DEPARTMENT OF APPLIED MECHANICS

Scheme of Instructions and Syllabus
for Post Graduate Studies

M. Tech in Structural Engineering
M. Tech. in Structural Dynamics & Earthquake Engineering

Visvesvaraya National Institute of Technology, Nagpur

July 2012

Department of Applied Mechanics offers two M. Tech program, namely, *M. Tech. in Structural Engineering and M. Tech. in Structural Dynamics & Earthquake Engineering*. These are four semester program, wherein student has to complete certain number of credits as indicated in Table 1. Each subject (or course) has certain number of credits. There are two types of subjects: Core and elective. Core courses are compulsory and some course from electives are to be taken to complete the required credits.

TABLE 1. CREDIT REQUIREMENTS FOR POST GRADUTE STUDIES

Postgraduate Core (PC)		**Postgraduate Elective (PE)**	
Category	Credit	Category	Credit
Departmental Core (DC)	74	Departmental Electives (DE)	30
Basic Science (BS)	00	Other Courses (OC)	00
Total	74	Total	30
Grand Total PC + PE			104

The number of credits attached to a subject depends on number of classes in a week. For example a subject with 3-1-0 (L-T-P) means it has 3 Lectures, 1 Tutorial and 0 Practical in a week. This subject will have eight credits (3x2 + 1x1 + 0x1 = 8). If a student is declared pass in a subject, then he/she gets the credits associated with that subject. Depending on marks scored in a subject, student is given a Grade. Each grade has got certain grade points as follows:

Grades	AA	AB	BB	BC	CC	CD	DD	FF
Grade Points	10	09	08	07	06	05	04	Fail

The performance of a student will be evaluated in terms of two indices, viz. the Semester Grade Point Average (SGPA) which is the Grade Point Average for a semester and Cumulative Grade Point Average (CGPA) which is the Grade Point Average for all the completed semesters at any point in time. SGPA & CGPA are:

$$\boldsymbol{SGPA} = \frac{\sum_{semester}(Course\ credits\ X\ Grade\ points) for\ all\ courses\ except\ audit}{\sum_{semester}(Course\ credits\ ) for\ all\ courses\ except\ audit}$$

$$\boldsymbol{CGPA} = \frac{\sum_{All\ semester}(Course\ credits\ X\ Grade\ points) for\ all\ courses\ with\ pass\ grade\ except\ audit}{\sum_{All\ semester}(Course\ credits\ ) for\ all\ courses\ except\ audit}$$

Students can Audit a few subjects. i.e., they can attend the classes and do home work and give exam also, but they will not get any credit for that subject. Audit subjects are for self enhancement of students.

Scheme of Instructions for M Tech (Structural Engineering)

I Semester				II Semester			
CORE				**CORE**			
Code	**Course**	**L-T-P**	**Cr**	**Code**	**Course**	**L-T-P**	**Cr**
AML421	Matrix method of structural analysis	3-1-0	8	AML425	Advanced Design of Steel Structures	3-1-0	8
AML422	Theory of Plates and Shells	3-0-0	6	AML426	Advanced Design of Reinforced Concrete Structures	3-1-0	8
AML423	Theory of Elasticity and Elastic Stability	3-0-0	6	AML429	Substructure and Foundation design	3-0-0	6
AML424	Structural Dynamics	3-0-0	6				
AMP424	Structural Dynamics Laboratory	0-0-2	2				
ELECTIVE (Any one)				**ELECTIVE (Any two)**			
AML428	Structural Instrumentation and Rehabilitation of Structures	3-0-2	8	AML507	Analysis and Design of Bridges and Retaining Walls	3-1-0	8
CEL 406	Advanced Concrete Technology	3-1-0	8	AML431	Finite Element Method	3-1-0	8
AML427	Introduction to Earthquake Engineering	3-0-0	6	AML432	Analysis and Design of Multistoried Buildings	3-1-0	8
AML435	Computer Programming and Numerical Methods	3-1-0	8	AML504	Wind Effects on Structures	3-1-0	8
CEL 413	Pre-stressed Concrete Structures	3-1-0	8	AML512	Foundations subjected to Vibrations	3-1-0	8
				AML501	Earthquake Resistant Design of RC str.	3-1-0	8
		36/34					**38**
III Semester				**IV Semester**			
AMD501	Project Phase-I	-	6	AMD502	Project Phase-II	-	18
ELECTIVE (Any one)							
AML430	Analysis and Design of Industrial Buildings	3-1-0	8				
AML514	Analysis and Design of Environmental Engineering Structures	3-1-0	8				
AML506	Analysis and Design of Special structures	3-1-0	8				
AML509	Advanced Finite Element Method	3-1-0	8				
			14				**18**

Scheme of Instructions for M Tech (Structural Dynamics & Earthquake Engineering)

I Semester				II Semester			
CORE				**CORE**			
Code	**Course**	**L-T-P**	**Cr**	**Code**	**Course**	**L-T-P**	**Cr**
AML421	Matrix method of structural analysis	3-1-0	8	AML501	Earthquake Resistant Design of RC structures	3-1-0	8
AML423	Theory of Elasticity and Elastic Stability	3-0-0	6	AML502	Earthquake Resistant Design of Steel Structure	3-1-0	8
AML427	Introduction to Earthquake Engineering	3-0-0	6	AML505	Earthquake Dynamics	3-0-0	6
AML424	Structural Dynamics	3-0-0	6				
AMP424	Structural Dynamics Laboratory	0-0-2	2				
ELECTIVE (Any one)				**ELECTIVE (Any two)**			
AML435	Computer Programming and Numerical Methods	3-1-0	8	AML431	Finite Element Method	3-1-0	8
CEL 413	Pre-stressed Concrete Structures	3-1-0	8	AML504	Wind Effects on Structures	3-1-0	8
AML428	Structural Instrumentation and Rehabilitation of Structures	3-0-2	8	AML512	Foundations subjected to Vibrations	3-1-0	8
CEL 406	Advanced Concrete Technology	3-1-0	8	AML432	Analysis & Design of Multistoried Buildings	3-1-0	8
AML422	Theory of Plates and Shells	3-0-0	6	AML507	Analysis and Design of Bridges and Retaining Walls	3-1-0	8
		36/34					**38**
III Semester				**IV Semester**			
AMD501	Project Phase-I		6	AMD502	Project Phase-II		**18**
ELECTIVE (Any one)							
AML506	Analysis and Design of Special str.	3-1-0	8				
AML509	Advanced Finite Element Method	3-1-0	8				
AML430	Analysis and Design of Industrial Buildings	3-1-0	8				
AML 514	Analysis and Design of Environmental Engineering Structures	3-1-0	8				
			14				

AML 421 - MATRIX METHOD OF STRUCTURAL ANALYSIS [(3-1-0); Credits: 8]

Introduction to stiffness and flexibility approach, Stiffness matrix for spring, Bar, torsion, Beam (including 3D), Frame and Grid elements, Displacement vectors, Local and Global co-ordinate system, Transformation matrices, Global stiffness matrix and load vectors, Assembly of structure stiffness matrix with structural load vector, Solution of equations, Gauss elimination method, Cholesky Decomposition method, Analysis of spring and bar assembly, Analysis of plane truss, plane frame, plane grid and space frames subjected to joint loads, Analysis of Structures for Axial Load.
Analysis for member loading (self, Temperature & Imposed) Inclined supports, Lack of Fit, Initial joint displacements. Finite (Rigid & flexible) size joint, Effect of shear deformation, internal member end releases.
Use of MATLAB/MATHCAD / other software.
Effect of axial load on stiffness of members, Analysis of building systems for horizontal loads, Buildings with and without rigid diaphragm, various mathematical models, Buildings with braces, shear walls, non-orthogonal column members.
Advanced topics such as static condensation, substructure technique, constraint equations, Symmetry and antisymmetric conditions, Modeling guidelines for framed structures.

REFERENCES

1. Cheng, F. Y. "Matrix Analysis of Structural Dynamics", M. Dekke, NY, 2000.
2. Kanchi, M.B. "Matrix Analysis of Structural Analysis", John Willey & Sons, 2nd Edition 1999.
3. Bathe K.J. "Finite Element Procedures", Springer; 2nd Edition, 2002.
4. Kasmali Aslam "Matrix Analysis of Structures", Brooks/Cole Publishing Co., 1999.
5. Cook, R.D.et.al "Concept and Applications of Finite Element Analysis", John Willey & Sons, NY, 1995.
6. Gere, W. and Weaver, J.M "Matrix Analysis of Structural Analysis 3rd Edition", Van Nostrand Reinhold, NY, 1990.
7. Martin, H.C. "Introduction to Matrix Method of Structural Analysis", McGraw Hill Book Co., 1996.

AML 422 - THEORY OF PLATES AND SHELLS [(3-0-0); Credits: 6]

Governing differential equations of thin rectangular Plates with various boundary conditions and loadings.
Bending of long thin rectangular plate to a cylindrical surface, Kirchhoff plate theory, Introduction to orthotropic plates
Circular plates with various boundary conditions and loadings.
Numerical methods for solution of plates, Navier's, Levy's solutions.
General shell geometry, classifications, stress resultants, equilibrium equation, Membrane theory for family of Shells (Parabolic, Catenary, Cycloid, Circular, hyperbolic).
Classical bending theories of cylindrical shells with and without edge beams such as approximate analysis of cylindrical shells.

REFERENCES

1. Timoshenko, S.P. & Kriegar, W., "Theory of Plates & Shells", McGraw Hill, NY, 1970.
2. Szilard, R. "Theory and Analysis of Plates", Prentice Hall, 1974.
3. Novozhilov, V.V, "Thin Shells", Noordho of Groningen, 1964.
4. Ramaswamy, G. S "Design of Concrete Shells", Krieger Publ. Co, 1984.
5. Chandrashekhar, K. "Theory of Plates", University Press India Ltd., Hyderabad, 1st Edition, 2001.
6. Bairagi, N. K. a Text book of Plates Analysis.
7. Chattergee, B.K., "Theory and Design of Concrete Shells.

AML 423 - THEORY OF ELASTICITY AND ELASTIC STABILITY [(3-0-0); Credits: 6]

Stress at a point, relationship between stresses and strains, Elastic modulii, Basic equations of theory of Elasticity. Plane stress-strain, Airy's stress function, strain-displacement relationship, Principal Planes and Principal stresses in three dimensions, equilibrium and compatibility in rectangular coordinates and other coordinate systems.
Simple applications in tension, bending and torsion.
Concept of Stability, Axial buckling of columns by Energy Criteria of Stability & approximate methods, lateral torsional buckling of beams and beam columns, Coupled axial torsion and flexural buckling.
Buckling of rectangular thin plates.

REFERENCES

1. Timoshenko, S.P., "Theory of Elasticity", McGraw Hill, 3rd Edition, NY, 1970.
2. Timoshenko, S.P., "Theory of Elastic Stability", McGraw Hill, 2rd Edition, NY, 1961.
3. Trahair, N.S., "Flexural Torsional Buckling of Structures", E & FM SPON, London.
4. Chen, W.F., "Theory of Beam-Columns-Space Behaviour and Design", 2nd Vol., McGraw Hill.

AML 424 - STRUCTURAL DYNAMICS [(3-0-2); Credits: 8]

Sources of vibration, types of excitations, Principle and working of piezoelectric transducers, Spring action and damping; Degrees of freedom; Application of Newton's laws, D'Alembert's principle, Single degree of freedom systems; Mathematical model of physical systems; Free vibrations of undamped and viscously damped systems;
Coulomb damping material and radiation damping. Response of viscously damped SDOF systems to harmonic excitation; Vibration Isolation, Force transmissibility and base motion; Principle of vibration measuring instruments; Equivalent viscous damping; structural damping, Response of an undamped SDOF to short duration impulse; unit impulse response.
Response of undamped system of rectangular, triangular and ramp loading; response to general dynamic excitation;
Duhamel integral method. Response spectra, Numerical evolution of dynamic response of linear systems, Frequency domain analysis, Fast Fourier Transform
Multiple degree of Freedom system: Vibration of undamped 2 DOF systems; Response of 2 DOF to harmonic excitation, mode superposition, vibration absorber, Lagrange equation and their application to lumped parameter models of MDOF (up to 3 DOF). Free vibration of MDOF (up to 3 DOF) systems, methods of solving eigen value problems; iteration methods.
Dynamic response of MDOF (2 DOF) systems-modal superposition method.
Vibration of Continuous Systems: Free vibrations of Continuous systems-axial and transverse vibration of bars / beams. Response of continuous systems to dynamic loads.
Energy Principle, Rayleigh-Ritz method.

REFERENCES

1. Chopra, A.K., "Dynamics of Structures", Prentice Hall, 3rd Edition, NY, 1970.
2. Clough, R.W. & Penzin, J., "Dynamics of Structures", McGraw Hill, 1993.
3. Humar, J.L., "Dynamics of Structures", Prentice Hall, 1990.
4. Mario, Paz, "Structural Dynamics", CBS Publ. N-Delhi, 1995.
5. Timoshenko, S., "Advanced Dynamics", McGraw Hill Book Co, NY, 1948.
6. Meirovitch, L., "Elements of Vibration Analysis", 2nd Edition, McGraw Hill International Edition, Singapore, 1986.
7. Biggs, J.M., "Introduction of Structural Dynamics", McGraw Hill, NY, 1964.

AML 425 ADVANCED DESIGN OF STEEL STRUCTURES [(3-1-0); Credits: 8]

Introduction to Allowable Stress Design, Plastic design, Load and Resistance Factor Design (LFRD).
Loadings as per IRC, IRS, IS (IS:800, IS:875 part 1-V, IS:1893) applicable to various steel structures.
Design of Beams, Beam-column, Plate Girders, Open web structures and Space structures.
Bridges, Industrial Buildings including crane girders.
Welded and riveted connections.
Composite structures.

REFERENCES

1. Owens, G.W. & Knowles, P.R. "Steel Designers Manual", Blackwell, 1994.
2. Gaylord, E.H. & Gaylord, C.N. "Design of Steel Structures", McGraw Hill Pulb. 1998.
3. "Steel Design Manual", ELBS and Granada Publishers, London.
4. Johnson, R.P. "Composite Structures of Steel and Concrete", Vol-I, Granado Publishing Ltd., London, 1994.
5. Salmon and Johnson, "Steel Structures-Design and Behaviour", Harper and Collins Publishers.

AML 426 - ADVANCED DESIGN OF REINFORCED CONCRETE STRUCTURES
[(3-1-0); Credits: 8]

Review of Limit State Design of RC members. Confinement of concrete, ductile detailing.
Beams (Flexural, Shear and torsion)
Uni-axial and biaxial Beam-column (Axial, shear and moments)
Slabs (one way & two way and slabs on grades. Preliminary sizing and modeling of RC structures.
Basics of Prestressed concrete Design, Material, Prestressing systems, Losses, Stress checks, Strength check, Deflection of prestressed concrete beams, prestressed slabs and Beams, Behavior of unbounded and bonded prestressed concrete beams, Shear and Torsional resistance of the prestressed concrete members, Analysis and design of End blocks.

REFERENCES

1. Paulay, T. and Prestiley, M.J.N. "Seismic Design of RC & Masonry Building", John Willey & Sons, 2nd Edition, 1999.
2. Booth, E, "Concrete Structures in Earthquake Regions", Longman Higher Education, 1994.
3. Raynolds, C. E., "Reinforced Concrete Design Handbook", 9nd Edition, Rupa & Company Calcutta, 1981.
4. Raynolds, C. E., "Design Reinforced Concrete Design", Vol.-II, Conc. Publications Ltd., 1981.
5. Fintel, M., "Handbook of Concrete Engineering", 2nd Edition, CBS Publishers, Delhi, 1986.
6. Park and Paulay, "Reinforced Concrete Structures", John Willey & Sons.
7. Krishna Raju, N. "Prestressed Concrete Structures", TMH, Delhi, 1981.
8. Lin, T. Y. and Burns, N.H., "Design of Prestressed Concrete Structures", 3rd Edition, John Willey & Sons, N.Y., 1981.
9. Chen, W.F. and Duan, L. "Bridge Engineering Handbook", CRC Press, 1999.

AML 427 - INTRODUCTION TO EARTHQUAKE ENGINEERING [(3-0-0); Credits: 6]

Origin of earthquakes, Engineering geology, Seismicity of the world, Faults, Propagation of earthquake waves. Quantification of earthquake (magnitude, energy, intensity of earthquake), Measurements of earthquake (accelerograph, accelogram recording), Determination of magnitude, Epicental distance, focal depth, etc. Ground motion and their characteristics, Factors affecting ground motions.
Concept of response spectra, generation of site-specific spectrum, Estimation of PGA, Earthquake design spectrum and inelastic spectra.
Concept of earthquake Resistant design, design philosophy, Four virtues of EQRD: Stiffness, Strength, ductility and Configurations, Introduction to Capacity design concepts, Introduction to IS:1893, Codal Coefficient and Response Spectrum Method.

REFERENCES

1. Dowrick, D. L. "Earthquake Resistance Design for Engineers and Architects", John Willey & Sons, 2nd Edition, 1987.
2. Housner, G. W. & Jenning, P.C. "Earthquake Design Criteria", Earthquake Engineering Research Institute, Oakland, California, USA, 1982.
3. Newmark, N. M. & Hall, W.J. "Earthquake Spectra & Design , Earthquake Design Criteria", Earthquake Engineering Research Institute, Oakland, California, USA, 1982.
4. Wakabayashi, M. "Design of Earthquake Resistance Buildings", McGraw Hill Books Company, 1986.
5. Okamoto, S. "Introduction to Earthquake Engineering", University of Tokyo press, 2nd Edition, 1984.
6. Kramer, S. L. "Geotechnical Earthquake Engineering", Prentice Hall, New Jersey, 1996.
7. Bolt, B. A. "Earthquakes", W. H. Freeman & Company, NY, 1988.

AML 428 - STRUCTURAL INSTRUMENTATION AND REHABILITATION OF STRUCTURES [(3-0-2); Credits: 8]

Study of various transducers, Principle of their working, displacement, velocity, acceleration etc, strain gauge & piezoelectric type of transducers.
Strain measurements, strain gauges (static and dynamic), calculation of stresses and loads from measurements of strains and deflections. Special concrete constructions: fibre reinforced concrete; fibre wrapping, Special concrete like lightweight concrete, ferro cement, fly ash concrete, High performance concrete, concrete admixtures.
Corrosion of steel and concrete: Theory and prevention.
Cracks in buildings: causes and remedial measures.
Techniques for Rehabilitation of RC, Steel and Masonry structures.
Non-destructive testing of concrete, steel structures, Various NDT tests, codal provisions, Proof Load testing.

REFERENCES

1. Singh, Sadhu "Experimental Stress Analysis", Khanna Publishers.
2. Soisson, H. E. "Instrumentation in Industry", John Willey & Sons, NY, 1975.
3. BoomField, J.P. "Corrosion of Steel in Concrete", E & FN SPON, 1997.
4. Ganesan, T.P. "Modal Analysis of Structures", University Press, 2000.
5. "IS: 13925 Repair and Seismic Strengthening of Buildings-Guidelines", Bureau of Indian Standard, New Delhi, 1993.
6. "SP: 25 Causes and Prevention of Cracks in Buildings", Bureau of Indian Standard, New Delhi, 1984.

AML 429 - SUBSTRUCTURE AND FOUNDATION DESIGN [(3-0-0); Credits: 6]

Analysis and design of Piers, Abutments and Retaining walls. Shallow foundations: Individual and combined footings for axial and bending loads (Uniaxial and biaxial), Loss of contacts. Rafts, Annular Footings, Rigid and flexible foundations, Beams and slabs on elastic foundations. Deep Foundations: Piles and Wells foundations. Design of Machine Foundations.

REFERENCES

1. Hetenyi, M. "Beam on Elastic Foundation", University of Michigan Press, 1946.
2. Bowles, J. E. "Foundation Analysis & Design", McGraw Hill, 5th Edition, 1996.
3. Swami Saran, "Soil Dynamics and machine Foundations", Galgotia Publications (P) Ltd, New Delhi, 1999.
4. Srinivasulu, P., Vaidyanathan C.V. "Handbook of Machine Foundation".
5. Kurian, N. P. "Modern Foundations-Introduction to Advanced Techniques".

AML 430 - ANALYSIS AND DESIGN OF INDUSTRIAL BUILDINGS [(3-1-0); Credits: 8]

Design of Industrial building, Crane, Gantry Girder, North Light and Lattice girder structure, Multistory steel building (Maximum 2 bay and four storey), including composite construction.
Design of Bunker and Silo (Rectangular or Square or Circular)
Design of Pressure vessels and storage tanks (Circular and Square)
IS 1893 Part IV

REFERENCES

1. Owens, G.W. & Knowles, P.R. "Steel Designers Manual", Blackwell, 1994.
2. Gaylord, E.H. & Gaylord, C.N. "Design of Steel structures", McGraw Hill Pulb., 1998.
3. "Steel Design Manual", ELBS and Granada Publishers, London.
4. Johnson, R.P. "Composite Structures of Steel and Concrete", Vol-I, Granado Publishing Ltd, London, 1975.
5. Salmon and Johnson "Steel Structures-Design and Behaviour", Harper and Collins Publishers.
6. BIS, New Delhi "IS 1893 Part IV".

AML 431 - FINITE ELEMENT METHOD [(3-1-0); Credits: 8]

Introduction to Finite element method, History, Applications, Introduction to Rayleigh Ritz Method, Stress strain relationship, strain displacement relationship, Equilibrium equations (Total potential approach, Virtual work approach)
Shape function, Stiffness matrix, load vector for 2-D elements (Plane stress, Plane strain & Axi-symmetric) using Displacement formulation. Cartesian and Iso-parametric element formulation. Numerical Integration, convergence study.
Formulation of 1-D elements (BAR, TORSION, BEAM) and 3-D solid elements.
Computer Implementation of FEM procedure for plane truss, Plane stress, plane strain and Axi-symmetric problems.
Constraint Equations (Penalty method, Lagrangian method), Patch test, mathematical modeling of structures.

REFERENCES

1. Zienkiewicz, O. C. & Taylor, R. L., "Finite Element Method", Vol-I, II & III; Elsevier, 2000.
2. Hughes, T .R. J., "Finite Element Method", Dover Publication, 2000.
3. Bathe, K.J., "Finite Element Procedures", Pringor; 2nd Edition, 2002.

4. Reddy, J. N., "Finite Element Method", John Willey & Sons, 1982.
5. Buchanan, G.R, "Finite Element Analysis", McGraw Hill Publ.; NY, 1995.
6. Belegundu, A.D. & Chandrupatla, T.R., "Finite Element Method in Engineering", Prentice Hall India, 1991.
7. Pilkey, W.D. & Wunderlich, W., "Mechanics of Structures, Variation and Computational Methods", CRC Press, 2nd Edition.
8. Cook, R. D., "Concepts and Applications of Finite Element Analysis", John Willey & Sons; NY, 1995.
9. Prathap, G., "Finite Element Method", Kluwer Academic Publ, Dordrecht; 1993.
10. Irons, B. & Ahmad, S., "Techniques of Finite Elements", Elliswood London, 1980.

AML 432 - ANALYSIS AND DESIGN OF MULTI-STORIED BUILDINGS [(3-1-0); Credits: 8]

Building frames, frame-shear wall buildings, Braced Buildings, Mathematical modeling of buildings with different structural systems with and without diaphragms,
Earthquake, wind and other (i.e. blast, snow) load calculations along with dead load and live loads and their combinations.
Special aspects in Multi-storeyed buildings: Effect of torsion, flexible first story, P-delta effect, soil-structure interaction on building response, drift limitation.
Analysis and Design of multi-storeyed buildings with masonry infills, Sequential analysis for multistoried buildings.
Design for Fire Resistant, Creep, Shrinkage and Thermal stresses.

REFERENCES

1. Farzad Naeim, "Handbook on Seismic Analysis and Design of Structures", Kluwer Academic Publisher, 2001.
2. Paulay, T. & Prestiley, M.J.N., "Seismic design of R C & Masonry Buildings", John Willey & Sons; 2nd Edition, 1999.
3. Booth, E., "Concrete Structures in Earthquake Regions", Longman Higher Education, 1994.
4. Park, R. & Paulay, T., "Reinforced Concrete Structures", John Willey & Sons; 2nd Edition, 1975.

AML 435 - COMPUTER PROGRAMMING AND NUMERICAL METHODS [(3-1-0); Credits: 8]

Computer programming fortran 95/C–Programming fundamentals, Introduction to algorithm development, Computer Implementation of Matrices, Guidelines for development of a large sized problem.
NUMERICAL METHODS-Solution of Linear Simultaneous equations – Method of Gauss Elimination, Cholesky''s, 1 Gauss – Seidel method of Iteration, Solution based on Band width and its Variants.
Numerical Integration – Trapezoidal, Simpson's and other Newton – Cotes formulae, Method of Gauss Quadrature. Interpolation (Lagrange Interpolation, Taylor series expansion, Extrapolation) 2 Solution of non Linear Equations, Newton Raphson schemes. Eigen value and Eigen vectors. Problems associated with choice and implementation of solution techniques in the eigen solution of large problems arising in dynamic systems. Initial and boundary value problem, Euler's, Runge-kutta, Milne's etc, Computer oriented Algorithms.
1 Jacobi iteration, 2 Regression

REFERENCES

1. Scarborough J. B., "Numerical Mathematical Analysis", Oxford and IBH publishers, 1966.
2. Gerald C. F., "Applied Numerical Analysis", Addison – Wesley Publishing Company, 1970.
3. Jain M. K., Iyengar S. R. K. and Jain R. K, "Numerical Methods for Scientific and Engineering Computations", John Wiley – New Age International Limited, 1993.
4. Balgurusamy E., "Numerical Methods", Tata McGraw Hill, New Delhi, Fifth Edition, 2001.

5. Rajaraman, V., "Fortran-95", Prentice Hall of India, 1988.
6. McCormic J. M. and Salvadori M. G., "Numerical Methods in FORTRAN", Prentice Hall of India, New Delhi, 1966.
7. Press, W.H; Tenkolsky, S.A.; Vetterling, W.T.; & Flannery, B.P., "Numerical Recipes-the art of scientific Computing; 2nd Edition", Cambridge University Press, 1993.
8. Kanetkar Y. P., "Let us C", BPB Publication, New Delhi.
9. Bathe, K. J., "Finite Element Procedures", Springor, 2nd Edition, 2002

AML 501 - EARTHQUAKE RESISTANT DESIGN OF RC STRUCTURES [(3-1-0); Credits: 8]

Review of Limit State Method (LSM), Confinement of Concrete, Ductility, Capacity Design of RC Members, Design of Beams, Beam-Column, Shear wall with ductile detailing.
Performance of RC buildings, behaviors of RC buildings in past earthquakes, influence of unsymmetry, infill walls, foundations, soft story, Strong Column –Weak Beams etc.
Preliminary sizing and Modelling of RC Buildings, Ductility and factors affecting ductility of RC members.
Design for Strong column & weak beam, Design of Beam-Column Joints.
Pushover analysis of Buildings. Concepts of Performance based design.

REFERENCES

1. Farzad Naeim, "Handbook on Seismic Analysis and Design of Structures", Kluwer Academic Publisher, 2001.
2. Paulay, T. & Prestiley, M.J.N., "Seismic design of R C & Masonry Buildings", John Willey & Sons, 2nd Edition; 1999.
3. Dowrick, D. J., "Earthquake Resistant Design for Engineers & Architects", John Willey & Sons, 2nd Edition; 1987.
4. Booth, E., "Concrete Structures in Earthquake Regions", Longman Higher Education, 1994.
5. Park, R. & Paulay, T., "Reinforced Concrete Structures", John Willey & Sons, 2nd Edition; 1975.

AML 502 – EARTHQUAKE RESISTANT DESIGN OF STEEL STRUCTURES [(3-1-0); Credits: 8]

Basics of Steel Design, Introduction to plastic analysis and design, Design philosophy for steel structures.
Performance of steel structures in past earthquakes, Capacity design concept, Ductility of steel buildings, Seismic behaviour of steel structures, Stability considerations,
Seismic Design and detailing of Moment Resistant Frames (MRFs): Beams and Columns.
Seismic design and detailing of MRFs: Panel Zones and Connections.
Seismic design and detailing of Concentric Brace Frames (CBFs), Introductions to Eccentric Brace Frames (EBFs) and Special Truss Moment Frames (STMFs).

REFERENCES

1. Englekirk, R, "Steel Structures Controlling Behaviour Through Design", John Wiley& Sons Inc, 2003.
2. Bruneau, M.; Uang, C.M.; & Whittaker, A, "Ductile Design of Steel Structures", McGraw Hill.
3. Mazzolani, F.M.; & Piluso, "V.; Theory and Design of Seismic Resistant Steel Frames", E&FN Spon.

AML 504 – WIND EFFECTS ON STRUCTURES [(3-1-0); Credits: 8]

Wind Characteristics: Variation of wind velocity, atmospheric circulations – pressure gradient force, coriolis force, frictionless wind balance, geostrophic flow, boundary layer. Extra ordinary winds – Foehn, Bora, Cyclones, Tornadoes etc.
Static wind effects and building codes with particular reference to IS 875 (Part-III), wind speed map of India, introduction to the proposed revisions of IS 875 (Part III).
Dynamic wind effects: Wind induced vibrations, flow around bluff bodies, along wind and across wind response, flutter, galloping, vortex shedding, locking, ovalling; analysis of dynamic wind loads, codal provisions – gust factor, dynamic response factor; vibration control and structural monitoring; exposure to perturbation method, averaging techniques
Wind tunnel testing : Open circuit and closed circuit wind tunnels, rigid and aeroelastic models, wind tunnel measurements and instruments along with site visit.
Case studies: low rise buildings, parking sheds, workshop building, multistory building, water tanks, towers, chimneys, bridges.

REFERENCES

1. Emil Simiu and R. H. Scanlan, "Wind Effects on Structures – An Introduction to Wind Engineering", John Wiley and Sons, New York, 986.
2. C. Scruton, "An Introduction to Wind Effects on Structures", Oxford University Press, Oxford, UK, 1981.
3. Peter Sachs, "Wind Forces in Engineering", Pergamon Press. Oxford UK, 1972.
4. Lawson T. V., "Wind Effects on Buildings", Applied Science Publishers, London, UK, 1980.
5. Cook, N. J., "The designer's guide to wind loading of building structures. Part 1 Background, damage survey, wind data and structural classification. Building Research Establishment", Butterworths, U. K., 1985.
6. Cook, N. J., "Designer's guide to wind loading of building structures. Part 2: Static structures. Building Research Establishment", Butterworths, U. K., 1990.
7. Simiu, E., Scanlan, R. H., "Wind Effects on Structures: fundamentals and applications to design", 3rd Edition, John Wiley & Sons, New York, 1996.
8. Dyrbye, C., Hansen, S. O., "Wind loads on structures", John Wiley, New York, 1997.
9. Holmes, J. D., "Wind loading on Structures", Spon Press, London, U. K., 2001.
10. Nayfeh, E.H., "Introduction to perturbation techniques", Wiley-Interscience
11. Blevins, R.D., "Flow induced vibration", Van Nostrand Reinhold

AML 505 – EARTHQUAKE DYNAMICS [(3-0-0); Credits: 6]

Equation of Motion for SDOF and MDOF system subjected to base excitation, Response spectrum analysis and Time history analysis.
Modal superposition & Step by step integration for MDOF system, Numerical evaluation of dynamic response, Computer implementation.
Response spectrum analysis, Modal participation factor, Mass Participation factor, Modal combination rules, missing mass correction.
Analysis of Secondary systems, Evaluation of floor response spectra.
Response of elasto-plastic system, Effect of yield force, ductility, use of NONLIN software.
Earthquake response of multistory buildings, Torsional response of buildings.

REFERENCES

1. Chopra, A. K, "Dynamics of Structures", Prentice Hall, 1995.
2. Clough, R.W.; Penzin, J., "Dynamics of Structures", McGraw Hill, 1993.
3. Humar, J. L., "Dynamics of Structures", Prentice Hall, 1990.
4. Timoshenko, S., "Advanced Dynamics", McGraw Hill Book Co; NY, 1948.
5. Paz M, "Structural Dynamics", CBS Publishers; N-Delhi, 1995.

AML 506 - ANALYSIS AND DESIGN OF SPECIAL STRUCTURES [(3-1-0); Credits: 8]

Earthquake analysis of overhead, underground, ground supported water tanks, Single mass and two mass systems, various mathematical modeling, IS code recommendations.
ERD and detailing of Masonry buildings, Industrial structures, Chimneys, Dams.

REFERENCES

1. Farzad Naeim, "Handbook on Seismic Analysis and Design of Structures", Kluwer Academic Publisher, 2001.
2. IS 4326, "Earthquake Resistant Design and Construction of Buildings - Code of Practice", Bureau of Indian Standard; New Delhi, 1993.
3. Jain, S.K. & Jaiswal, O.R., "Guidelines for Seismic Design of Liquid Storage Tanks", NICEE, IITK, 2004.
4. Fintel, M., "Handbook of Concrete Engineering", CBS Publishers Delhi, 1986.
5. Witendry, A., "Structural Masonry", Macmillan Press Ltd..
6. Drusdale, R.; Hamid, R.; & Baker, L., "Masonry Structures - Behavior & Design", Prentice Hall, 2nd Edition; 1994.

AML 507 - ANALYSIS AND DESIGN OF BRIDGES AND RETAINING WALLS [(3-1-0); Credits: 8]

Types of bridge superstructure and introduction to their design, sub-structure, bearings, IRC / IRS Bridge loadings and other codal recommendations, Performance of Bridges in past earthquakes.
Seismic design philosophy for Bridges, State of art Modelling of bridges, Seismic Design of Substructures, Capacity design of substructures and ductile detailing, Seismic design of well and pile foundations, Modelling soil flexibility.
Earthquake behavior and Design of retaining wall and Abutments, IS code recommendations.
Design of Bearings (Free, Guided and Restrained).

REFERENCES

1. Chen, W.F. and Duan, L, "Bridge Engineering Handbook", CRC Press, 1999.
2. Fintel, M., "Handbook of Concrete Engineering" 2nd Edition, CBS Publishers Delhi, 1986.

AML 509 – ADVANCED FINITE ELEMENT METHOD [(3-1-0); Credits: 8]

Plate elements (Kirchoff theory, Mindlin plate element: triangular and rectangular, conforming / nonconforming elements), Shell elements (flat faced triangular and rectangular elements, Degenerated shell elements) Axisymmetric plate & shell elements, Ring elements.
Advanced elements: Mixed formulation, Infinite elements.
Formulation for Geometrical and Material Nonlinear problems.

Formulation of Dynamic problems, Consistent and lumped mass matrices, Implicit and Explicit numerical integration.

REFERENCES

1. Zienkiewicz, O. C. & Taylor, R. L., "Finite Element Method", Vol-I, II & III; Elsevier, 2000.
2. Hughes, T .R. J., "Finite Element Method", Dover Publication, 2000.
3. Bathe, K.J., "Finite Element Procedures", Pringor; 2nd Edition, 2002.
4. Reddy, J. N., "Finite Element Method", John Willey & Sons, 1982.
5. Pilkey, W.D. & Wunderlich, W., "Mechanics of Structures, Variation and Computational Methods", CRC Press, 2nd Edition.

AML 512 – FOUNDATIONS SUBJECTED TO VIBRATION [(3-1-0); Credits: 8]

Introduction to Foundation Vibration, Dynamic Soil Properties, Field Test and Laboratory Techniques, Elastic Modulus and Elastic Constants.
Wave Propagation in Elastic Homogeneous and Isotropic Materials, Vibration of Elastic Media, Elastic Waves
General Principle of Machine Foundation, Analysis and Design, Type of Machine Foundation, Block Type Foundation, Foundation for Impact Type Machine, Reciprocating Machine Framed Foundation
Introduction to IS Codes, Design of Different Machine Foundations based on IS Code Method
Elastic Half Space Method, Analysis based on Elastic Half Method, Different Methods based on Elastic Half Space.
Bearing Capacity of Shallow Foundation, Pile Foundation under Dynamic Load, Vibration Isolation

REFERENCES

1. Krammer., "Earthquake Geotechnical Engineering".
2. Bowles, J. E., "Foundation Analysis & Design", McGraw Hill, 5th Edition, 1996.
3. Richart; F.E.; Hall, Jr. J.R. & Wood, R.D., "Vibrations of Soil & Foundations", Prentice Hall; New Jersey, 1970.
4. Prakash; S., "Soil Dynamics", McGraw-Hill Book Co.; New York, 1981.
5. Wolf, J.P., "Dynamic soil structure interaction", Prentice-Hall, Inc. Eaglewood Cliffs, N. J., 1985.
6. Swami Saran, "Soil Dynamics and Machine Foundations", Galgotia Publications (P) Ltd, New Delhi, 1999.
7. Bhatia K. A., "Foundation for Industrial Machine", D-CAD Publishers, New Delhi, 2008.

AML 514 – ANALYSIS AND DESIGN OF ENVIRONMENTAL ENGINEERING STRUCTURES [(3-1-0); Credits: 8]

Analysis of circular water tanks with various boundary conditions at base slab, variation of hoop tension, moment and deflection of wall with various H/RT ratios, deep and shallow tanks.
Analysis of rectangular water tanks with various boundary conditions at base slab, variation of moments with respect to height/span ratio.
Design (un-cracked and cracked design) of water tank sections subjected to moment, Moment and compression, moment and tension.
Earthquake Analysis of water tanks on ground and over head tanks,
SDOF and MDOF model.
Analysis and design of jack well, WTP units and GSR etc.
Analysis and design of ESR (container and staging)

REFERENCES

1. Jain, S.K., Jaiswal, O.R., "Guidelines for seismic design of liquid storage tanks", NICEE, IITK, 2004.
2. Anchor, R.D., "Design of liquid retaining concrete structure", Edward Arnold, London, 1992.
3. BIS, IS 3370, "Indian Standard code of practice for concrete structures for the storage of liquids", Part I to IV.
4. Ghali, A, "Circular Storage Tanks and Silos", E & F N Spon, London. 1979.

CEL413 – PRESTRESSED CONCRETE STRUCTURES [(3-1-0); Credits: 8]

Design of high strength concrete mixes. Loss of prestress in single span and continuous beams. Use of IS 1343-1980, Analysis Limit State Design of beams for Tension Type II and III problems, Cracking moment, untensioned reinforcement, Partial prestressing, Stress Corrosion.

Transfer of prestress by bond, Transverse tensile stresses, End zone reinforcement. Behaviour of Bonded and unbounded prestress concrete beams.

Deflection of Prestressed concrete members, short and long term, control of deflections. Crack width considerations. Flexural strength of prestressed concrete sections: Types of flexural failures, Limit state concept.

Shear resistance of prestressed concrete members: Principal stresses and ultimate shear Resistance, Design of shear reinforcement, prestressed concrete, members in Torsion, Design of reinforcement in torsion shear and bending.

Stress distribution in end block, Analysis and Anchorage Zone reinforcement. Composite Construction of prestressed precast and cast in situ concrete. Statically Indeterminate structures: Continuous beams, primary and secondary moments, Continuity, concordant cable profile, Analysis and Design of continuous beams.

Prestressed concrete pipes and poles.Design of Prestressed concrete tanks. Prestressing of dams and bridges: Method of construction. Stage prestressing, Dynamic and Fatigue behaviour of prestressed concrete.

REFERENCES

1. Nigel R Hewon, "Prestressed Concrete Bridge, Design and construction", Thomas Telford London, 2003.
2. Devid A.Sheppard & William R. Phillps,"Plan Cast Precast and Prestressed concrete (A Design Guide)" , Mcgraw Hill Publication Co., 1989.
3. N. Krishnaraju, "Prestressed Concrete", Tata McGraw Hill, 3rd Edition, 1981.
4. Lin T.Y,Burns N.H, "Design of Prestressed Concrete Structures", John Wiley & sons, 3rd Edition,1982.

CEL 406 - ADVANCE CONCRETE TECHNOLOGY AND CONSTRUCTION [(3-1-0); Credits: 8]

Review of properties of cement, their physical and chemical properties, special purpose cements, Classification and properties of aggregates, soundness of aggregates, alkali aggregate reaction, thermal properties of aggregates, Importance of shape and Surface area and grading, gap graded and aggregates. Admixtures & construction chemicals, Use of Fly Ash, Silica Fumes, Metakaolin & GGBS in concrete Rheological behavior of concrete, requirements of workability of concrete, Durability & Effect of

environmental conditions, Strength & maturity of hardened concrete, Impact, Dynamic and fatigue behaviour of concrete, shrinkage and creep of concrete, behaviour of concrete under fire.

Permeability and Durability of concrete, Parameters of durability of concrete, chemical attack on concrete, Production of concrete; batching mixing, transportation, placing, compaction of concrete. Special methods of concreting and curing, Hot weather and cold weather concreting, Guniting (Shotcreting)

Concrete mix design, Basic considerations and choice a mix proportions, various methods of mix designs including IS Code method. Quality control and quality assurance of concrete, Acceptance criteria, Quality management in concrete construction, Inspection and testing of concrete. Non-destructive testing of concrete, core test and load test.

Special concrete such as high strength, Lightweight, heavy weight, vacuum processed concrete, Mass concrete, high performance concrete, Pumpable concrete, Self Compacting concrete, Air entrained concrete, Ferro cement, fiber reinforced concrete, Polymer impregnated concrete. Jet concrete. Recycling & re-use of industrial waste material. Deterioration and repair technology of concrete, Distress and type of repairs, crack sealing techniques

REFERENCES

1. Gambhir M.L., "Concrete Technology", Tata McGraw Hill, 2nd Edition, 1995.
2. M.S.Shetty, "M.S.Shetty", S.Chand & Company New Delhi, 2005.
3. P.Kumar Mehata, Paulo & J.M. Monteiro, "Concrete microstructure, properties & materials", Prentice Hall INC & Mcgraw Hill USA.
4. Short & Kenniburg, "Light Weight Concrete", Asia Publishing House, Bombay, 1963.
5. Orchard D.F, "Concrete Technology -Vol I. & II", Applied Science Publishers, 4th Edition, 1979.
6. Neville A.M., J.J.Brook, "Properties of Concrete", Addison Wesley, 1999.