50
Total No. of Contact Hours	60 L: T: P:: 50 : 0 : 10	**SEE**	50
No. of Contact Hours/Week	4	**Total**	100
Credits	4	**Exam Duration**	3Hrs

Course objective is to: This course will enable the students to

- Make students to learn principles of bridge design
- Illustrate the various loads to be considered in bridge design.
- Design different types of bridge structures and to detail them using Limit State method of design.
- Evaluate performance of the Bridge structure.
- Design and understand bridge substructures.

Module-1	**L3**	**12 Hrs**

Introduction: Historical Developments, Site Selection for Bridges, Classification of Bridges, Forces on Bridges. Bridge substructures: Abutments, piers and wing walls. Economic span length-Types of loading-Dead load live load-Impact Effect-Centrifugal force-wind loads-Lateral loads-Longitudinal forces-Seismic loads Frictional resistance of expansion bearings-Secondary Stresses-Temperature Effect-Erection Forces and effects-Width of roadway and footway-General Design Requirements.

Experimental learning:

- To compare the codal provisions of limit state and working stress method.

Applications:

- Knowledge of loads is important in the design of any bridge structure.

Video link:

- https://www.youtube.com/watch?v=RB2k5hSYO3U&list=PL3MO67NH2XxJxMvfgAgdohx5-ksPZruA8

Module-2	**L3, L5**	**12 Hrs**

Box Culvert and Slab Culvert: Different Loading Cases IRC Class AA Tracked, Wheeled and Class A Loading, working out the worst combination of loading, Moment Distribution, Calculation of BM & SF, Structural Design of Slab Culvert, with Reinforcement Details. Specification for culverts as per MORTH Specifications for Road and Bridge Works, IRC Publication.

Experimental learning:

- Analyse and design slab and box culvert using StaadPro/Csi bridges

Applications:

- In designing slab and box culverts as per codes.

Video link:

- https://www.youtube.com/watch?v=RX-WImcb73Y

Module-3	L3, L5	12 Hrs

Analysis and design of T-beam bridge:

Proportioning of components, analysis of slab using IRC Class AA tracked vehicle, structural design of slab, analysis of cross girder for dead load & IRC Class AA tracked vehicle, structural design of cross girder, analysis of main girder using Courbon's method, calculation of dead load BM and SF, calculation of live load B M & S F, Structural design of main girder. Guidelines per MORTH Specifications for Road and Bridge Works, IRC Publication

Experimental learning:

- Analyse and design T Beam bridge using StaadPro / Csi bridges

Applications:

- In designing T beam bridges as per codes.

Video link:

- https://www.youtube.com/watch?v=TDuvNevZwp0&list=PL8gfIRC-iTgkn-LsZf9VQoJtLd4FRhkpz&index=17

Module-4	L3, L5	12 Hrs

PSC Bridges: Introduction to Pre and Post Tensioning, Proportioning of Components, Analysis and Structural Design of Slab, Analysis of Main Girder using COURBON's Method for IRC Class AA tracked vehicle, Calculation of pre-stressing force, cable profile and calculation of stresses, Design of End block and detailing of main girder Guidelines per MORTH Specifications for Road and Bridge Works, IRC Publication

Experimental learning:

- Analyse and design PSC bridge using StaadPro/Csi bridges

Applications:

- In designing PSC slab and PSC T beam bridges as per codes.

Video link:

- https://www.youtube.com/watch?v=e6h8wzM7pBU

Module-5	L3, L5	12 Hrs

Substructures and Balanced Cantilever Bridge:

Substructures - Design of Piers and abutments, Introduction to Bridge bearings, Hinges and Expansion joints. Specification for bearings as per MORTH Specifications for Road and Bridge Works, IRC Publication.

Balanced Cantilever Bridge: Introduction and proportioning of components, Design of simply supported portion and design of cantilever portion, design of articulation

Experimental learning:

- Study the feasibility of different types of bridge bearings.

Applications:

- For designing the substructure of any bridge structure.

Video link:

- https://www.youtube.com/watch?v=7nTdkPV_AAE

Course outcomes: On completion of the course, students would be able to

CO1	Describe historical growth, various forces acting on bridges and select ideal site for bridge.
CO2	Analyse and design box and slab culverts using limit state method of design.
CO3	Analyse and design T-beam bridges using limit state method of design.
CO4	Analyse and design psc slab bridge and T-beam bridge using limit state method of design.
CO5	Design piers and abutments and describe the proportioning of components of a Balanced Cantilever bridge.

Reference Books:

1.	Johnson Victor. D, "Essentials of Bridge Engineering", Oxford Publishing Company, 6th Edition, 2019.
2.	N Krishna Raju, "Design of Bridges, Oxford and IBH publishing company, 5th edition, 2019.
3.	T R Jagadeesh and M A Jayaram, "Design of bridge structures", Prentice Hall of India, 2nd Edition, 2009.

4.	Design of Concrete Bridges by M.G. Aswani, V.N. Vazirani and M.M. Ratwani, 8th Edition, 2014.
5.	IS: 456 – 2000 “Indian Standard Plain and Reinforced Concrete Code of Practice”- (Fourth Revision) BIS New Delhi.
6.	IS :1343 – 2012, “Indian Standard Prestressed Concrete Code of Practice”- BIS New Delhi.
7.	IRC:112-2019, “Code of Practice for Concrete Road Bridges”.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	1	1	1	-	-	2	1	1	1
CO2	3	3	2	2	3	2	1	1	1	1	-	1
CO3	3	3	2	2	3	2	1	1	1	1	-	1
CO4	3	3	2	2	3	2	1	1	1	1	-	1
CO5	3	3	2	2	3	2	1	1	1	1	-	1

High-3, Medium-2, Low-1

Course Title	**DESIGN OF SUBSTRUCTURES**	Semester	III
Course Code	MVJ19CSE321	**CIE**	50
Total No. of Contact Hours	60 L: T: P:: 40 : 0 : 20	**SEE**	50
No. of Contact Hours/week	3	**Total**	100
Credits	3	**Exam. Duration**	3

Course objective is to: This course will enable the students to

- Learn principles of subsoil exploration
- Design the sub structures
- Evaluate the soil shear strength parameters
- Design of deep foundation
- Design of well foundation

Module-1	**L4**	**12Hrs.**

Pre requisites: *Geotechnical Engineering*

Introduction, Site investigation, In-situ testing of soils, Subsoil exploration, Classification of foundations systems. General requirement of foundations, Selection of foundations, Computations of Loads, Design concepts.

Laboratory Sessions/ Experimental learning:

- Basic testing of soil

Applications:

- Practical procedure for extraction of soil sample and laboratory testing

Video link / Additional online information:

- https://nptel.ac.in/courses/105105168/
- https://www.youtube.com/watch?v=f1K-918AxrY

Module-2	**L3,L5**	**12Hrs.**

Concept of soil shear strength parameters, Settlement analysis of footings, Shallow foundations in clay, Shallow foundation in sand & C-Φ soils, Footings on layered soils and sloping ground, Design for Eccentric or Moment Loads.

Laboratory Sessions/ Experimental learning:

- Model making different types of rafts

Applications:

- Design of raft foundation

Video link / Additional online information:

- https://nptel.ac.in/courses/105104162/

Module-3	L3,L4	12Hrs.

Types of rafts, bearing capacity & settlements of raft foundation, Rigid methods, Flexible methods, soil structure interaction, different methods of modeling the soil. Combined footings (rectangular & trapezoidal), strap footings & wall footings, Raft – super structure interaction effects & general concepts of structural design, Basement slabs, Machine foundation.

Laboratory Sessions/ Experimental learning:

- Model making different types of caissons

Applications:

- Calculation of bearing capacity of raft foundation

Video link / Additional online information:

- https://www.youtube.com/watch?v=xytmHFEuUQM

Module-4	L3,L4	12Hrs.

Deep Foundations: Load Transfer in Deep Foundations, Types of Deep Foundations, Ultimate bearing capacity of different types of piles in different soil conditions, Laterally loaded piles, tension piles & batter piles, Pile groups: Bearing capacity, settlement, uplift capacity, load distribution between piles, Proportioning and design concepts of piles.

Laboratory Sessions/ Experimental learning:

- Testing on load distribution between piles in Deep Foundations

Applications:

- Design of deep foundation

Video link / Additional online information:

- https://www.youtube.com/watch?v=SZefeLiaiIE

Module-5	L3,L4	12Hrs.

Types of caissons, Analysis of well foundations, Design principles, Well construction and sinking. Foundations for tower structures: Introduction, Forces on tower foundations, Selection of foundation type, Stability and design considerations, Ring foundations – general concepts

Laboratory Sessions/ Experimental learning:

- Preparing checklist for selection of type of foundation

Applications:

- Design concepts of well foundation

Video link / Additional online information:

- https://www.youtube.com/watch?v=2T9s5i21yCs

Course outcomes: On completion of the course, students would be able to	
CO1	Achieve Knowledge of design and development of problem solving skills.
CO2	Understand the principles of subsoil exploration
CO3	Design and develop analytical skills.
CO4	Identify and evaluate the soil shear strength parameters.
CO5	Understand the concepts of Settlement analysis.

Reference Books:	
1.	J.E. Bowles – "Foundation Analysis and Design"- McGraw-Hill Int. Editions, Fifth Ed., 2nd Edition 1996.
2.	Nainan P Kurian – "Design of Foundation Systems"- Narosa Publishing House, 1st Edition 1992.
3.	Swami Saran – "Analysis & Design of Substructures"- Oxford & IBH Pub. Co. Pvt. Ltd., 2nd Edition 1998.
4.	W.C. Teng – "Foundation Design"- Prentice Hall of India Pvt. Ltd., 3rd Edition 1983.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	-	-	-	-	-	-	1	1	-	1
CO2	2	2	-	1	-	-	-	-	1	1	-	1
CO3	2	2	-	1	-	-	-	-	1	1	-	1
CO4	2	2	1	2	1	-	-	-	1	1	-	1
CO5	2	2	1	2	1	-	-	-	1	1	-	1

High-3, Medium-2, Low-1

Course Title	**REPAIR AND REHABILITATION OF STRUCTURES**	Semester	III
Course Code	MVJ19CSE322	**CIE**	50
Total No. of Contact Hours	60 L : T : P :: 40 : 0 : 20	**SEE**	50
No. of Contact Hours/Week	3	**Total**	100
Credits	3	**Exams Duration**	3Hrs

Course objective is to: This course will enable the students to

- Investigate the cause of deterioration of concrete structures.
- To strategize different repair and rehabilitation of structures.
- To evaluate the performance of the materials for repair

Module-1	**L3, L5**	**12 Hrs**

Prerequisites: *Knowledge in the fundamentals of Advanced Concrete Technology*

General: Introduction, Cause of deterioration of concrete structures, Diagnostic methods & analysis, preliminary investigations,Rapid assessment, Investigation of damage, Evaluation of surface and structural cracks, experimental investigations using NDT, load testing, corrosion mapping, core drilling and other instrumental methods, Quality assurance for concrete construction, as built concrete properties strength, permeability, thermal properties and cracking

Laboratory Sessions/ Experimental learning:

- Investing on Deterioration of Concrete Structures by Chemical tests.
- Experiment on concrete structures by NDT methods.

Applications:

- Deterioration of concrete can be reduced by great extent.
- NDT gives the quality of the concrete structures.

Video link / Additional online information:

- https://nptel.ac.in/noc/courses/noc20/SEM1/noc20-ce26/
- https://nptel.ac.in/content/storage2/nptel_data3/html/mhrd/ict/text/105104030/lec38.pdf

Module-2	**L3, L4, L5**	**12 Hrs**

Prerequisites: *Knowledge in the fundamentals of Advanced Concrete Technology*

Influence on Serviceability and Durability: Effects due to climate, temperature, chemicals, wear

and erosion, Design and construction errors, corrosion mechanism, Effects of cover thickness and cracking, methods of corrosion protection, corrosion inhibitors, corrosion resistant steels, coatings, and cathodic protection.

Laboratory Sessions/ Experimental learning:

- Testing of Concrete due to Environmental impacts.

Applications:

- Behavior of Concrete due to environmental impacts can be understood.
- Metals can be protected against Corrosion.

Video link / Additional online information:

- https://nptel.ac.in/courses/113108051/
- https://www.youtube.com/watch?v=5OxdXq91TV0

Module-3	**L2, L3, L5**	**12 Hrs**

Prerequisites: *Knowledge in the fundamentals of Advanced Concrete Technology*

Maintenance and Repair Strategies: Definitions: Maintenance, repair and rehabilitation, Facets of Maintenance, importance of Maintenance, Preventive measures on various aspects. Inspection, Assessment procedure for evaluating a damaged structure, causes of deterioration, testing techniques.

Laboratory Sessions/ Experimental learning:

- Determining the causes of deterioration the different methods.

Applications:

- Structures can be maintained which fulfills the efficient usage of structure.
- By understanding the causes of deterioration the strength of structure can be increased.
- The Structures can be repaired against deterioration.

Video link / Additional online information:

- https://nptel.ac.in/courses/105/106/105106202/
- https://nptel.ac.in/content/storage2/nptel_data3/html/mhrd/ict/text/105102176/lec54.pdf

Module-4	**L2**	**12 Hrs**

Prerequisites: *Knowledge in the fundamentals of Advanced Concrete Technology*

Materials for Repair: Special concretes and mortars, concrete chemicals, special elements for accelerated strength gain, Expansive cement, polymer concrete, sulphur infiltrated concrete, Ferro cement, Fiber reinforced concrete. Techniques for Repair: Rust eliminators and polymers coating for rebar during repair foamed concrete, mortar and dry pack, vacuum concrete, Gunite and Shot Crete

Epoxy injection, Mortar repair for cracks, shoring and underpinning.

Laboratory Sessions/ Experimental learning:

- Testing of concrete by special elements for accelerated strength gain.
- Manufacturing of Fibre Reinforced Concrete.
- Analysing the strength of concrete by repairing the crack.

Applications:

- Strength of Concrete can be increased by repairing the crack.
- The fibre reinforced concrete can be used for improved strength.
- The rust formation can be eliminated by rust eliminators.
- Concrete repair can be achieved by various methods.

Video link / Additional online information:

- https://nptel.ac.in/content/storage2/nptel_data3/html/mhrd/ict/text/105104030/lec38.pdf
- https://swayam.gov.in/nd1_noc20_ce26/preview

Module-5	**L2,L5**	**12 Hrs**

Prerequisites: *Knowledge in the fundamentals of Advanced Concrete Technology*

Examples of Repair to Structures: Repairs to overcome low member strength, Deflection, Cracking, Chemical disruption, weathering wear, fire, leakage, marine exposure, engineered demolition techniques for dilapidated structures - case studies.

Laboratory Sessions/ Experimental learning:

- Determining the amount of deflection in concrete by external loading.
- Analyzing the concrete for its low member strength due to Cracking.

Applications:

- Increasing the strength of structures can be achieved by repairing the cracks.
- The deterioration of structure against chemical, fire, marine effects can be understood

Video link / Additional online information:

- https://nptel.ac.in/content/storage2/nptel_data3/html/mhrd/ict/text/105104030/lec38.pdf

Course outcomes: On completion of the course, students would be able to

CO1	Achieve knowledge of design and development of problem solving skills.
CO2	Understand the cause of deterioration of concrete structures.
CO3	Design and develop analytical skills.
CO4	Summarize the principles of repair and rehabilitation of structures

CO5	Understands the concept of Serviceability and Durability.

Reference Books:	
1.	Sidney, M. Johnson "Deterioration, Maintenance and Repair of Structures".3rd Edition,2018
2.	Denison Campbell, Allen & Harold Roper, "Concrete Structures – Materials, Maintenance and Repair"- Longman Scientific and Technical 3, 7h Edition,2013
3.	R.T.Allen and S.C. Edwards, "Repair of Concrete Structures"-Blakie and Sons, 9th Edition,2015
4.	Raiker R.N., "Learning for failure from Deficiencies in Design, Construction and Service"-R&D Center (SDCPL0, 5th Edition,2012

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	2	-	-	3	3	-	1	-	1
CO2	1	3	2	2	-	-	3	3	-	1	-	1
CO3	3	2	1	3	-	3	3	-	1	1	2	1
CO4	3	2	-	1	2	3	1	3	2	-	2	1
CO5	3	1	-	2	3	3	2	1	1	-	3	1

High-3, Medium-2, Low-1

Course Title	**THEORY OF PLATES AND SHELLS**	Semester	III
Course Code	MVJ19CSE323	**CIE**	50
Total No. of Contact Hours	60 L : T : P :: 40 : 0 :20	**SEE**	50
No. of Contact Hours/week	3	**Total**	100
Credits	3	**Exam. Duration**	3 Hrs

Course objective is to:

- Make students learn different methods of analysis of plates and shells.
- Make students learn different methods of design of plates and shells.
- Energy methods for different types of plates.
- To critically detail the plates & folded plates.
- To evaluate the performance of spatial structures.

Module-1	**L3**	**12 Hrs.**

Prerequisites: *Knowledge in the fundamentals of Deflections & Bending Theory*

Introduction:

Introduction to plate theory, Small deflection of laterally loaded thin rectangular plates for pure bending. Navier's and Levy's solution for various lateral loading and boundary conditions,Numerical Study of Buckling of Thin Plates.

Laboratory Sessions/ Experimental learning:

- To determine Small-Deflection of Thin Plates
- To make model and check the behaviour of thin plates under bending

Applications:

- Analytical Solutions of Static Rectangular Plate Bending Problems
- Analytical Solutions of Linear-Elastic Plate Problems subjected to lateral loading

Video link :-

- Navier Solution and Levy Solution-https://youtu.be/yNMfqsoSLEw
- Classification of plate theories and some basics-https://youtu.be/WZN8SDXOX5Q

Module-2	**L3**	**12 Hrs.**

Prerequisites: *Knowledge in the fundamentals of Energy Principles*

Energy Methods:

Energy methods for rectangular and circular plates with clamped edges subjected to symmetric loadings.

Laboratory Sessions/ Experimental learning:

- To create drawings of various Types of Circular Plates
- Case Study on Techniques to Improve Energy Solutions

Applications:

- To apply & solve for Energy Methods of Moderately Thick Plates
- To find Analytical solutions for Plates with Edge Moments

Video link:-

- Energy Principles-https://youtu.be/02p5T_WCre0
- Reduced stiffness & Plate Stiffness-https://youtu.be/qaOzuDTQVBU

Module-3	**L3**	**12 Hrs.**

Prerequisites: Knowledge on different shape of shells

General Introduction to Shell Theory:

Introduction to curved surfaces and classification of shells, Membrane theory of spherical shells, cylindrical shells, hyperbolic paraboloids, elliptic paraboloid and conoids

Laboratory Sessions/ Experimental learning:

- To make models of various shell surfaces
- Case Study on membrane theory of different shells

Applications:

- To apply Membrane Theory for Shells of Revolution
- To apply Membrane Theory for Shells of Translation

Video link:-

- Shell Structures -https://youtu.be/-BYC6cNSO78
- Nonlinear Analysis for Solids and Structures-https://youtu.be/EsiGSf2bt9k

Module-4	**L3**	**12 Hrs.**

Prerequisites: Knowledge on fundamentals of Bending theory& Stress Resultants

Bending Theory of Shells:

Axially symmetric bending of shells of revolution, Closed cylindrical shells, Buckling of thin cylindrical shells ,water tanks, spherical shells and Geckler's approximation. Bending theory of

doubly curved

shallow shells.

Laboratory Sessions/ Experimental learning:

- To make drawings of various shell surfaces
- Case Study on methods of analysis of shells

Applications:

- To find solutions to simply supported cylindrical shells.
- To apply Bending Theory in Various forms of shells.

Video link :-

- Bending theory of cylindrical shells- https://youtu.be/ko3i8quXzF4
- Shell Theory Overview-https://youtu.be/HoU63TV7Z28

Module-5	**L4**	**12 Hrs.**

Prerequisites: Knowledge on fundamentals of Bending theory& Stress Resultants

Folded Plates:

Introduction, folded plate behaviour, methods of analysis by Simpson's method, Design and detailing of folded plates with numerical examples.

Laboratory Sessions/ Experimental learning:

- To select dimensions of folded plate for various Problems.
- Case Study on Whitney method of analysis.

Applications:

- To analyze the behaviour of folded plates.
- To design the reinforcement for folded plates.

Video link :-

- Folded Plate Structures-https://youtu.be/CDHbtZKmn4s
- Interlocking Folded Plate-https://youtu.be/uDieRHcG3x8

Course outcomes: On completion of the course, students would be able to

CO1	Achieve Knowledge of design and development of problem solving skills.
CO2	Understand the principles of Analysis and Design
CO3	Design and develop analytical skills.
CO4	Summarize the performance of shells
CO5	Understand the concepts of energy principle

Reference Books:	
1.	Timoshenko, S. and Woinowsky-Krieger, W., "Theory of Plates and Shells" 2nd Edition, McGraw-Hill Co., New York, 2nd edition,1959
2.	R. Szilard, "Theory and analysis of plates - classical and numerical methods", Prentice Hall,3rd Edition,1994
3.	Chatterjee. B. K. – "Theory and Design of Concrete Shell", – Chapman & Hall, New York-3rd edition, 1988
4.	Ramaswamy G.S. – "Design and Constructions of Concrete Shell Roofs" – CBS Publishers and Distributors – New Delhi – 2nd Edition1986.
5.	Ugural, A. C. "Stresses in Plates and Shells", , McGraw-Hill, 2nd edition, 1999.

CO-PO Mapping												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	2	2	3	1	2	2	3	2	
CO2	2	2	2	3	1	2	1	1	3	2	1-	-
CO3	3	3	2	3	1	3	2	2	1	1	2	-
CO4	2	1	2	-	3	2	3	-	2	3	2	1
CO5	3	2	2	1	2	3	2	3	1	2	2	3

High-3, Medium-2, Low-1

Course Title	**FRACTURE MECHANICS APPLIED TO CONCRETE**	Semester	III
Course Code	MVJ19CSE331	**CIE**	50
Total No. of Contact Hours	60 L : T : P :: 40 : 0 : 20	**SEE**	50
No. of Contact Hours/week	3	**Total**	100
Credits	3	**Exam. Duration**	3 Hrs

Course objective is to:

- Learn basic concepts of fracture mechanics.
- Impart knowledge on the mechanisms of failure during static and dynamic loading.
- Understand the failure mechanism of creep rupture.
- Study nonlinear fracture mechanics.

Module-1	**L3**	**12 Hrs.**

Prerequisites: *Knowledge on Concrete Technology*

Fracture mechanism and crack growth: Fundamentals of Fracture Mechanics, Mechanisms of fracture and crack growth

Laboratory Sessions/Experimental learning :

- Identify a crack and state the reasons of its occurrence and its growth mechanism

Applications:

- Fracture analysis on structures

Video link / Additional online information :

- Fracture - https://nptel.ac.in/courses/105/106/105106053/

Module-2	**L3**	**12 Hrs.**

Prerequisites: *Knowledge on Strength of Materials*

Different Fractures and Cracking: Cleavage fracture, ductile fracture, fatigue cracking, Environment assisted cracking, Quasi-brittle materials.

Laboratory Sessions/Experimental learning :

- Do a case study on different types of fracture occurring on buildings (consider any commercial building)

Applications:

- Fracture analysis on structures

Video link / Additional online information:

- Fracture - https://nptel.ac.in/courses/105/106/105106053/

Module-3	**L3, L4**	**12 Hrs.**

Fracture Analysis : Service failure analysis, linear elastic fracture mechanics, Griffith's criteria, stress intensity factors, crack tip plastic zone, Erwin's plastic zone correction, R curves, compliance, J Integral, nonlinear analysis, Review of concrete behaviour in tension and compression, Basic frameworks for modelling of quasibrittle materials.

Laboratory Sessions/Experimental learning :

- A Case study to be carried out by incorporating any of the theories.

Applications:

- Differentiate occurance of failure due to static and dynamic loading

Video link / Additional online information :

- Griffith's criteria - https://nptel.ac.in/courses/113102080/

Module-4	**L3, L4**	**12 Hrs.**

NonLinear Fracture Mechanics : Nonlinear Fracture Mechanics, Discrete crack concept/smeared crack concept, Size effect, Plasticity models for concrete, Associated and non-associated flow, Failure surfaces for quasibrittle materials.

Laboratory Sessions/Experimental learning :

- Design a structure to prevent fatigue and creep

Applications:

- Fracture analysis due to static and dynamic loading

Module-5	**L4, L5**	**12 Hrs.**

Continuum Damage Mechanics :

Concept of CTOD and CMD, Material models, crack models, band models, models based on continuum damage mechanics, Toughness Property of materials Fatigue loads.

Laboratory Sessions/Experimental learning :

- Use any commercially available software to analyze a structure

Applications:

- Non-linear fracture analysis on structures

Course outcomes: On completion of the course, students would be able to

CO1	Identify the behaviour of concrete with tension and compression failure surfaces

CO2	Ability to design the structure to prevent fatigue and creep.
CO3	Ability to define different deformation and related theories.
CO4	Understand the concepts of CTOD and CMD

Reference Books:	
1.	David Broek, Sijthoff & Noordhoff and Alphen aan den Rijn, "Elementary Engineering Fracture Mechanics", Netherlands, 3rd Edition,2015
2.	Rilem Report, "Fracture Mechanics of Concrete Structures – Theory and Applications", Edited by L. Elfgreen, Chapman and Hall,1st Edition, 1989.
3.	Victor, C., Li and Z. P. Bazant, "Fracture Mechanics – Applications to Concrete", ACI SP 118.
4.	Valliappan S., "Continuum Mechanics Fundamentals", Oxford IBH, New Delhi, 2nd Edition,1982.
5.	Venkataraman and Patel, "Structural Mechanics with introduction to Elasticity and Plasticity", McGrawHill, 1990.
6.	Shanes, "Introduction to Solid Mechanics – II Edition, PH, 1989.
7.	T.L. Anderson "Fracture Mechanics: Fundamentals and Applications, CRC Press, Jun 24, 2005
8.	Prashant Kumar "Elements of Fracture Mechanics", Tata McGraw-Hill Education, 2009

CO-PO Mapping												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	2	-	-	3	-	-	3	-	3
CO2	3	3	3	-	-	3	-	3	3	3	2	3
CO3	3	3	2	2	-	-	-	-	3	3	3	3
CO4	3	3	3	2	-	2	3	-	3	3	-	3

High-3, Medium-2, Low-1

Course Title	**DESIGN OF MASONRY STRUCTURES**	Semester	III
Course Code	MVJ19CSE332	**CIE**	50
Total No. of Contact Hours	60 L : T : P :: 40 : 0 : 20	**SEE**	50
No. of Contact Hours/week	3	**Total**	100
Credits	3	**Exam. Duration**	3 Hrs

Course objective is to:

- Learn performance of masonry structures.
- Evaluate the strength and stability of the masonry structures.
- Design the masonry structures for different loading conditions.
- Introduce to various code provisions.
- Design the masonry structures for earthquake resistance.

Module-1	**L3**	**12 Hrs.**

Prerequisites: *Knowledge in the fundamentals of Building materials.*

Introduction, Masonry units, materials and types: History of masonry, Masonry units – Brick- Types of bricks, Tests conducted on bricks. Other masonry units - stone, clay block, concrete block, laterite block, stabilized mud block masonry units Masonry materials – Classification and properties of mortars, selection of mortars. Cracks - Cracks in masonry structures, Type of crack, causes and prevention of crack.

Laboratory Sessions/Experimental learning:

- Testing of individual bricks and concrete blocks and testing of mortar cubes for 7 days.
- Visit to the manufacturing unit.
- Preparation and testing of stabilized mud block units.

Applications:

- Understanding the properties and performance of different masonry units and materials.

Video link / Additional online information : Introduction, materials and properties.

- https://nptel.ac.in/courses/105106197/

Module-2	**L3 & L4**	**12 Hrs.**

Prerequisites: *Knowledge of solid mechanics.*

Strength of Masonry in Compression: Behaviour of Masonry under compression, strength and elastic properties, influence of masonry unit and mortar characteristics, effect of masonry unit height on compressive strength, influence of masonry bonding patterns on strength, prediction of strength

of masonry in Indian context, Failure theories of masonry under Compression. Effects of slenderness and eccentricity, effect of rate of absorption, effect of curing, effect of ageing, workmanship on compressive strength.

Masonry Bond Strength and Masonry in Shear and Flexure:

Bond between masonry unit and mortar, tests for determining flexural and shear bond strengths, factors affecting bond strength, effect of bond strength on compressive strength, orthotropic strength properties of masonry in flexure, shear strength of masonry, test procedures for evaluating flexural and shear strength.

Laboratory Sessions/Experimental learning:

- Casting of masonry wallettes and Prisms of different sizes and bonding arrangements.
- Prism tests to familiarize to the possibility of debonding of the masonry from the mortar.

Applications:

- Understanding of strength and elasticity of masonry under compression.
- Better knowledge on bond strengths between the masonry unit and mortar in flexure and shear.

Video link / Additional online information : Strength and behaviour of masonry.

- https://nptel.ac.in/courses/105106197/

Module-3	**L3, L4 & L5**	**12 Hrs.**

Design of load bearing masonry wall- Permissible stresses:

Prerequisites: *Knowledge in the fundamentals of Building materials and solid mechanics.*

Types of walls, permissible compressive stress, stress reduction and shape modification factors, increase in permissible stresses for eccentric vertical and lateral load, permissible tensile stress and shear stresses. Design Considerations: Effective height of walls and columns, openings in walls, effective length, effective thickness, slenderness ratio, eccentricity, load dispersion, arching action in lintels. Problems on design considerations for solid walls, cavity walls, wall with pillars.

Load considerations and design of masonry subjected to axial loads: Design criteria, design examples of walls under UDL, solid walls, cavity walls, solid wall supported at the ends by cross wall, walls with piers.

Laboratory Sessions/Experimental learning:

- Investigation of different types of walls with different end conditions under the loads to calculate the tensile and shear stresses.

Applications:

- Better understanding of design aspects in accessing the behaviour of types of walls subjected to the axial loads.

Video link / Additional online information : Design of load bearing masonry walls.

- https://nptel.ac.in/courses/105106197/

Module-4	**L3, L4 & L5**	**12 Hrs.**

Prerequisites: *Knowledge in the fundamentals of construction technology.*

Design of walls subjected to concentrated axial loads:

Solid walls, cavity walls, solid wall supported at the ends by cross wall, walls with piers, design of wall with openings. Design of walls subjected to eccentric loads: Design criteria – stress distribution under eccentric loads – problems on eccentrically loaded solid walls, cavity walls, walls with piers.

Design of laterally and transversely loaded walls:

Design criteria, design of solid wall under wind loading, design of shear wall – design of compound walls.

Laboratory Sessions/Experimental learning:

- Model making to understand the structural behavior of masonry walls under eccentric loads.
- Analysis and design of masonry shear wall.
- Case study on design and construction of masonry structures subjected to wind loading.

Applications:

- Understanding of design aspects of solid walls, cavity walls, walls with piers and walls with openings.
- Gaining of knowledge on the structural performance of masonry shear walls and solid walls under wind loading.

Video link / Additional online information : Design of laterally and transversely loaded walls

- https://nptel.ac.in/courses/105106197/

Module-5	**L3, L4 & L5**	**12 Hrs.**

Earthquake resistant masonry buildings:

Behaviour of masonry during earthquakes, concepts and design procedure for earthquake resistant masonry, BIS code provisions. In-filled frames: Types – modes of failures.

Reinforced brick masonry:

Methods of reinforcing masonry, analysis of reinforced masonry under axial, flexural and shear loading.

Laboratory Sessions/Experimental learning:

- Software analysis and design to understand seismic performance of masonry structures along with seismic design aspects.
- Experiencing reinforced masonry construction at site.
- Preparation of complete construction documents (structural calculations, structural plans and structural specifications) for real masonry structures using architectural plans.

Applications:

- Familiarize with the usage of code provisions in structural design of masonry structures.
- Practical outlook on construction of masonry structures.

Video link / Additional online information : Infilled frames

- https://nptel.ac.in/courses/105106197/

Course outcomes: On completion of the course, students would be able to

CO1	Acquire the knowledge and ability to assess various engineering properties of masonry components.
CO2	Understand the principles of design and construction of masonry structures.
CO3	Design and develop analytical skills.
CO4	Summarize the masonry characteristics.
CO5	Evaluate the strength and stability of the masonry structures.

Reference Books:

1.	Henry, A.W., "Structural Masonry", Macmillan Education Ltd., 1990.
2.	K.S. Jagadish, "Structural masonry", I.K. International Publishing House Pvt. Ltd, 2015.
3.	Dayaratnam P, "Brick and Reinforced Brick Structures", Oxford & IBH, 1987.
4.	MJN Priestley and T Paulay (1997) Seismic design and assessment of reinforced concrete and masonry buildings, John Wiley and Sons.
5.	M. L. Gambhir, "Building and Construction Materials", Mc Graw Hill education Pvt. Ltd, 5th edition, 2014.
6.	M Tomazevic (1999) Earthquake-resistant design of masonry buildings, Series on Innovation in Structures and Construction, Vol. 1, Imperial College Press, London, pp. 268.
7.	IS 1905–1987 "Code of practice for structural use of un-reinforced masonry- (3rd revision) BIS, New Delhi.
8.	SP 20 (S&T) – 1991, "Hand book on masonry design and construction (1st revision) BIS, New Delhi.

9.	National Building Code of India 2016 Vol.1, Part 6 Section 4 Structural Design - Masonry

CO-PO Mapping												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	1	1	-	-	-	-	-	1	-	1
CO2	3	3	3	2	-	-	-	-	-	1	-	1
CO3	3	3	1	1	-	-	-	-	-	1	-	1
CO4	3	1	-	-	-	-	-	-	-	-	-	1
CO5	3	2	-	-	-	-	-	-	-	-	-	1

High-3, Medium-2, Low-1

Course Title	**DESIGN OF FORMWORK**	Semester	III
Course Code	MVJ19CSE333	**CIE**	50
Total No. of Contact Hours	60 L : T : P :: 40 : 0 : 20	**SEE**	50
No. of Contact Hours/Week	3	**Total**	100
Credits	3	**Exams Duration**	3Hrs

Course objective is to: This course will enable the students to

- To impart knowledge on common form work and special form works.
- To design form work with different materials for various structural elements.
- To evaluate the performance of the materials for repair

Module-1	**L3**	**12 Hrs**

Formwork and false work – Temporary work systems, construction planning site constraints & Trenchless technology

Video link:

- https://civildigital.com/formwork-construction-types-applications-shuttering/
- https://www.youtube.com/watch?v=I4NDRJy_xKY

Module-2	**L4, L5**	**12 Hrs**

Materials and construction of the common formwork and false work systems; Special, and proprietary forms. Types of supports, Horizontal and Vertical Formwork Supports.

Module-3	**L4, L5**	**12 Hrs**

Concrete pressure on forms. Design of timber and steel forms; Loading and moment of formwork. Concepts, Formwork Systems and Design for Foundations, Walls, Columns Slab and Beams.

Laboratory Sessions :

· Designing of formwork and modelling the scaled model

Module-4	**L5**	**12 Hrs**

Types of beams, decking and column formwork; Design of decking; False work design; Effects of wind load . Formwork Design for Special Structures: Shells, Domes, Folded Plates, Overhead Water Tanks, Tower, Bridges.

Laboratory Sessions :

- Testing of Formwork due to construction load and wind load.

Module-5	**L3,L5**	**12 Hrs**

Foundation and soil on false work design; The use and applications of special forms; Sequence of construction; Safety use of formwork and false work. Flying Formwork: Table Form, Tunnel Form, Slip Form, Formwork for Precast Concrete, Formwork Management Issues – Pre- and Post-Award.

Laboratory Sessions :
· Practical outlook on construction of formwork by field visit (mandatory and marks considered for CIE).

Course outcomes: On completion of the course, students would be able to

CO1	Achieve knowledge of design and development of problem solving skills.
CO2	Understand the cause of wind loads on form work.
CO3	Design and develop analytical skills.
CO4	Able to design ensuring the safety of structure
CO5	Understands the concept of special forms and sequence of Construction.

Reference Books:

1.	Austin, C.K., Formwork for Concrete, Cleaver, Hume Press Ltd., London, 3rdEdition,1996
2.	Michael P. Hurst, Construction Press, London and New York, 4th Edition,2003.
3.	Robert L Peurifoy, and Garold D, "Formwork for Concrete Structures"-5th Edition 2005
4.	Dr Janaradhan jha, S.K Sinha "Modern Practices in formwork for Civil Engineering Construction Works"- 3rd Edition , 2014
5.	Peurify, Formwork for Concrete Structures, McGraw Hill Publication India
6.	Kumar Neeraj Jha, Formwork for Concrete Structures, Tata McGraw Hill Education.
7	IS 14687: 1999, False work for Concrete Structures - Guidelines, BIS

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	1	2	1	2	2	3	2	2	1
CO2	2	2	1	3	1	2	3	1	2	3	2	1
CO3	2		3	2	3	2	-	1	2	3	1	-
CO4	2	3	1	2	1	2	3	1	-	2	1	-
CO5	-	2	-	-	-	1	1	2	1	2	2	3

High-3, Medium-2, Low-1