S. No	New Course code	Name of Course	L-T-P-C	Proposed Level (UG/PG)
1	CE 601	Pavement Engineering	3-0-0-6	PG
2	CE 602	Geosynthetic Engineering	3-0-0-6	PG
3	CE 910	Seminar	0-0-4-4	PG
4	CE 603	3D Concrete Printing Technology	2-0-2-6	PG
5	CE 604	Modern Construction Materials and Techniques	2-0-2-6	PG
6	CE 605	Advanced Soil Mechanics	2-1-0-6	PG
7	CE 606	Vibrations and Structural Dynamics	2-1-0-6	PG
8	CE 607	Advanced Concrete Structures	2-1-0-6	PG

1	**Title of the course** (L-T-P-C)	**Pavement Engineering** **(3-0-0-6)**
2	**Pre-requisite courses(s)**	--
3	**Course content**	• Materials used for construction of subgrade, aggregate base course, bituminous base, and surface course of pavements. • Understanding different tests: CBR, Durability, Freeze-Thaw, Rasilient Modulus, Soil-suction, relationship between DCP and CBP, CBP and Mr, and other parameters. • Introduction to bitumen production and process, penetration, and viscosity grading system for bitumen. Modification of bitumen using polymer and crumb rubber. Visco-elastic system. Understanding mixing and Compaction temperature of bitumen. • Introduction to different type of mixes: Hot mix asphalt, cold mix asphalt. Understanding volumetric calculation. Marshall and Superpave mix design of different types of mixes. Performance tests: fatigue and rutting tests, moisture induced damage and test, resilient modulus, dynamic modulus/flow number/flow time. • Recycling, foam mix asphalt, recycle technologies, and warm mix asphalt, construction of perpetual pavements. Cement concrete mix design for pavements. • Introduction to flexible pavements and design factors, Stress, and strain analysis of flexible pavement. Introduction to multilayers elastic theory. Analysis of pavements. Using software such as IITPAVE and KENPAVE • Stress and Stain (Deflection) analysis of rigid pavements. Analysis of pavement using software such as IITRIGID and KENLAYER, and others. • Design of flexible pavement as per IRC 37 method for stabilized and un-stabilized base and subgrade layers • Introduction to different types of overlays on flexible and rigid pavements and their design philosophy. • Pavement performance evaluation and distresses. Different types of rehabilitation and maintenance strategies. • Construction practices for building flexible and rigid pavement.
4	**Texts/References**	• F. L. Roberts, P.S. Kandhal, E.R. Brown, D.Y. Lee, and T.W. Kennedy “Hot Mix Asphalt Materials, Mixture Design and Construction,” National Asphalt Pavement Association Research and Education Foundation, Second Edition, 1996, USA. • Y.H. Huang “ Pavement Analysis and Design,” 2nd Edition, 2004, Pearson Prentice Hall, USA • Asphalt Institute, SP-1: Performance Grading of Asphalt Binder Specification and Testing. • N. Delatte “ Concrete Pavement Design, Construction, and Performance” Taylor and Francis • MORT&H- Specifications for Roads and Bridges, 5th Revision, 2013. • IRC: 37-2012. “ Tentative Guidelines for the Design of Flexible Pavements, “ Indian Road Congress, Delhi. • IRC: 58-2011. “ Tentative Guidelines for the design of Rigid pavements,” Indian Road Congress, Delhi.

1	**Title of the course** (L-T-P-C)	**Geosynthetic Engineering** **(3-0-0-6)**
2	**Pre-requisite courses(s)**	--
3	**Course content**	• Introduction: Principles of reinforced soil through Mohr circle analysis; an overview of the development and applications of various geosynthetic- the geotextiles, geogrids, geonets, geomembranes, and recomposites; Testing methods for geosynthetics-Techniques for testing of different index properties, strength properties, Apparent opening Size, In-Plane, and cross-plane permeability tests, assessment of construction induced damage, extrapolation of long term strength properties from short term tests. • Reinforced soil retaining walls and slops: Different types of wall like wrap-around walls, full-height panel walls, discrete-facing panel walls, and modular block wall Design methods as per BS-8006 and FHWA methods bi-linear wedge method, and circular slip methods • Geosynthetics applications in foundations, landfills, drainage, and filtration: Binquet and Lee's approach for analysis of foundations with reinforcement layers: Different components of modern landfills, collection techniques for leachate, application of different geosynthetic like geonets, geotextiles for drainage in landfills, use of geomembranes and Geosynthetic Clay Liner (GCL) as barriers; Filtration in different type of soil and criteria for selection of geotextiles • Geosynthetic application in Transportation Engineering: Geosynthetics for separation and reinforcement in flexible pavements, design by Giroud Noiray approach, reflection cracking, and control using geosynthetics; Use of geosynthetic for railway Tracks.
4	**Texts/References**	• R. M. koener, "Designing with geosynthetic", 6th Edition (Vols 1 and 2) Xlibris., 2012. • R. A. Jewell, "Soil Reinforcement with Geotextiles", Special Publication No. 123, CIRIA, Thoms Telford. Landon, UK, 1996. • G. L. Sivakumar Babu, "An Introduction to soil reinforcement and Geosynthetics", University Press, 2005. • G.V. Rao. And G. V. S. S. Raju, "Engineering with Geosynthetics", McGraw Hill Education India Pvt Ltd., 1998. • S.K. Shukla, " An Introduction to Geosynthetic Engineering", CRC Press, UK, 2016. • K. Rajagopal, "Geosynthetics and Reinforced Soil Structure " NPTEL Video Course, MHRD, Govt. India 2013.

1	**Title of the course** (L-T-P-C)	**3D Concrete Printing Technology**
2	**Pre-requisite courses(s)**	CE 201 Building and Construction Materials CE203 Building Planning and Drawing CE 205 Structural Analysis CE 302 Design of Concrete Structures CE 307 Instrumentation in Civil Engineering
3	**Course content**	**UNIT – I: Introduction to 3D Concrete Printing** History and evolution of 3D concrete printing, types of 3D concrete printers and their capabilities, various 3D printing technologies, advantages, and challenges of 3D concrete printing, and problems facing in the construction industry. **UNIT – II: Material Sciences, Process, and Sustainability** Materials properties, materials characterization, concrete mix design for 3D printing, fibre reinforcement and additives, sustainable materials for 3D printing. Components of 3D concrete printing system, on-site printing vs. Factory printing. On-site mixing systems; delivering print materials to the site. Economic Breakdown and life cycle assessment of to achieve sustainability. **UNIT – III: Structural Design and Analysis** Design considerations for 3D printed structures, mechanical properties, engineering properties of 3D printed concrete, durability aspects of 3D printed concrete, finite element analysis (FEA) for 3D printed elements. Case studies on 3D printed buildings. **UNIT – IV: Automation and Robotics** Robotics systems in 3D concrete printing; sensors and feedback control, programming, and scripting for automation; Building Information Modelling (BIM) for sustainable design of 3D concrete printing. 5D modelling of 3D printing concrete structure. Technology prospectives and insights. **UNIT – V: 3D Subtractive Manufacturing in Construction** Concept of 3D subtractive manufacturing and its integration with 3D concrete printing, Potential applications, and benefits of combining additive and subtractive processes in construction, designing and manufacturing components using integrated technologies. **Practice Sessions:** • Operating 3D concrete printers • Designing and 3D printing small-scale projects • Troubleshooting and maintenance
4	**Texts/References**	**1.** Sanjayan, J. G., Nazari, A., & Nematollahi, B. (2019) D concrete printing technology: construction and building applications. Butterworth-Heinemann. **2.** Miryousefi Ata, Sara; Kazemian, Ali; Jafari, Amirhosein (March 7, 2022). "Application of Concrete 3D Printing for Bridge Construction: Current Challenges and Future Directions". Construction Research Congress 2022. American Society of Civil Engineers. pp. 869–879. **3.** Mohammad, Malek; Masad, Eyad; Al-Ghamdi, Sami G. (December 17, 2020). "3D Concrete Printing Sustainability: A Comparative Life Cycle Assessment of Four Construction Method Scenarios". Buildings. 10 (12): 245. doi:10.3390/buildings10120245. **4.** Varun Sharma; P.M. Pandey (November 16, 2022), “Additive and Subtractive Manufacturing Processes: Principles and Applications”, CRC Press.

1	**Title of the course** (L-T-P-C)	**Modern Construction Materials and Techniques**
2	**Pre-requisite courses(s)**	CE201 Building and Construction Materials CE 205 Structural Analysis
3	**Course content**	**UNIT – I: Introduction to Modern Construction Materials and Techniques** Overview of the construction industry; Trends in construction materials and techniques and sustainability and resilience in construction. **UNIT – II: Admixtures and Special Concretes** Cement chemistry and concrete performance overview; chemical admixtures: water reducers, set controllers. Mineral Admixtures: fly ash, LC^3; GGBS and other industrial by-products. High strength concrete, high performance concrete, self-compacting concrete, self-healing concrete, light weight concrete and mass concrete, high density concrete and concrete for 3D printing. Nanotechnology in concrete. **UNIT – III: Sustainable Building and Composite Materials** Green building materials and their properties; Energy-efficient materials and technologies; Life cycle assessment and environmental impact. Life cycle assessment and environmental impact, Fibre-reinforced composites, and use of composites in structural applications. **UNIT – IV: Emerging Building Systems and Techniques** Prefabrication and modular construction, 3D printing in construction; Smart buildings and IoT applications. Building with renewable materials (wood, bamboo), Passive design and energy-efficient construction; Case studies on sustainable construction projects. Case studies on resilience in construction.
4	**Texts/References**	**1.** Mehta, P. K., and Monteiro, P. J. M., Concrete: Microstructure, Properties, and Materials, Fourth Edition (Indian Edition), McGraw Hill, 2014. **2**. Neville, A. M., Properties of Concrete, Pitman Publishing, Inc., MA, 1981. **3**. J. Newman and B. S. Choo, Eds., Advanced Concrete Technology, Four Volume Set, Elsevier, 2003. **4.** Council, E., & Faculties, E. Modern Building Materials, Structures and Techniques. **5**. ENGINEERS, C. Modern Building Materials, Structures and Techniques. **6**. Watts, A. (2019). *Modern Construction Case Studies: Emerging Innovation in Building Techniques*. Birkhäuser. 7. Academic Papers

1	**Title of the course** (L-T-P-C)	**Advanced Soil mechanics**
2	**Pre-requisite courses(s)**	Geotechnical Engineering
3	**Course content**	**Module 1 (Introduction)**: Soil Composition, Index Properties, Soil Classification, Soil Structure **Module 2 (Shear Strength of Soils):** Mohr-Coulomb Failure Theory, Response of Soils to Shearing Force, Drained and Undrained Strength, Laboratory and Field Tests, Factors Affecting Shear Strength, Useful Correlations. **Module 3 (Theory of Elasticity):** Stress-Strain Relationship for various loading conditions, Elastic Stress Analysis, Introduction to Computer Program SIGMAW. **Module 4 (Theory of Plasticity and Models for Soils):** Elements of Plasticity, Yield Criteria, Post-yield Behavior, Elastic-Perfectly Plastic Model, Hardening Plasticity Based Model. Introduction to computer program PLAXIS **Module 5 (Slope Instability):** Introduction, Infinite Slope, Finite Slope, Stability analyses: General, Ordinary & Bishop's Methods of slices, Spencer & Janbu Metods of Slope Stability Analysis, Application of software: SLOPE/W, Wedge Method, Stability Charts
4	**Texts/References**	**Textbooks/ Reference Books:** **1**. Das, B.M., Advanced Soil Mechanics (5th edition), CRC Press, Taylor and Francis Group, 2020 **2**. Budhu, M., Soil Mechanics and Foundation (3rd edition), John Wiley & Sons Inc, 2011 **3**. A.P.S. Selvadurai, Plasticity & Geomechanics, Cambridge University Press, 2002 **4**. Jean-Louis Briaud. Geotechnical Engineering: Unsaturated and Saturated Soils (1st Edition). Wiley, 2013. **5**. Renato Lancellotta. Geotechnical Engineering (2nd Edition), CRC Press, 2009.

1	**Title of the course** (L-T-P-C)	**Vibration and Structural Dynamics**
2	**Pre-requisite courses(s)**	-
3	**Course content**	**Module 1 (Introduction)**: • **Basics of Structural Dynamics** Introduction of Structural Dynamics Equation of Motion Types of Analysis/Static and Dynamic load Degrees of Freedom . (Ex: Generation of Stiffness matrix) Dynamic Equilibrium Equation Solution of Equilibrium Equation • **Free Vibration of SDOF** Undamped free Vibration Solution, Natural Period/Frequency Energy in Free Vibration Damped Free Vibration Types of damping Logarithmic decrement equation **Module 2** • **Forced Vibration of SDOF** Undamped Forced vibration Amplitude & Phase Angle Dynamic amplification factor for deflection (Rd) Damped Forced vibration Relationship between Rd, Rv and Ra • **Force Transmission, Vibration Measurement** Resonant frequency and Half power band width Force Transmission and Isolation Design of Vibration Measuring Instruments **Module** • **Response to Arbitrary Motions** Response to Unit Impulse Response to Arbitrary Force (Duhamel's Integral) Response to Step and Ramp Forces Response to Rectangular Pulse, Half Sinusoidal wave • **Numerical Methods of Solution** Time Stepping Methods Central Difference Method Newmark's Method **Module 4 Response Spectrum** Concept of Response Spectrum Uses of Response Spectrum Special Cases in Spectrum Development of Tripartite Plot Example: Base Shear and Base Moment Response of Structure in Frequency Domain • **Multi-Degree of Freedom Systems** Equation of Motion for MDOF System Solution of Equation, Natural Frequencies, and mode Shapes Modal Orthogonality Approximate Method for finding Natural frequency **Module 5 Earthquake Response of MDOF Systems** Time History Analysis Response Spectrum Analysis 3D Dynamic Analysis • **Dynamic Response of Continuous Systems** Vibration of Continuous systems Shear behavior and bending behavior Generalized SDOF • **Dynamics of Rigid Blocks** Dynamics of Rigid Blocks Non Structural Elements Floor Response Spectrum

		• **Vibration Control** Introduction to Vibration Control Active Control Passive Control Design of Tuned Mass Damper
4	**Texts/References**	**Textbooks:** • Anil K. Chopra, Dynamics of structures, 3rd Edition, 2007, Pearson. • R. W. Clough, Joseph Penzien, Dynamics of structures, 1st Edition, 1975, McGraw-Hill. • W. T. Thompson, M.D.Dahleh, C. Padmanbhan ,Theory of Vibrations, 5th Ed.,2008, Pearson Education. **Reference Books:** • Leonard Meirovitch, Elements of Vibration Analysis, 1st Edition,1986 ,McGraw-Hill

1	**Title of the course** (L-T-P-C)	**Advanced Concrete Structure**
2	**Pre-requisite courses(s)**	
3	**Course content**	**Introduction:** History of Reinforced Concrete (RC), advantages of RC, load paths, introductions to different structural systems used in modern concrete construction **Materials:**Stress-Strain Behaviour of concrete and steel under Compression and Tension, Behaviour of concrete under multi-axial stress, High strength concrete, lightweight concrete, Failure theories for concrete under Combined stress state, Tension-stiffening of Concrete, Effects of creep, shrinkage and temperature on material and structural behaviour **Durability Aspects in Reinforced Concrete Design:**Deterioration mechanisms of concrete, Alkali silica reaction, Sulphate attack, corrosion of steel, durability considerations in concrete mix design, methods to check loss of durability in concrete. Cover to reinforcement, Cracking and spalling of concrete, Periodic maintenance and its cost, Breakdown of concrete due to Freezing and thawing effect. **Behaviour under Pure Axial Loads:** Basic Laws of Mechanics, Load displacement behaviour of RC members under pure axial compression and tension, Role of concrete and steel in compression and tension; differences in Behaviour of high strength and normal strength concrete **Behaviour and Design under Flexure:** Analysis at ultimate; Moment-curvature and load-deflection relationships, Effect of reinforcement ratios and concrete strength on moment-curvature Behaviour; Flexural design aspects using IS Code **Analysis and Design for Shear:** Relationship between flexure and shear, Effect of shear span to depth ratio, Definition of nominal shear, critical sections for shear, concept of Mohr circle; different failure modes in shear; Internal resisting mechanisms under shear **Analysis and Design for Torsion:** Behaviour of reinforced concrete members subjected to Torsion, Design methods of Torsion, Difference between equilibrium and compatibility torsion; concepts behind the derivation of code equations; concept of equivalent shear and bending; design examples, Design for combined loading (Torsion + Bending + Shear) **Columns:** Concept of effective length; short columns vs slender column, Effect of confinement, Derivation of axial compression and bending interaction curves, Design of slender columns; Design for biaxial bending **Serviceability Checks:** Difference between short-term and long-term deflections; estimation of deflections, estimation of crack widths and shrinkage cracks, vibrations and fatigue **Analysis and Design of Two-way Slabs:** Difference between one way and two-way slabs; limitations of code coefficient method; direct design method; equivalent frame method; Yield line analysis of slabs, Design of two-way slabs with a commercial package and comparing results from direct Design and equivalent frame methods **Special Topics:** Design of Shear Walls, Design of Curved beams, Moment redistribution in continuous beams; bond and development length, curtailment of reinforcing steel Introduction to Strut and Tie Method; Design of Deep beams and corbels, Design of Footings: isolated and combined footings; Beam-column joints.

4	**Texts/References**	**Textbooks:** • S. Unnikrishna Pillai and Devdas Menon, Reinforced Concrete Design, 3rd Edition, 2009, Tata Mcgraw Hill • J. Wight and J.G. MacGregor, Reinforced Concrete - Mechanics & Design, 6th Edition,2011, Prentice-Hall. • A Nilson, D Darwin, C Dolan Design of Concrete Structures, 14 edition, 2009, McGraw-Hill Education. **Reference Books:** • N.SUBRAMANIAN ,Design of RCC Structures,2013,1st Ed., Oxford University Press **Codes and Standards:** **1. IS 456: 2000** — Plain and reinforced concrete – Code of practice (fourth revision) **2. SP 16: 1980** — Design Aids (for Reinforced Concrete) to IS 456: 1978. **3. IS 875 (Parts 1-5): 1987** — Code of practice for design loads (other than earthquake) for buildings and structures (second revision) **4. SP 24: 1983** — Explanatory Handbook on IS 456: 1978 **5. SP 34: 1987** — Handbook on Concrete Reinforcement and Detailing.