List of Course Work Subjects for Ph. D.

Sl No.	Course Code	Course Title	L		T		P		Cr
1.	GTE 7051	Scaled Boundary Finite Element Method	3	-	1	-	0	:	4
2.	GTE 7052	Applications of Finite Elements:	1	-	0	-	6	:	4
3.	CE 7051	Water Resources Systems	3	-	1	-	0	:	4
4.	CE 7052	Hydraulics of Open Channels	3	-	1	-	0	:	4
5.	CE 7053	Stochastic Hydrology	3	-	1	-	0	:	4
6.	CE 7054	Groundwater Flow and Contaminant Transport Modelling	3	-	1	-	0	:	4
7.	CE 7055	Sediment Transportation	3	-	1	-	0	:	4
8.	CE 7056	Geographical Information Systems (GIS)	3	-	1	-	0	:	4
9.	CE 7057	Matrix Method of Structural Analysis (Computational Structural Mechanics)	3	-	1	-	0	:	4
10.	CE 7058	Advance Mechanics of Solids	3	-	1	-	0	:	4
11.	CE 7059	Bridge Engineering	3	-	1	-	0	:	4
12.	CE 7060	Prestressed Concrete	3	-	1	-	0	:	4
13.	CE 7061	Advanced RCC Design and Construction Techniques	3	-	1	-	0	:	4
14.	CE 7062	Traffic Engineering	3	-	1	-	0	:	4
15.	CE 7063	Traffic Flow Modeling and Simulation	3	-	1	-	0	:	4
16.	CE 7064	Urban Transportation Systems Planning	3	-	1	-	0	:	4
17.	CE 7065	Geopolymer Concrete	3	-	1	-	0	:	4
18.	CE 7066	Durability of Concrete	3	-	1	-	0	:	4

Course Code: GTE 7051
Course Title: Scaled Boundary Finite Element Method
LTP: 3-1-0=4 Cr.

Course Content:

Units	Topic	Lectures/Practice

		Sessions
Unit-I	Introduction, Concept of Scaled Boundary (SB) Transformation, Scaled Boundary Finite Element Method: Advantages over other methods: Finite Element and Boundary Element Methods, Major Application Areas	6
Unit II	SB Transformation based Derivation: SB Transformation, Governing equations in Scaled Boundary Coordinates, Method of Weighted Residual, SBFE equations in Displacement and Stiffness Dynamic Stiffness Matrix,	12
Unit -III	Solution Procedures for SBFE equation: Illustration with Single line Element, Solutions in Statics, Mass of Bounded Medium, High frequency Asymptotic expansion of Dynamic Stiffness of Unbounded medium, Numerical solution.	12
Unit-IV	Solution in Time Domain: Continued Fraction Technique for Bounded and Unbounded Domain	12

Books / references:

1. Wolf, J. P. and Song, C. (1996). *Finite-Element Modelling of Unbounded Media.* John Wiley & Sons Ltd, England.
2. Wolf, J. P. (2003). *The Scaled Boundary Finite Element Method.* John Wiley & Sons Ltd, England.
3. Lehmann, L. (2007). *Wave Propagation in Infinite Domains. With Applications to Structure Interaction.*(https://link.springer.com/content/pdf/10.1007%2F3-540-71109-0.pdf)
4. Mohasseb, S. (2015) The Scaled Boundary Finite Element Method – Introduction
5. (https://www.ethz.ch/content/dam/ethz/special-interest/baug/ibk/structural-mechanics-dam/education/femII/SBFEM1.pdf)
6. Mohasseb, S. (2015) The Scaled Boundary Finite Element Method – Theory
7. (https://www.ethz.ch/content/dam/ethz/special-interest/baug/ibk/structural-mechanics-dam/education/femII/SBFEM2.pdf)

Course Code: GTE 7052
Course Title: Applications of Finite Elements:
LTP: 1-0-6=4 Cr.

Course Content:

Units	Topic	Lectures/Practice Sessions

Unit-I	Programming Finite Element Method: Overall Program Structure of FE Frame-works, Object Oriented Frameworks	2
Unit-II	Element Stiffness Matrices for common 1-D, 2-D and 3D elements, Plane-strain, Plane-stress, Axisymmetric and Isoparametric Elements	12
Unit-III	Methods of Handling Material/Geometric/Contact Nonlinearity, Solution Techniques, Common Convergence issues related to meshing and solution methods.	12
Unit-IV	Civil Engineering Applications of FE Codes like ABAQUS, ANSYS, OpenSees, Code-Aster/Salome-Meca etc. Structural, Geotechnical/ Fluid-Mechanics and other Problems. (Any one/combination thereof)	24

Books / References:

1. Kwon, Y. W. and Bang, H. (2011), The Finite Element Method using MATLAB, CRC Press
2. ANSYS tutorials (https://sites.ualberta.ca/~wmoussa/AnsysTutorial/)
3. ABAQUS tutorials (http://www.abaquspython.com/videos.html)
4. Wiki pages for OpenSees (https://opensees.berekeley.edu)
5. OpenSees Example Manual (http://opensees.berkeley.edu/wiki/index.php/Examples)
6. Aubry, J. P. (2013), Beginning with Code-Aster, A Practical Introduction to FEM using Code-Aster, Gmsh and Salome, Frama Book.
7. (https://framabook.org/docs/Code_Aster/beginning_with_Code_Aster_JPAubry_20131206.pdf)
8. Relevant You-Tube and other online Resources

Course Code: CE 7051
Course Title: Water Resources Systems
LTP: 3-1-0=4 Cr.

Course Content:

Units	Topic	Lectures

Unit I	Systems concepts and system analysis, System techniques in water resources	6 lectures
Unit II	Economic consideration in water resources systems	5 lectures
Unit III	Application of system analysis in irrigation, flood control, hydropower generation, water supply and drainage, Storage-yield analysis, Rule curves, Reservoir sizing,	14 lectures
Unit IV	Multireservoir systems, Real time operation, Systems reliability	10 lectures
Unit V	Recent modelling tools and Case studies	8 lectures

Books :

1. Water Resources Systems: Modelling Techniques and Analysis, S. Vedula and P. P. Majumdar, McGraw Hill Publishing Company, New Delhi, 2005.

2. Water Resources Systems:Planning and Analysis, D. P. Loucks, J. R. Stedinger, D. A. Haith, Prentice Hall Inc., NJ, 1981

Course Code: CE 7052
Course Title: Hydraulics of Open Channels
LTP: 3-1-0=4 Cr.

Course Content:

Units	Topic	Lecture

Unit I	Open channel flow and its classification: Description and types. Energy and momentum equation for prismatic and non-prismatic open channel sections, Critical flow, its computation and application, and depth in channels	8 lectures
Unit II	Uniform flow: Its computation and application, other uniform flow formulae, conveyance of a channel section, section factor and hydraulic exponent.	8 lectures
Unit III	Gradually varied flow: Basic assumptions, dynamic equation of gradually varied flow, flow profiles, method of singular point and transitional depth. Computation, analytical and graphical methods. Channel transitions in sub-critical and super-critical flow.	10 lectures
Unit IV	Spatially varied flow : Basic principles and assumption, dynamic equation for spatially varied flow, analysis of flow profile, methods of numerical integration and the isoclinal method	10 lectures
Unit V	Rapidly varied flow: Characteristics of the flow, hydraulic jump and jump as an energy dissipater, flow in channels of non-linear alignment, discharge measurement techniques in open channels.	10 lectures

Books:

1. Open Channel Hydraulics, V. T. Chow, McGraw Hill Book Co., Inc., New York
2. Open Channel Flow, F. M, Henderson, The MacMillan Co. Inc., New York.

Course Code: CE 7053
Course Title: Stochastic Hydrology
LTP: 3-1-0=4 Cr.

Course Content:

Units	Topic	Lecture

Unit I	Probability concepts and advance distribution, Stochastic processes	8 lectures
Unit II	Regression and correlation, Autoregressive and moving average processes	10 lectures
Unit III	Sequential generation of data, Generation of stochastic fields, Markovian process, Dis-aggregation, Intervention analysis	10 lectures
Unit IV	Time series analysis and modeling	8 lectures
Unit V	Stochastic models, Spatial and temporal modeling of hydrological variables, Risk analysis in hydrology.	8 lectures

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Books :

1. Stochastic Subsurface Hydrology, L. W. Gelhar, Prentice Hall, N. J., 1993.
2. Stochastic Hydrology, Reddy, P. J., Laxmi Publication, New Delhi, 1997.

Course Code: CE 7054
Course Title: Groundwater Flow and Contaminant Transport Modelling
LTP: 3-1-0=4 Cr

Course Content:

Units	Topic	Lecture
Unit I	Groundwater contamination, Sources and causes of groundwater contamination	5 lectures
Unit II	Contaminant transport process, advection and hydrodynamics dispersion, advection- dispersion equation, Biodegradation, Radioactive decay, Reactive processes, Multiphase contamination, NAPLs, VOCs, Site specific groundwater quality problems in Indian context	8 lectures
Unit III	Numerical models, Finite difference method (FDM), Finite element method (FEM) Numerical modeling of steady and transient flows in saturated and unsaturated domain, Contaminant transport modeling	8 lectures
Unit IV	Application of FEM and FDM in groundwater modeling, Regional aquifer simulation, Contaminated groundwater systems and their remediation	10 lectures
Unit V	Development and optimization based management of aquifer systems, Stochastic models, Random field concepts in groundwater models	7 lectures
Unit VI	Groundwater remediation, pump and treat. Bioremediation, phytoremediation processes.	8 lectures

Books :

1. Numerical Groundwater Modelling, A, K. Rastogi, Penram International Publishing, Mumbai, 2007.

2. Introduction to Groundwater Modelling, H. F. Wang and M. P. Anderson, W. H. Freeman and Company, New Yor, 1982.

3. Ground Water Contamination: Transport and Remediation, P. B. Bedient, H. S. Rifai and C. J. Newell, Prentice Hall, NJ, 1999.

Course Code: CE 7055
Course Title: Sediment Transportation
LTP: 3-1-0=4 Cr

Course Content:

Units	Topic	Lecture
Unit I	Properties of sediments, Sediment yield, Models of sediment transport, regimes of flow, forms of bed roughness, Resistance to flow	8 lectures
Unit II	Bed load transport and related equations, theory of sediment suspension, sediment distribution along vertical, total load equations, sediment distribution in a stream section, sediment distribution with time, fine sediments and bed materials discharge, bed load and suspended load samples.	13 lectures
Unit III	Design of alluvial channels, Principles of stream power and minimum energy. meandering and braiding of streams, reservoir sedimentation, density currents, coastal sediment problems, sediment transport through pipelines, sediment sampling and measuring devices.	17 lectures

Books :

1. Fluvial Process in River Engineering, Howard Chang, John Wiley & Sons, New York, 1988.

2. Gadre, R. J. and Ranga Raju, K. G. Mechanics of Sediment Transport and Alluvial Stream Problems, New Age, New Delhi, 2000.

Course Code: CE 7056
Course Title: Geographical Information Systems (GIS)

LTP: 3-1-0=4 Cr

Course Content:

Units	Topic	Lecture
Unit I	Introduction to Geographical Information Systems (GIS), Databases and database management systems, Spatial databases, Coordinate systems and geo referencing, Interpolation methods: Deterministic and Statistical	12 lectures
Unit II	Digital elevation models and their applications, Strategies for development, Implementation and Management of GIS, Case studies on use of GIS selected from various areas such as water and Land resources, Environment, transportation, etc.,	14 lectures
Unit III	Projects involving creation of small GIS modules related to water resources problems and other generic areas.	12 lectures

Books:

1. Principles of Geographical Information Systems, Burrough, Peter A. and McDonnell, Rachael A., Oxford University Press, 1998

2. Introduction to Geographical Information Systems, Chang, K. T, Tata McGraw Hill, New Delhi, 2002.

Course Code: CE 7057
Course Title: Matrix Method of Structural Analysis (Computational Structural Mechanics)

LTP: 3-1-0=4 Cr.

Course Content:

Units	Topic	Lecture
Unit I	Basic concepts of Structural Analysis; Actions and Displacements; Equilibrium and Compatibility; Static and Kinematic Indeterminacy;	**8**
Unit II	Energy Concepts; Virtual Work; Flexibility Method; Effects of Temperature, Prestrain and Support Displacements; Equivalent Joint Loads;	**10**
Unit III	Stiffness Method; Computer Oriented Direct Stiffness Method; Member Stiffness Matrices for beams, Plain Truss, Plain Frames and Grids, Space Truss, Space Frame Members;	**10**
Unit IV	Rotation of Axes; Formation of Joint Stiffness Matrices;	**6**
Unit V	Term Projects on Computer Programmes.	**8**

Books:

1. Devdas Menon,"Advanced StructuralAnalysis", Narosa Publishing House, 2009.
2. Asslam Kassimali,"Matrix Analysis of Structures", Brooks/Cole Publishing Co., USA, 1999.
3. Amin Ghali,Adam M Neville and Tom G Brown,"Structural Analysis:A Unified Classical and Matrix Approach",Sixth Edition, 2007, Chapman & Hall.
4. Devdas Menon,"StructuralAnalysis", Narosa Publishing House, 2008.

Course Code: CE 7058

Course Title: Advance Mechanics of Solids
LTP: 3-1-0=4 Cr.

Course Content:

Units	Topic	Lecture
Unit I	Analysis of Stress-Stress Vector, State of Stress at a Point, Rectangular Stress Components, Stress on an Arbitrary Plane, Transformation of axes; Principal Stress and Plane, Stress Invariants	**8**
Unit II	Mohr's Circle, Octahedral Stresses, Lame's Ellipsoid, Equations of Equilibrium in Cartesian and Cylindrical Coordinates; Axisymmetric and Plane Stress case	**8**
Unit III	Analysis of Strain-Deformations, definition of Strain, State of Strain at a Point, Finite and Infinitesimal Strains, Geometrical Meaning of Shearing Strains, Principal Strain, Dilatation, Strain Invariants, Compatibility Conditions;	**8**
Unit IV	Stress Strain Relationship-Generalised Hooks Law, Stress- Strain Relations for Isotropic Materials; Displacement Equations of Equilibrium; Theories of Failure- Mohr's Theory of Failure, Yield Locus, Tresca and Von Mises Theories, Saint-Venant's Equations	**10**
Unit V	Bending of Curved Beams; Unsymmetrical Bending; Shear Centre and Flexure Centre; Torsion-Torsion of Thin Walled Tubes, Torsion of Noncircular Sections, Membrane Analogy, Torsion of Multicellular Axisymmetric Problems- Thick Walled Cylinders, Shrink Fit of Composite Tubes, Rotating Disks and Cylinders. Sections;	**8**

Books:

1. L. S. Srinath, "Advanced Mechanics of Solids" Tata McGraw Hill, 2007.
2. A.R. Ragab, and S. E. Bayoumi, "Engineering Solid Mechanics: Fundamentals and Applications", CRC Press, 1999.
3. M.H.Sadd, "Elasticity: Theory, Applications and Numerics", Academic Press, 2006.

Course Code: CE 7059
Course Title: Bridge Engineering
LTP: 3-1-0=4 Cr.

Course Content:

Units	Topic	Lecture
Unit I	Components of Bridges; Types of Bridges; Investigations for Bridge Sites-Soil and Hydraulic Considerations;	**8**
Unit II	Standard Specifications for Road Bridges; Substructures and their Design Considerations;	**8**
Unit III	Foundations-Piles and Caissons; Bearing and Joints;	**8**
Unit IV	IRC Loads and Specifications; Illustrative Design Examples of RCC Culverts, T-beam Bridges, Prestressed Concrete and Composite Bridges;	**10**
Unit V	Introduction to Steel Railway Bridges Specifications; Introduction to Cable Supported Bridges.	**8**

Books:

1. D. J. Victor, *Essentials of Bridge Engineering*, Oxford IBH, 1980.
2. V. K. Raina, *Concrete Bridge Practice Analysis Design and Economics*, Tata McGraw Hill, 2nd Ed, 1994.
3. N. Rajagopalan, *Bridge Superstructure*, Narosa Publishing House, 2006.
4. W. F. Chen and L. Duan, Bridge Engineering Handbook, CRC press, 2003.
5. B. Bakht and L.G. Jaeger, *Bridge Analysis Simplified*, McGraw Hill, 1987.
6. 4. E. J. O'Brien, and D. L. Keogh, *Bridge Deck Analysis*, Taylor and Francis, 1999.
7. H. Eggert and W. Kauschke, *Structural Bearings*, Ernst & Sohn, 2002.
8. T. Y. Lin and N. H. Burns, *Design of Prestressed Concrete Structures*, John Wiley and Sons, 1981.
9. L. Fryba, *Dynamics of Railway Bridges*, Thomas Telford, 1996.

Course Code: CE 7060
Course Title: Prestressed Concrete
LTP: 3-1-0=4 Cr.

Course Content:

Units	Topic	Lecture
Unit I	Introduction to Prestressed Concrete; Techniques of Prestressing	**6**
Unit II	Anchorage Systems; Shrinkage, Creep and Losses in Prestressed concrete;	**8**
Unit III	Design for Shear, Bond and Anchorage;	**8**
Unit IV	Illustrative Design Examples for Members and Structures;	**10**
Unit V	Construction and Application, Case Study	**10**

Books:

1. E. G. Nawy, *Prestressed Concrete: A fundamental approach*, Prentice Hall, 1995.
2. T.Y. Lin, *Design of Prestressed Concrete Structures*, John Wiley, & Sons, 1963.
3. S.K. Mallick and A.P. Gupta, *Prestressed Concret*, Oxford & IBH, 1992.
4. G.S. Charles and J.E. Johnson, *Steel Structures-Design and Behaviour*, Addison –Wesley, Pub Co., 1997.
5. W.F.Chen and S.Toma, *Advanced analysis of steel frames*, CRC press,1994.

Course Code: CE 7061
Course Title: Advanced RCC Design and Construction Techniques
LTP: 3-1-0=4 Cr.

Units	Topic	Lecture
Unit I	Review of Limit State Design Method; Yield Line Theory;	**8**
Unit II	Design of Flat and Waffle slabs; Design of Water tanks;	**12**
Unit III	Design of Silos and Bunkers; Design of Shear Walls in Multistoreyed Buildings;	**12**
Unit IV	Different Construction Techniques; Term Project.	**10**

Books:

1. S. U. Pillai and D. Menon, *Reinforced Concrete Design*, Tata McGraw-Hill 3rd edition, 2009.
2. P.C. Varghese, *Limit State Design of Reinforced Concrete*, Prentice Hall India, 2008.
3. S.N. Sinha, *Reinforced Concrete Design*, Tata McGraw-Hill, 2nd Edition, 2002.
4. M.L. Gambhir, *Fundamentals of Reinforced Concrete Design*, Prentice Hall India, 2006.
5. A. K. Jain, *Reinforced concrete: Limit state design*, Nem Chand and Bros. 1999.
6. J. Macgregor and J. K. Wight, *Reinforced Concrete: Mechanics and Design*, Prentice Hall, 5th edition, 2008.
7. R. Park and T. Paulay, *Reinforced Concrete Structures*, John Wiley and Sons, 1975.

Course Code: CE 7062
Course Title: Traffic Engineering
LTP: 3-1-0=4 Cr.

Course Content:

Units	Topic	Lecture
Unit I	Driver behavior, traffic information and control systems, traffic studies- volume, speed and delay studies,	10 lectures
Unit II	Elements of traffic flow theory, characteristics of uninterrupted traffic, capacity and LOS of Uninterrupted facilities, characteristics of interrupted traffic, design of signalized intersections, capacity and LOS of signalized intersections, actuated signal control, signal coordination,	10 lectures
Unit III	Traffic Analysis and Management: Capacity and Level of Service concepts, Queuing models and applications, Basics of traffic management. Traffic intersection control: Principles of Traffic Control and Traffic Signs, Road Markings and Channelization, Uncontrolled Intersection: Gap acceptance and capacity concepts, Uncontrolled Intersection: Capacity and LOS analysis, Traffic Rotaries and Grade Separated Intersection.	12 lectures
Unit IV	Design of parking, lighting and terminal facilities, simulation of traffic systems, statistics and probability in traffic engineering, trends in traffic engineering.	10 lectures

Books:

1. Roger P. Roess, William R. McShane & Elena S. Prassas, Traffic Engineering, Prentice-Hall, 1990.
2. Pignataro L. J., Traffic Engineering – Theory and Practice, Prentice Hall, 1973.
3. P. Chakroborty and A. Das, Principles of Transportation Engineering, Prentice Hall of India Pvt. Ltd., 2003.
4. C. J. Khisty and B. K. Lall, Transportation Engineering: An Introduction, Prentice- Hall India, 2003.
5. Wohl M. and Martin B. V., Traffic System Analysis, McGraw-Hill Book Company, 1967.
6. L. R. Kadiyali, Traffic Engineering, Khanna Publishers, 2000.
   A. D. May, Traffic Flow Fundamentals, Prentice–Hall, 1990.
7. C.S. Papacostas, Transportation Engineering and Planning, Prentice-Hall India, 2001.
8. Highway Capacity Manual (HCM), Transportation Research Board, USA, 2010.

Course Code: CE 7063
Course Title: Traffic Flow Modeling and Simulation
LTP: 3-1-0=4 Cr.

Course Content:

Units	Topic	Lecture
Unit I	Traffic flow characteristics; deterministic and stochastic models of stream flows;	10 lectures
Unit II	Microscopic traffic flow modeling: Car Following Models: Linear models, Car Following Models: Non-linear models, Lane Changing Models, Microscopic Traffic Simulation (Vehicle generation, model frame work, calibration and validations, statistical error analysis, applications). Macroscopic and mesocopic models: Traffic Flow Modeling Analogies: First order models, analysis of shock waves, Traffic Flow Modeling Analogies: Numerical implementation and higher order models, Cell transmission models, Cellular automata models: Discrete Simulation, Traffic Progression and Platoon dispersion.	14 lectures
Unit III	Signalized and unsignalised intersections; coordination and optimization of network of signalized intersections; Pedestrian flow problems;	08 lectures
Unit IV	Fundamentals of traffic simulation modeling; simulation methodologies and model design; simulation languages; application of macro and micro simulation packages.	10 lectures

Books:

1. A. D. May, Traffic Flow Fundamentals, Prentice–Hall, 1990
2. Wohl M. and Martin B. V., Traffic System Analysis, McGraw-Hill Book Company, 1967.
3. Drew D. R., Traffic Flow Theory and Control, McGraw-Hill, 1968.
4. P. Chakroborty and A. Das, Principles of Transportation Engineering, Prentice Hall of India Pvt. Ltd., 2003.
5. Pignataro L. J., Traffic Engineering – Theory and Practice, Prentice Hall, 1973.
6. Krishna Rao K. V. and Tom V. M., Lecture Notes on Recent Developments in Urban Transportation Systems Planning, IIT Bombay, 2003.

Course Code: CE 7064
Course Title: Urban Transportation Systems Planning
LTP: 3-1-0=4 Cr.

Course Content:

Units	Topic	Lecture
Unit I	Introduction to transportation planning; Urban Travel and Transportation Systems Characteristics, systems approach to transportation planning; types of models; concept of travel demand and supply; socio-economic, land use, network, and transport system characteristics affecting transportation planning; study area definition, zoning principles, cordon and screen lines, data collection through primary and secondary sources, sampling techniques;	12 lectures
Unit II	Travel Demands Forecasting; four-stage sequential modeling approach; trip generation; trip distribution; modal split; trip assignment;	12 lectures
Unit III	Transport Behavior of Individuals and Households, land use-transport models; public transport planning, integration of different modes;	10 lectures
Unit IV	Travel demand management measures; case studies. Introduction to Urban Freight Transportation and Urban Mass Transportation Systems.	08 lectures

Books:

1. J. de D. Ortuzar and L.G. Willumsen, Modelling Transport, John Wiley and Sons, 2001.
2. C.J. Khisty and B.K. Lall, Transportation Engineering – An Introduction, Prentice Hall of India Pvt. Ltd., 2002.
3. C. S. Papacostas and P. D. Prevedouros, Transportation Engineering and Planning, Prentice Hall of India Pvt. Ltd., 2001.
4. P. Chakroborty and A. Das, Principles of Transportation Engineering, Prentice Hall of India Pvt. Ltd., 2003.
5. B.G. Hutchinson, Principles of Urban Transport Systems Planning, McGraw- Hill Book Co., New York, 1974.
6. L.R. Kadiyali, Traffic Engineering and Transport Planning, Khanna Publishers, New Delhi, 2000.
7. G. E. Gray and L. A. Hoel, Public Transportation, Prentice Hall, New Jersey, 1992.

Course Code: CE 7065
Course Title: Geopolymer Concrete
LTP: 3-1-0=4 Cr.

Course Content:

Units	Contents	Lectures
Unit I	Geopolymer Concrete: Inorganic polymeric new materials, basics of geopolymer concrete and impact on global warming, types of geopolymer concrete.	[8]
Unit II	Making materials : Aggregates, Fly ash, Sodium silicate, Sodium hydroxide	[6]
Unit III	Mix proportioning, production process, effects of curing temperature, properties with aging and testing methods.	[12]
Unit IV	Uses of geopolymer concrete and its composites: Fire resistant wood panels , Insulated panels and walls, Decorative stone artifacts, Foamed (expanded) panels for thermal insulation, Low-tech building materials, Low energy ceramic tiles, Refractory items, Thermal shock refractory, Aluminum foundry application, Geopolymer concrete composites, Fire resistant and fire proof composite for infrastructures repair and strengthening,.	[8]
Unit V	Special application of geopolymer for repair and rehabilitation of concrete structures, Fireproof high-tech applications in aircraft interior, automobile, High-tech resin systems, Ultra high temperature resistant members, Safe disposal of toxic metals, nuclear and uranium waste.	[8]

Books:

1. Davidovits, J. Geopolymers-Inorganic polymeric new materials, Journal of Thermal Analysis, Vol. 37, pp. 1633-1656, 1991.
2. Hardjito, D., Wallah, S.E., Sumajouw, D.M.J. and Rangan, B.V. On the Development of Fly Ash Based Geopolymer Concrete ACI Materials Journal, Vol. 101, No. 1, 2004.
3. Davidovits, J. Geopolymer chemistry and application, Geopolymers Institute, ISBN 2-651-4820-1-9, 2008.
4. Davidovits, J. Global Warming Impact on the Cement and Aggregates Industries, World Resource Review, Vol. 6, No. 2, pp. 263-278, 1994. 2
5. Hardjito, D. and Rangan, B.V. Development and properties of Low-Calcium Fly Ash-based, Geopolymer Concrete, Research Report GC-I, Faculty of Engineering, Curtin University of Technology, 2005.
6. Hardjito, D., Wallah, S.E. and Rangan, B.V. Study on Engineering Properties of Fly Ash-Based Geopolymer Concrete, Journal of the Australasian Ceramic Society, Vol. 38, No. 1, pp. 44-47, 2002.
7. Anuradha, R., Sreevidya, V., Venkatasubramani, R. and Rangan, B.V. Modified guidelines for geopolymer concrete mix design using Indian standard, Asian Journal of Civil Engineering (Building and Housing) Vol. 13, No. 3, pp. 353-364, 2012.
8. Buchwald, A. and Schulz, M. Alkali-activated binders by use of industrial by - products, Cement Concrete Research, Vol. 35, pp. 968-973, 2005.

9. Daniel, L.Y.K. and Jay Sanjayan, G. Effect of elevated temperatures on Geopolymer paste, mortar and concrete, Cement and Concrete Research, Vol. 40, pp. 334-339, 2010.

Course Code: CE 7066
Course Title: Durability of Concrete
LTP: 3-1-0=4 Cr.

Course Content:

Units	Contents	Lectures
Unit I	Introduction to durability, Microstructure of cement based systems, Bonding, Pore system, Distribution capillary voids, Permeability, Aggregate-hydrated cement paste interface, Microstructure, Transition zone.	[8]
Unit II	Mix proportioning of high-volume fly ash and slag concrete; their life time performance.	[8]
Unit III	Deterioration of concrete, Causes, Transport mechanism, Controlling concrete degradation; Corrosion of reinforcement system: Understanding, Investigation and Repair etc.	[10]
Unit IV	Admixtures interface in concrete; effects of superplasticisers, air entraining, corrosion inhibitor, expansion producing, mineral and other admixtures on durability of concrete.	[8]
Unit V	Durability of special concrete: High strength, Self compacting, Pervious, Lightweight, Fibre reinforced, High density, Roller compacted, High performance and Mass concrete in different exposure conditions.	[8]

Books:

1. P.K.Mehta and Paulo J.M.Monteiro, “Concrete: microstructure, properties and materials”, The McGrawHill Companies
2. AM Neville, Properties of concrete, Pearson
3. ML Gambhir, Concrete Technology, Tata McGraw Hill Companies
4. AR Santakumar, Concrete Technology, Oxford University Press.
5. Non-destructive test methods by Nicholas J. Carino (http://fire.nist.gov/bfrlpubs/build98/PDF/b98019.pdf).
6. V.M. Malhotra, Nicholas J. Carin; Handbook on Nondestructive Testing of Concrete Second Edition
7. GUIDELINES ON NON-DESTRUCTIVE TESTING OF BRIDGES BS – 103, (http://www.rdso.indianrailways.gov.in/uploads/files/1296882621315-bs_103.pdf).
8. Practical Non-Destructive Testing, By Baldev Raj, Tammana Jayakumar, M