DEPARTMENT OF APPLIED MECHANICS

Course Book for

M. Tech. in Structural Engineering

For

Academic Year
2019 - 2020

Visvesvaraya National Institute of Technology,

Nagpur-440 010 (M.S.)

Institute Vision Statement

To contribute effectively to the National and International endeavour of producing quality human resource of world class standard by developing a sustainable technical education system to meet the changing technological needs of the Country and the World incorporating relevant social concerns and to build an environment to create and propagate innovative technologies for the economic development of the Nation.

Institute Mission Statement

The mission of VNIT is to achieve high standards of excellence in generating and propagating knowledge in engineering and allied disciplines. VNIT is committed to providing an education that combines rigorous academics with joy of discovery. The Institute encourages its community to engage in a dialogue with society to be able to effectively contribute for the betterment of humankind.

Department Vision Statement

The Department is committed to provide post graduate academic and research programs to produce high quality human resource with ability to meet the global challenges associated with built environment and to emerge as centre for advanced studies in the field of structural engineering.

Department Mission Statement

The mission of the department is to achieve excellence in structural and earthquake engineering education, research and professional service. It is endeavored to equip students to assume leadership positions in engineering practice, education, research and serve mankind with structures designed for safety, serviceability and economy.

Brief about Department of Applied Mechanics:

Established in 1966, the Department of Applied Mechanics offers two post graduate programs. The department offers structural engineering subjects to B.Tech. (Civil) and B.Arch, Student along with the subject of Engineering Mechanics to the first year B. Tech. students. Since its inception, department has been actively involved in the consultancy work of structural design of structures, with emphasis on water tanks. In last decade, department has pursued many earthquake engineering related activities. Faculty members have visited earthquake affected areas after Bhuj earthquake of 2001 and Andman earthquake of 2004. At present, government funded research projects in the areas of seismic response control and damage detection are being pursued. Recently, department has procured servo-hydraulic shake table of 3m x 3m for seismic ground motion simulation.

List of faculty Members

Sr No	Name of Faculty	Designation	Qualifications	Areas of specialization
1	Mahajan M M	Professor & Head	PhD	Analysis and Design of RC structures and Machine foundation.
2	Gupta L M	Professor	PhD	Steel structures, pre stressing steel structure, Bridges rehabilitation and retrofitting of structures.
3	Ingle R K	Professor	PhD	Analysis and design of bridges, Water tanks, Buildings and special structures, Earthquake resistant design, FEM Analysis
4	Jaiswal O R	Professor	PhD	Dynamic analysis of structures (wind and earthquake loads), Analysis and Design of elevated water tank, Structural Control
5	Ronghe G N	Professor	PhD	Structural Instrumentation, Prestressed steel structures
6	Sonparote R S	Associate Professor	PhD	Software development, Soil-structure interaction, Machine foundation
7	Bakre S V	Associate Professor	PhD	FE analysis, Response control and base isolation
8	Gadve S S	Associate Professor	PhD	Repairs, Rehabilitation, RC/PSC structures, Concrete technology, FE analysis
9	Borghate S B	Associate Professor	PhD	RC structures
10	Ratnesh Kumar	Associate Professor	PhD	Performance-based design, Seismic evaluation and retrofitting, Seismic vulnerability and risk assessment
11	Vyavahare A Y	Assistant Professor	PhD	FEM analysis, Steel structures, Steel connection
12	Khatri A P	Assistant Professor	PhD	Steel structures, Stability of structures, RC and prestressed structures
13	Datta D	Assistant Professor	PhD	Structural dynamics, Seismic response of structures, Structural reliability
14	Goel M D	Assistant Professor	PhD	Blast Resistant Design of Structures, Behavior of Materials at Low, Medium and High Rate of Loadings, Numerical Simulation and Analysis of Blast and Impact Events, Crashworthiness and Impact Mechanics

UG/ PG Programmes Offered by Department of Applied Mechanics:

The department offers following postgraduate programmes

	Program	Description
PG	M. Tech. in 1. Structural Engineering 2. Structural Dynamics and Earthquake Engineering	Intake 25 25

Credit System at VNIT

Education at the Institute is organized around the semester-based credit system of study. The prominent features of the credit system are a process of continuous evaluation of a student's performance / progress and flexibility to allow a student to progress at an optimum pace suited to his/her ability or convenience, subject to fulfilling minimum requirements for continuation. A student's performance/progress is measured by the number of credits he/she has earned, i.e. completed satisfactorily. Based on the course credits and grades obtained by the student, grade point average is calculated. A minimum number of credits and a minimum grade point average must be acquired by a student in order to qualify for the degree.

Course credits assignment

Each course, except a few special courses, has certain number of credits assigned to it depending on lecture, tutorial and laboratory contact hours in a week.

For Lectures and Tutorials: One lecture hour per week per semester is assigned one credit and

For Practical/ Laboratory/ Studio: One hour per week per semester is assigned half credit.

Example: Course XXXXXX with (3-0-2) as (L-T-P) structure, i.e. 3 hr Lectures + 0 hr Tutorial + 2 hr Practical per week, will have (3x1 + 0x1 + 2x0.5 =) 4 credits.

Grading System

The grading reflects a student's own proficiency in the course. While relative standing of the student is clearly indicated by his/her grades, the process of awarding grades is based on fitting performance of the class to some statistical distribution. The course coordinator and associated faculty members for a course formulate appropriate procedure to award grades. These grades are reflective of the student's performance vis-à-vis instructor's expectation. 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, a student is given a Grade. Each grade has got certain grade points as follows:

Grade	Grade points	Description
AA	10	Outstanding
AB	9	Excellent
BB	8	Very good
BC	7	Good
CC	6	Average
CD	5	Below average
DD	4	Marginal (Pass Grade)
FF	0	Poor (Fail) /Unsatisfactory / Absence from end-sem exam
NP	-	Audit pass
NF	-	Audit fail
SS	-	Satisfactory performance in zero credit core course
ZZ	-	Unsatisfactory performance in zero credit core course
W	-	Insufficient attendance

Performance Evaluation

The performance of a student is 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. CGPA is rounded up to second decimal.

The Earned Credits (ECR) are defined as the sum of course credits for courses in which students have been awarded grades between AA to DD. Grades obtained in the audit courses are not counted for computation of grade point average.

Earned Grade Points in a semester (EGP) = **Σ** (Course credits x Grade point) for courses in which AA- DD grade has been obtained

SGPA = EGP / Σ (Course credits) for courses registered in a semester in which AA- FF grades are awarded

CGPA= EGP / Σ (Course credits) for courses passed in all completed semesters in which AA- DD grades are awarded

Overall Credits Requirement for Award of Degree

SN	Category of Course	Symbol	Credit Requirement			
			B. Tech. (4-Year)	B. Arch. (5 Year)	M. Tech. (2 Year)	M. Sc. (2 Year)
	Program Core					
1	Basic Sciences (BS)	BS	18	04	-	-
2	Engineering Arts & Sciences (ES)	ES	20	18	-	-
3	Humanities	HU/ HM*	05	06	-	-
4	Departmental core	DC	79-82	168	33-39	54-57
	Program Elective					
3	Departmental Elective	DE	33-48	17-23	13-19	06-09
4	Humanities & Management	HM	0-6	0-3	-	-
5	Open Course	OC	0-6	0-3	-	-
Total requirement :BS + ES + DC+ DE + HM + OC =			**170**	**219**	**52**	**63**
Minimum Cumulative Grade Point Average required for the award of degree			**4.00**	**4.00**	**6.00**	**4.00**

Attendance Rules

1. All students must attend every class and 100% attendance is expected from the students. However, in consideration of the constraints/ unavoidable circumstances, the attendance can be relaxed by course coordinator only to the extent of not more than 25%. Every student must attend minimum of 75% of the classes actually held for that course.
2. A student with less than 75% attendance in a course during the semester, will be awarded W grade. Such a student will not be eligible to appear for the end semester and re-examination of that course. Even if such a student happens to appear for these examinations, then, answer books of such students will not be evaluated.
3. A student with W grade is not eligible to appear for end semester examination, reexamination & summer term.

Program Outcomes for M.Tech in
Structural Engineering

a) PO1: An ability to independently carry out research /investigation and development work to solve practical problems
b) PO2: An ability to write and present a substantial technical report/document
c) PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
d) PO4: Student should be able to understand the state of art need, professional, ethical practices, servicesto the society and socio economic relevance while executing the civil engineering project.

Scheme of Instructions for M. Tech. in Structural Engineering

Semester I

Sr.No.	Course Code	Course Name	Type	Structure L-T-P	Credits
1	AML521	Matrix Method of Structural Analysis	DC	3-1-0	4
2	AML522	Structural Dynamics	DC	3-1-0	4
3	AMP522	Structural Dynamics Laboratory	DC	0-0-2	1
4	AML523	Theory of Elasticity and Plasticity	DC	3-0-0	3
5	AMP529	Research Methodology and Communication Skill	DC	0-0-2	1
					Core Credits = 13
		Elective			
7		Elective-I	DE	3-0-0	3
8		Elective-II	DE	3-0-0	3
					Elective Credits = 6
					DC + DE = 19 Credits

Semester II

Sr.No.	Course Code	Course Name	Type	Structure L-T-P	Credits
1	AML524	Design of Advanced Reinforced Concrete Structures	DC	3-0-0	3
2	AMP524	Design of Advanced Reinforced Concrete Structures	DC	0-0-2	1
3	AML525	Design of Advanced Steel Structures	DC	3-0-0	3
4	AMP525	Design of Advanced Steel Structures	DC	0-0-2	1
5	AMP530	Technical Writing and Presentation	DC	0-0-2	1
					Core Credits = 9
		Elective			
7		Elective-III	DE	3-0-0	3
8		Elective-IV	DE	3-0-0	3
		Elective-V	DE	3-0-0	3
					Elective Credits = 9
					DC + DE = 18 Credits

Semester III

Sr.No.	Course Code	Course Name	Type	Structure L-T-P	Credits
1	AMD501	Project Phase-I	DC	-	3
					Core Credits = 3
		Elective			
2		Elective-VI	DE	-	3
					Elective Credits = 3
					DC + DE = 6 Credits

Semester IV

Sr.No.	Course Code	Course Name	Type	Structure L-T-P	Credits
1	AMD502	Project Phase-II	DC	-	9
					Core Credits = 9
		Elective			
-		-	-	-	-
					Elective Credits = 0
					DC + DE = 9 Credits

Total Credits Required for Award of Degree	DC	DE	DC+DE
	34	**18**	52

List of Departmental Electives

Sr No	Code	Name of Subject	L-T-P	Credits	Pre-requisite/Remark
1	AML523	Theory of Elasticity and Plasticity	3-0-0	3	Available as Elective to M. Tech. (SDEE)
2	AML524	Design of Advanced Reinforced Concrete Structures	3-0-0	3	Available as Audit to M. Tech. (SDEE)
3	AML525	Design of Advanced Steel Structures	3-0-0	3	Available as Audit to M. Tech. (SDEE)
4	AML526	Introduction to Earthquake Engineering	3-0-0	3	Available as Elective to M. Tech. (STR)
5	AML527	Earthquake Resistant Design of Reinforced Concrete Buildings	3-0-0	3	Available as Audit to M. Tech. (STR)
6	AML528	Earthquake Resistant Design of Steel Buildings	3-0-0	3	Available as Audit to M. Tech. (STR)
7	AML541	Theory of Plates and Shells	3-0-0	3	
8	AML542	Stability of Structures	3-0-0	3	
9	AML543	Earthquake Dynamics	3-0-0	3	AML522
10	AML544	Soil Dynamics	3-0-0	3	AML522
11	AML545	Wind Effects on Structures	3-0-0	3	AML522
12	AML546	Earthquake Effect on Structures	3-0-0	3	AML522
13	AML547	Numerical Methods and Programming	3-0-0	3	
14	AML548	Soil Structure Interaction	3-0-0	3	
15	AML549	Finite Element Method	3-0-0	3	
16	AML550	Design of Prestressed Concrete Structures	3-0-0	3	

Sr No	Code	Name of Subject	L-T-P	Credits	Pre-requisite/Remark
17	AML551	Analysis and Design of Foundations	3-0-0	3	
18	AML552	Analysis and Design of Industrial Steel Structures	3-0-0	3	
19	AML553	Analysis and Design of Bridges	3-0-0	3	
20	AML554	Analysis and Design of Water Retaining Structures	3-0-0	3	
21	AML555	Analysis and Design of Machine Foundations	3-0-0	3	AML522
22	AML556	Analysis and Design of Multistoried Buildings	3-0-0	3	
23	AML557	Analysis and Design of Irrigation Structures	3-0-0	3	
24	AML558	Analysis and Design of Composite Structures	3-0-0	3	
25	AML559	Analysis and Design of Masonry Structure	3-0-0	3	
26	AML560	Analysis and Design of Gravity Dams and Retaining Walls	3-0-0	3	
27	AML561	Design of Prestressed Steel Structures	3-0-0	3	
28	AML562	Instrumentation and Rehabilitation of Structures	2-0-2	3	
29	AML563	Seismic Evaluation and Retrofitting of Structures	3-0-0	3	AML522
30	AML564	Seismic Risk and Hazard Assessment	3-0-0	3	
31	AML565	Structural Reliability Analysis	3-0-0	3	
32	AML566	Random Vibration Analysis	3-0-0	3	AML522
33	AML567	Structural Vibration Control	3-0-0	3	AML522
34	AML568	Advanced Concrete Technology	3-0-0	3	
35	AML569	Disaster Management and Mitigation	3-0-0	3	
36	AML570	Design of Blast Resistant Structures	3-0-0	3	

AML521 MATRIX METHOD OF STRUCTURAL ANALYSIS (DC)

Credit: **4**

Contact hours (L-T-P): **3-1-0**

Pre-requisites: **Nil**

Overlaps with: **Nil**

Course Objective

The objective of this course is to introduce to the students, matrix-based approach for linear elastic analysis of skeletal structure.

Course Outcomes

After successfully completion of this course, the students shall acquire,

i. Knowledge of development of stiffness matrix for prismatic members,
ii. Knowledge of matrix computations,
iii. Ability to analyze determinate and indeterminate plane and space truss / frame system,

Relationship of Course Outcomes to Program Outcomes

H = 100; M = 75; L = 50

POs → COs ↓	PO1	PO2	PO3	PO4
CO1	H			
CO2	H			
CO3	H			

Content

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. Problems on beam on elastic foundation

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 anti-symmetric conditions, modeling guidelines for framed structures.

Use of MATLAB/MATHCAD / other software.

Text Books/ Reference Books

1. Cheng, F. Y. (2000). Matrix analysis of structural dynamics: applications and earthquake engineering. CRC Press.
2. Kanchi, M. B. (1993). *Matrix methods of structural analysis*. New Age International.
3. Kassimali, A. (2011). *Matrix Analysis of Structures SI Version*. Cengage Learning.
4. Cook, R. D. (2007). Concepts and applications of finite element analysis. John Wiley & Sons.
5. Weaver, W., & Gere, J. M. (1990). *Matrix Analysis Framed Structures*. Springer Science & Business Media.
6. Martin, H. C. (1966). Introduction to matrix methods of structural analysis. MacGraw-Hill.
7. Godbole, P., Sonparote, R., &Dhote, S. (2014). M*atrix methods of structural analysis*. PHI Learning Pvt. Ltd..
8. Wang, C. K., *Matrix methods of structural analysis:* International Textbook Compant 1970.
9. Livesley, R. K. (2013). Matrix Methods of Structural Analysis: Pergamon International Library of Science, Technology, Engineering and Social Studies. Elsevier.
10. Mehgre, A. S., & Deshmukh S. K. (2015) Matrix method of structural analysis: Charotar Publishing House Pvt. Ltd.
11. McGuire, W., Gallaghar R. H. &Zimian, R. D. Matrix structure analysis. John Willey Publication.
12. Przemieniecki J. S. Theory of matrix structural analysis, Dover Pulication Inc. New York

AML522 STRUCTURAL DYNAMICS (DC)

Credit: **4**

Contact hours (L-T-P): **3-1-0**

Pre-requisites: **Nil**

Overlaps with: **Nil**

Course Objective

To introduce fundaments of vibrations of SDOF, MDOF and continuous systems.

Course Outcomes

At the completion of this course, the student shall acquire knowledge and ability,

i. To convert structure into SDOF system and find response of free and force vibration (harmonic, periodic and transient),
ii. To find natural frequency and mode shapes of MDOF system and carry out modal analysis

Relationship of Course Outcomes to Program Outcomes

H = 100; M = 75; L = 50

POs → / COs ↓	PO1	PO2	PO3	PO4
CO1	H		H	L
CO2	H		H	L

Content

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, viscous 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. Generation and use of response spectra, Numerical evolution of dynamic response of linear systems, Multiple degree of Freedom system: Vibration of MDOF systems; Response of MDOF to harmonic excitation, mode superposition, vibration absorber, Lagrange equation and their application to lumped parameter models of MDOF. Methods of solving eigen value problems;. Dynamic response of MDOF systems-response spectrum and 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.

Text Books/ Reference Books

1. Chopra, A. K. (1995). *Dynamics of structures* (Vol. 3). New Jersey: Prentice Hall.
2. Clough, R. W., &Penzien, J. (1993). Dynamics of structures, vol. 2.
3. Humar, J. L. Dynamics of Structures, Prentice-Hall, Englewood Cliffs, NJ, 1990.
4. Paz, M. (2012). *Structural dynamics: theory and computation*. Springer Science & Business Media.
5. Timoshenko, S. P., & Young, D. H. (1948). Advanced dynamics. McGraw Hill
6. Meirovitch, L. (1975). *Elements of vibration analysis*. McGraw-Hill.
7. Biggs, J. M., & Testa, B. (1964). Introduction to structural dynamics.
8. Craig, R. R., &Kurdila, A. J. (2006). *Fundamentals of structural dynamics*. John Wiley & Sons.
9. Filiatrault, A. (2013). Elements of earthquake engineering and structural dynamics. Presses inter Polytechnique.
10. Buchholdt, H. A. (1997). *Structural dynamics for engineers*. Thomas Telford.
11. Paultre, P. (2013). *Dynamics of structures*. John Wiley & Sons

AMP522 STRUCTURAL DYNAMICS LABORATORY (DC)

Credit: **1**

Contact hours (L-T-P): **0-0-2**

Pre-requisites: **Nil**

Overlaps with: **Nil**

Course Objectives

To introduce fundaments of vibrations of SDOF and MDOF systems through experiments and analytical simulations.

Course Outcomes

i. At the completion of this course, the student shall acquire knowledge and ability to perform experiments and computer simulation of vibrating system.

ii. Student shall write practical report with detailed theory, observations and conclusions.

Relationship of Course Outcomes to Program Outcomes

H = 100; M = 75; L = 50

POs → / COs ↓	PO1	PO2	PO3	PO4
CO1	M	H	L	
CO2	H	H	L	

Content

1. To find the time period of compound pendulum
2. To find natural frequency of SDOF system
3. To find natural frequency of two DOF system
4. To find natural frequency of three system
5. To observe liquefaction of soil
6. To observe phenomenon of vibration absorption
7. Frequency analysis of MDOF systems using software
8. Generation of response spectrum
9. Response of MDOF system using modal superposition
10. Response spectrum analysis of MDOF system using software

AML523 THEORY OF ELASTICITY AND PLASTICITY (DC)

Credit: **3**

Contact hours (L-T-P): **3-0-0**

Pre-requisites: **Nil**

Overlaps with: **Nil**

Course Objectives

The main objective of studying this course is to understand the theoretical concepts of material behavior with particular emphasis on their elastic and plastic properties.

Course Outcomes

At the completion of this course, the student shall acquire knowledge and ability,

i. To define state of stress and strains, equilibrium and compatibility,

ii. To derive the governing equations and their solutions for application to problems in plane stress state, plane strain state, torsion, bending.

Relationship of Course Outcomes to Program Outcomes

H = 100; M = 75; L = 50

POs → / COs ↓	PO1	PO2	PO3	PO4
CO1	H	M	H	M
CO2	H	M	H	M

Content

Stress transformation and strain transformation at a point in an elastic body, rigid body translation and rotation of an element in space. Generalized Hook’s law, Principal stresses and strains.

Two dimensional problems in elasticity: Plain stress, Plain strain and Axisymmetric problems. Boundary conditions, stress functions.

Three dimensional problems in elasticity: Differential equation of equilibrium in 3D, condition of compatibility determination of displacement, principle of superposition, uniqueness theorem, torsion of bars. Membrane analogy

Theory of failures

Introduction to plasticity: Criterion of yielding strain hardening rules of plastic flow different stress strain relation.total strain theory, theorem of limit analysis, elasto-plastic bending and torsion of bars.

Reference Books/Material

1. Ugural, A. C., & Fenster, S. K. (2003). *Advanced strength and applied elasticity*. Pearson education.
2. Timoshenko, S. P., & Goodier, J. N. (1971). Theory of Elasticity, McGraw-Hill, New York, 1970. Fok-Ching Chong received the BS degree from the Department of Electrical Engineering, National Taiwan University, Taipei, Taiwan, in.
3. Shames, I. H. (1964). Mechanics of deformable solids.
4. Srinath, L. S. (2003). *Advanced mechanics of solids*. Tata McGraw-Hill.
5. Chakrabarty, J. (2012). *Theory of plasticity*. Butterworth-Heinemann.
6. Timoshenko, S. (1953). History of strength of materials: with a brief account of the history of theory of elasticity and theory of structures. Courier Corporation.
7. Boresi, A. P., Chong, K., & Lee, J. D. (2010). *Elasticity in engineering mechanics*. John Wiley & Sons.
8. Popov, E. P., & Balan, T. A. (1968). Mechanics of solids. *Mexico City, Mexico: Pearson Education, 2000)(in Spanish)*.
9. NPTEL Lecture Notes: IIT, Madras.
10. Hill, R. (1998). *The mathematical theory of plasticity* (Vol. 11). Oxford university press.
11. Lubliner, J. (2008). *Plasticity theory*. Courier Corporation.

AML524 DESIGN OF ADVANCED REINFORCED CONCRETE STRUCTURES (DC)

Credit: **3**

Contact hours (L-T-P): **3-0-0**

Pre-requisites: **Nil**

Overlaps with: **Nil**

Course Objectives

To introduce method for design of RC structures with loading standards as per code provisions

Course Outcomes

At the completion of this course, the student shall acquire knowledge and ability,

i. To understand methods of reinforce concrete design,
ii. To design various types of RC structures
iii. To understand techniques and method of communicating engineering design to industry

Relationship of Course Outcomes to Program Outcomes

H = 100; M = 75; L = 50

POs → / COs ↓	PO1	PO2	PO3	PO4
CO1	H	L	M	L
CO2	H	L	M	L
CO3	H	L	M	L

Content

Review of limit state design and loadings as per applicable codes.

Analysis, design and detailing of simple buildings

Analysis, design and detailing of folded plates and cylindrical shells (beam and arch theory),

Analysis, design and detailing of deck slab bridges, Analysis, design and detailing cylindrical water tanks resting on ground (fixed and hinged boundary conditions at base),

Analysis, design and detailing of circular silos including foundations,

Analysis, design and detailing of cylindrical chimneys including foundations

Reference Books / Material

1. Naeim, F., & Kelly, J. M. (1999). Design of seismic isolated structures: from theory to practice. John Wiley & Sons.

2. Paulay, T., & Priestly, M. J. N. (2009). Seismic design of RC and masonry buildings. John Wiley & Sons, Inc..
3. Booth, E. D. (1994). *Concrete structures in earthquake regions: design and analysis*. Longman Scientific & Technical; Copublished in the US with J. Wiley.
4. Reynolds, C. E., Steedman, J. C., &Threlfall, A. J. (2007). *Reinforced concrete designer's handbook*. CRC Press.
5. Reynolds, C. E. (1962). *Basic Reinforced Concrete Design: Elementary* (Vol. 1). Concrete Publications.
6. Fintel, M. (Ed.). (1974). *Handbook of concrete engineering* (p. 801). New York: Van Nostrand Reinhold.
7. Chen, W. F., &Duan, L. (Eds.). (2014). Bridge Engineering Handbook: Construction and Maintenance. CRC press.
8. Gaylord, E. H., Gaylord, C. N., &Stallmeyer, J. E. (1997). *Structural engineering handbook.*
9. Wai-Fah, C., &Lian, D. (2000). Bridge engineering handbook. *New York: CRC Press.*
10. Nilson, A. (1997). *Design of concrete structures* (No. 12th Edition).

AMP524 DESIGN OF ADVANCED REINFORCED CONCRETE STRUCTURES (DC)

Credit: 1

Contact hours (L-T-P): 0-0-2

Pre-requisites: Nil

Overlaps with: Nil

Course Objectives

To develop skill for design and detailing of various reinforced concrete structures

Course Outcomes

The students will learn techniques and method of communicating engineering design to industry

Relationship of Course Outcomes to Program Outcomes

H = 100; M = 75; L = 50

POs → / COs ↓	PO1	PO2	PO3	PO4
CO1	H	L	M	L

Content

Study of construction materials and construction technique related to reinforced concrete structural design including site visits/visit to structural design office

Experimental evaluation of elements and design examples (2- 3) including report writing and drawing based on syllabus.

AML525 DESIGN OF ADVANCED STEEL STRUCTURES (DC)

Credit: **3**

Contact hours (L-T-P): **3-0-0**

Pre-requisites: **Nil**

Overlaps with: **Nil**

Course Objectives

To introduce method for design of steel structures with loading standards as per code provisions

Course Outcomes

At the completion of this course, the student shall acquire knowledge and ability,

i. To understand methods of structural steel design,
ii. To design various types of steel structures
iii. To understand techniques and method of communicating engineering design to industry

Relationship of Course Outcomes to Program Outcomes

H = 100; M = 75; L = 50

POs → / COs ↓	PO1	PO2	PO3	PO4
CO1	H	L	H	H
CO2	H	M	H	H
CO3	H	H	H	H

Content

Review of allowable stress, plastic design and limit state design and loadings as per applicable codes.

Design of Beams, Beam-column, Plate Girders

Design of open web structures and space structures

Design of bridges and composite structures

Design of industrial buildings including crane/gantry girders

Welded, riveted and bolted connections

Reference Books/Material

1. Trahair, N. S., Bradford, M. A., Nethercot, D., & Gardner, L. (2007). *The behaviour and design of steel structures to EC3*. CRC Press.

2. Englekirk, R. E. (1994). Steel structures: Controlling behavior through design.
3. Johnson, R. P. (2008). Composite structures of steel and concrete: beams, slabs, columns, and frames for buildings. John Wiley & Sons.
4. Oehlers, D. J., & Bradford, M. A. (2013). Composite Steel and Concrete Structures: Fundamental Behaviour: Fundamental Behaviour. Elsevier.
5. Manual, C. F. S. D. (2002). American Iron and Steel Institute. *Washington, DC*.
6. Yu, W. W., &LaBoube, R. A. (2010). *Cold-formed steel design*. John Wiley & Sons.
7. Brockenbrough, R. L., & Johnston, B. G. (1974). *Steel design manual*. United States Steel Corporation.
8. Schafer, B. W. (2002). Design Manual for Direct Strength Method of Cold-Formed Steel Design. Report to the American Iron and Steel Institute, Washington, DC (available online www. ce. jhu. edu/bschafer/direct_strength).
9. Brockenbrough, R. L., & Johnston, B. G. (1968). *USS Steel design manual*. United States Steel Corporation.
10. Chen, W. F., & Kim, S. E. (1997). *LRFD steel design using advanced analysis* (Vol. 13). CRC press.
11. Owens, G. W., & Knowles, P. R. (1992). *Steel designers manual*.
12. Manual, A. S. D. (1988). Rev. 2. American Iron and Steel Institute, Washington DC, USA, 1-4.
13. Packer, J. A., & Henderson, J. E. (1997). *Hollow structural section connections and trusses: a design guide*. Willowdale, Ont.: Canadian Institute of Steel Construction.

AMP525 DESIGN OF ADVANCED STEEL STRUCTURES (DC)

Credit: 1

Contact hours (L-T-P): 0-0-2

Pre-requisites: Nil

Overlaps with: Nil

Course Objectives

To develop skill for design and detailing of various steel structures

Course Outcomes

The students will learn techniques and method of communicating engineering design to industry

Relationship of Course Outcomes to Program Outcomes

H = 100; M = 75; L = 50

POs → / COs ↓	PO1	PO2	PO3	PO4
CO1	H	H	H	H

Content

Study of construction materials and construction technique related to steel structural design including site visits/visit to structural design office

Experimental evaluation of elements and design examples (2- 3) including report writing and drawing based on syllabus.

AML526 INTRODUCTION TO EARTHQUAKE ENGINEERING (DE)

Credit: **3**

Contact hours (L-T-P): **3-0-0**

Pre-requisites: **Nil**

Overlaps with: **Nil**

Course Objectives

To expose students to fundamentals of earthquake engineering and seismic conditions of the country and world

Course Outcomes

At the completion of this course, the student shall acquire knowledge and ability,

i. To understand the fundamentals of earthquake engineering and seismicity conditions of the country and world.
ii. To perform site specific deterministic seismic hazard analysis and to analyze earthquake characteristics and associated effects on structures, including linear responses.
iii. To evaluate the magnitude and distribution of seismic loads for strength, stress and load-resistant design and to apply the basic principles for seismic design and construction of structures in accordance with the provisions of Indian Standard Codes.

Relationship of Course Outcomes to Program Outcomes

H = 100; M = 75; L = 50

POs → / COs ↓	PO1	PO2	PO3	PO4
CO1	H	M	H	L
CO2	H	H	M	L
CO3	H	H	H	L

Content

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 (I-V), IS 4326, seismic forces on nonstructural elements.

Introduction to earthquake disaster management and mitigation

Use of MATLAB or similar software for Time history analysis and generation of Response spectra

Reference Books/Material

1. Dowrick, D. J. (2003). *Earthquake risk reduction*. John Wiley & Sons.
2. Dowrick, D. J. (2009). Earthquake resistant design and risk reduction. John Wiley & Sons.
3. Housner, G. W., & Jennings, P. C. (1982). *Earthquake design criteria*. Berkeley, California: Earthquake Engineering Research Institute.
4. Newmark, N. M., & Hall, W. J. (1982). Earthquake spectra and design. *Earth System Dynamics, 1*.
5. Wakabayashi, M. (1986). *Design of earthquake-resistant buildings*. McGraw-Hill Companies.
6. Okamoto, S. (1973). Introduction to earthquake engineering.
7. Wilson, E. L. (1998). Three dimensional static and dynamic analysis of structures: a physical approach with emphasis on earthquake engineering. Computers and Structures Inc..
8. Kramer, S. L. (1996). *Geotechnical earthquake engineering* (Vol. 80). Upper Saddle River, NJ: Prentice Hall.
9. Bullen, K. E., Bullen, K. E., & Bolt, B. A. (1985). *An introduction to the theory of seismology*. Cambridge university press.
10. Bolt, B. A., Horn, W. L., MacDonald, G. A., & Scott, R. F. (2013). *Geological Hazards: Earthquakes-Tsunamis-Volcanoes-Avalanches-Landslides-Floods*. Springer Science & Business Media.
11. Elnashai, A. S., & Di Sarno, L. (2008). *Fundamentals of earthquake engineering* (p. 347). New York: Wiley.

AML527 EARTHQUAKE RESISTANT DESIGN OF RC BUILDINGS (DE)

Credit: **3**

Contact hours (L-T-P): **3-0-0**

Pre-requisites: **Nil**

Overlaps with: **Nil**

Course Objectives

To introduce method for earthquake resistant design of RC buildings

Course Outcomes

At the completion of this course, the student shall acquire knowledge and ability,

i. to correlate information from various engineering and scientific discipline to understand design principles and complex behavior of RC buildings subjected to seismic forces,

ii. to design RC buildings elements in accordance with the provisions of Indian building codes with exposure to other national building codes.

iii. to compute various parameters required determine inelastic behavior of RC elements.

Relationship of Course Outcomes to Program Outcomes

H = 100; M = 75; L = 50

POs → / COs ↓	PO1	PO2	PO3	PO4
CO1	H	-	H	L
CO2	M	M	H	H
CO3	M	-	H	-

Content

Review of Limit State Method (LSM), Introduction to various Codes, Seismic Hazard Estimation, Introduction to international codes

IS Code provisions on various irregularities with seismic performance of structures in past earthquakes

Effect of stiffness, strength and ductility on seismic performance of structures

Analysis of buildings using equivalent static and response spectrum method

Design and detailing of RC framed building elements (beam, column, shear wall, diaphragm and beam-column joint), Introduction to nonlinear analyses methods, Analysis of a building using nonlinear static procedure

Introduction to capacity design concepts and displacement based design methods.

Reference Books/Material

1. Naeim, F. (1989). *The seismic design handbook*. Springer Science & Business Media.
2. Gupta, A. K. (1992). Response spectrum method in seismic analysis and design of structures (Vol. 4). CRC press.
3. Beskos, D. E., &Anagnostopoulos, S. A. (1997). Computer analysis and design of earthquake resistant structures: a handbook. WIT Press.
4. Paulay, T., & Priestly, M. J. N. (2009). *Frontmatter* (pp. i-xxiii). John Wiley & Sons, Inc..
5. Dowrick, D. J. (1977). Earthquake resistant design. A manual for engineers and architects (No. Monograph).
6. Booth, E. D. (1994). *Concrete structures in earthquake regions: design and analysis*. Longman Scientific & Technical; Copublished in the US with J. Wiley.
7. Park, R., &Paulay, T. (1975). *Reinforced concrete structures*. John Wiley & Sons.
8. FEMA, P. (2000). Commentary for the Seismic Rehabilitation of Buildings.*FEMA-356, Federal Emergency Management Agency, Washington, DC*.

AMP527 EARTHQUAKE RESISTANT DESIGN OF RC BUILDINGS (DE)

Credit: 1

Contact hours (L-T-P): 0-0-2

Pre-requisites: Nil

Overlaps with: Nil

Course Objectives

To develop skill for design and detailing of earthquake resistant RC buildings

Course Outcomes

The students will learn techniques and method of communicating engineering design to industry

Relationship of Course Outcomes to Program Outcomes

H = 100; M = 75; L = 50

POs → / COs ↓	PO1	PO2	PO3	PO4
CO1	M	H	H	H

Content

Study of construction materials and construction technique related to reinforced concrete structural design including site visits/visit to structural design office

Experimental evaluation of elements and design examples (2- 3) including report writing and drawing based on syllabus.

AML528 EARTHQUAKE RESISTANT DESIGN OF STEEL BUILDINGS (DE)

Credit: **3**

Contact hours (L-T-P): **3-0-0**

Pre-requisites: **Nil**

Overlaps with: **Nil**

Course Objectives

To introduce method for earthquake resistant design of steel buildings

Course Outcomes

At the completion of this course, the student shall acquire knowledge and ability,

i. To determine seismic actions on typical steel structures using simplified methods of analysis and to identify suitable lateral resisting systems which are capable of providing effective earthquake resistance for steel building structures.

ii. To understand the response characteristics of typical steel members and connections under cyclic and earthquake loads.

iii. To apply the main design rules and detailing requirements for moment resisting and braced steel systems according to the provisions of Indian Standard, IS 800:2007.

Relationship of Course Outcomes to Program Outcomes

H = 100; M = 75; L = 50

POs → / COs ↓	PO1	PO2	PO3	PO4
CO1	L	H	H	L
CO2	M	M	H	M
CO3	M	H	H	H

Content

Basics of Steel Design, Introduction to plastic analysis and design, Design philosophy for steel structures, Introduction to international codes

Performance of steel structures in past earthquakes, Capacity design concept, Ductility of steel buildings, Seismic behaviour of steel buildings, Stability considerations,

Analysis of buildings using equivalent static and response spectrum method

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).

Reference Books/Material

1. Englekirk, R. E. (1994). Steel structures: Controlling behavior through design. Wiley
2. Bruneau, M., Uang, C. M., &Sabelli, S. R. (2011). *Ductile design of steel structures*. McGraw Hill Professional.
3. Mazzolani, F., &Piluso, V. (1996). Theory and design of seismic resistant steel frames. CRC Press.
4. Trahair, N. S., Bradford, M. A., Nethercot, D., & Gardner, L. (2007). The behaviour and design of steel structures to EC3. CRC Press.
5. Johnson, R. P. (2008). Composite structures of steel and concrete: beams, slabs, columns, and frames for buildings. John Wiley & Sons.
6. Oehlers, D. J., & Bradford, M. A. (2013). Composite Steel and Concrete Structures: Fundamental Behaviour: Fundamental Behaviour. Elsevier.
7. Manual, C. F. S. D. (2002). American Iron and Steel Institute. Washington, DC.
8. Yu, W. W., &LaBoube, R. A. (2010). Cold-formed steel design. John Wiley & Sons.
9. Brockenbrough, R. L., & Johnston, B. G. (1974). Steel design manual. United States Steel Corporation.
10. Chen, W. F., & Kim, S. E. (1997). LRFD steel design using advanced analysis (Vol. 13). CRC press.
11. Owens, G. W., & Knowles, P. R. (1992). Steel designers manual.
12. Manual, A. S. D. (1988). Rev. 2. American Iron and Steel Institute, Washington DC, USA, 1-4.
13. Packer, J. A., & Henderson, J. E. (1997). Hollow structural section connections and trusses: a design guide. Willowdale, Ont.: Canadian Institute of Steel Construction.

AMP528 EARTHQUAKE RESISTANT DESIGN OF STEEL BUILDINGS (DE)

Credit: **1**

Contact hours (L-T-P): **0-0-2**

Pre-requisites: **Nil**

Overlaps with: **Nil**

Course Objectives

To develop skill for design and detailing of earthquake resistant steel buildings

Course Outcomes

The students will learn techniques and method of communicating engineering design to industry

Relationship of Course Outcomes to Program Outcomes

H = 100; M = 75; L = 50

POs → / COs ↓	PO1	PO2	PO3	PO4
CO1	H	H	H	H

Content

Study of construction materials and construction technique related to steel structural design including site visits/visit to structural design office

Experimental evaluation of elements and design examples (2- 3) including report writing and drawing based on syllabus.

AMP529 RESEARCH METHODOLOGY AND COMMUNICATION SKILL (DC)

Credit:	**1**
Contact hours (L-T-P):	**0-0-2**
Pre-requisites:	**Nil**
Overlaps with:	**Nil**

Course Objectives

To develop habit for understanding the state of art of research on given subject area and develop skill of good report writing and presentation.

Course Outcomes

The students will learn techniques and method of analyzing a research problem, technical report writing and presentation

Relationship of Course Outcomes to Program Outcomes

H = 100; M = 75; L = 50

POs → / COs ↓	PO1	PO2	PO3	PO4
CO1	M	H	L	M

Content

The seminar will be on review research paper given by faculty and it will be evaluated by faculties of the department (team wise).

AMP530 TECHNICAL WRITING AND PRESENTATION (DC)

Credit: **1**

Contact hours (L-T-P): **0-0-2**

Pre-requisites: **Nil**

Overlaps with: **Nil**

Course Objectives

To develop habit for understanding the state of art of research on given subject area and develop skill of good report writing and presentation.

Course Outcomes

The students will learn techniques of literature review, method of analyzing a research problem, technical report writing and presentation

Relationship of Course Outcomes to Program Outcomes

H = 100; M = 75; L = 50

POs → / COs ↓	PO1	PO2	PO3	PO4
CO1	M	H	L	M

Content

The seminar will be on the project allotted at the end of 1st semester.

AML541 THEORY OF PLATES AND SHELLS (DE)

Credit: 3

Contact hours (L-T-P): 3-0-0

Pre-requisites: Nil

Overlaps with: Nil

Course Objectives

To understand the basic concept, mathematical modeling, behavior and analysis of plate and shell structures.

Course Outcomes

At the completion of this course, the student shall acquire knowledge and ability,

i. To understand the behavior of plates and analytical techniques to solve the two dimensional structural engineering problems and ability to construct the mathematical models of structural systems.
ii. To apply differential equations for the calculation of response of two dimensional problems.

Relationship of Course Outcomes to Program Outcomes

H = 100; M = 75; L = 50

POs → / COs ↓	PO1	PO2	PO3	PO4
CO1	M	M	M	H
CO2	M	M	H	H

Content

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

Reference Books/ Material

1. Timoshenko, S., &Woinowsky-Krieger, S. (1959). *Theory of plates and shells* (Vol. 2, p. 120). New York: McGraw-hill.
2. Szilard, R. (1974). Theory and analysis of plates.
3. Novozhilov, V. V. (1959). *The theory of thin shells*. P. Noordhoff.
4. Ramaswamy, G. S. (1968). Design and construction of concrete shell roofs. McGraw-Hill.
5. Chandrashekhara, K. (2001). *Theory of plates*. Universities press.

AML542 STABILITY OF STRUCTURES (DE)

Credit: **3**

Contact hours (L-T-P): **3-0-0**

Pre-requisites: **Nil**

Overlaps with: **Nil**

Course Objectives

The main objective of studying this course is to understand the fundamental principles of structural stability and behavior.

Course Outcomes

At the completion of this course, the student shall acquire knowledge and ability,

i. To determine elastic critical loads for simple structures and the limitations of such analysis

ii. To apply approximation methods based on energy to determine the stability of simple systems

Relationship of Course Outcomes to Program Outcomes

H = 100; M = 75; L = 50

POs → / COs ↓	PO1	PO2	PO3	PO4
CO1	M	L	H	H
CO2	M	L	H	H

Content

Elastic stability: Geometric Non linearity –Basic Concepts

Elastic buckling of bars, Euler's formula

Buckling of continuous beams, buckling of nonprismatic members, effect of shear force on buckling of bars, use of energy method

Analysis of beam-columns with various end conditions, Use of trigonometric series, Buckling of single span portal frames

Torsional buckling: Pure torsion of thin walled open cross section, warping and warping rigidity, Torsional buckling of columns, combined buckling by torsion and flexure

Lateral torsional buckling of beams, lateral buckling of beams in pure bending, lateral torsional buckling of cantilever and S.S. beams

Introduction to buckling of plates

Reference Books/Material

1. Chajes, A. (1974). Principles of structural stability theory. Prentice Hall.
2. Iyengar, N. G. R. (2007). Elastic Stability of Structural Elements. Macmillan.
3. Gambhir, M. L. (2004). *Stability analysis and design of structures*. Springer Science & Business Media.
4. Timoshenko, S. P., Goodier, J. N., & Abramson, H. N. (1970). Theory of elasticity. *Journal of Applied Mechanics*, *37*, 888.
5. Timoshenko, S. (1953). History of strength of materials: with a brief account of the history of theory of elasticity and theory of structures. Courier Corporation.
6. Gerard, G. (1961). Introduction to structural stability theory. McGraw-Hill.

AML543 EARTHQUAKE DYNAMICS (DE)

Credit: **3**

Contact hours (L-T-P): **3-0-0**

Pre-requisites: **AML522**

Overlaps with: **Nil**

Course Objective

To impart knowledge of advance concepts and methods for earthquake analysis and design of structures

Course Outcome

At the completion of this course, the student shall acquire knowledge and ability,

i. To perform linear and nonlinear earthquake analysis of structures.
ii. To assess the seismic safety of structures.
iii. To impart changes in the structure to enhance its seismic resistance

Relationship of Course Outcomes to Program Outcomes

H = 100; M = 75; L = 50

POs → / COs ↓	PO1	PO2	PO3	PO4
CO1	M	L	H	M
CO2	M	L	H	H
CO3	H	L	H	M

Content

Equation of Motion for SDOF and MDOF system subjected to base excitation, Response spectrum analysis and Time history analysis

Modal superposition and 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 over strength and ductility, Use of NONLIN software.

Earthquake response of multistory buildings, Torsional response of buildings.

Frequency domain analysis of SDOF system, Introduction to Random Vibration

Reference Books/Material

1. Chopra, A. K. (1995). *Dynamics of structures* (Vol. 3). New Jersey: Prentice Hall.
2. Clough, R. W., &Penzien, J. (1993). Dynamics of structures, vol. 2.
3. Humar, J. L. Dynamics of Structures, Prentice-Hall, Englewood Cliffs, NJ, 1990.
4. Paz, M. (2012). *Structural dynamics: theory and computation*. Springer Science & Business Media.
5. Timoshenko, S. P., & Young, D. H. (1948). Advanced dynamics.
6. D'Souza, A. F., & Garg, V. K. (1984). *Advanced dynamics: modeling and analysis*. Prentice Hall.
7. Gupta, P. K. (2012). *Advanced dynamics of rolling elements*. Springer Science & Business Media.
8. Greenwood, D. T. (2006). *Advanced dynamics*. Cambridge University Press.
9. Meirovitch, L. (1990). *Dynamics and control of structures*. John Wiley & Sons.

AML544 SOIL DYNAMICS (DE)

Credit: **3**

Contact hours (L-T-P): **3-0-0**

Pre-requisites: **AML522**

Overlaps with: **Nil**

Course Objectives

To provide fundamental knowledge of soil-dynamics and seismic behavior of soils.

Course Outcomes

At the completion of this course, the student shall acquire knowledge and ability,

i. To understand the behavior of soil under dynamic loading
ii. To perform practical analysis of various structures

Relationship of Course Outcomes to Program Outcomes

H = 100; M = 75; L = 50

POs → / COs ↓	PO1	PO2	PO3	PO4
CO1	H	L	H	L
CO2	M	L	M	H

Content

Introduction: Background and lessons learnt from damages in past earthquakes.

Wave Propagation: Waves in semi-infinite media – one, two and three dimensional wave propagation; Attenuation of stress waves – material and radiation damping; Dispersion, waves in a layered medium.

Dynamic Soil Properties: Stress & strain conditions, concept of stress path; Measurement of seismic response of soil at low and high strain, using laboratory tests; Cyclic triaxial, cyclic direct simple shear, resonant column, shaking table, centrifuge and using field tests - standard penetration test, plate load test, block vibration test, SASW/MASW tests, cross bore hole; Evaluation of damping and elastic coefficients; Stress-strain behavior of cyclically loaded soils; Effect of strain level on the dynamic soil properties; Equivalent linear and cyclic nonlinear models; Static and dynamic characteristics of soils.

Ground Response Analysis: Introduction, one, two and three dimensional analyses; Equivalent and nonlinear finite element approaches; Introduction to soil-structure interaction.

Liquefaction: Introduction, pore pressure, liquefaction related phenomena – flow liquefaction and cyclic mobility, factors affecting liquefaction, liquefaction of cohesionless soils and sensitive clays, liquefaction susceptibility; State Criteria –CVR line, SSL, FLS; Evaluation of liquefaction potential: characterization of earthquake loading and liquefaction resistance, cyclic stress ratio, Seed and Idriss method; Effects of liquefaction.

Earth Pressure: Active and passive earth pressures; Terzaghi's passive wedge theory, numerical methods, earth pressure measurements.; Seismic design of retaining walls: types, modes of failures, static pressure, seismic response (including M-O Method), seismic displacement, design considerations.

Seismic Slope Stability: Types of earthquake induced landslides; Evaluation of slope stability – stability analysis with dynamic loading, friction circle method, effective and total stress methods of analysis, factor of safety, yield acceleration, damage potential, displacement analysis, effect of saturated and submerged conditions, FEM analysis of slope stability.

Ground Improvement Techniques: Densification, reinforcement, and grouting and mixing, drainage; Reinforced earth: application of reinforced earth under static and dynamic loads, determination of properties of reinforcements, composite materials, reinforced earth drains and other applications.

Reference Books/Material

1. Prakash, S. (1981). *Soil dynamics* (pp. 361-7). New York: McGraw-Hill.
2. Ranjan, G., & Rao, A. S. R. (2007). *Basic and applied soil mechanics*. New Age International.
3. Kameswara Rao, N. S. V. (2000). Dynamics soil tests and applications.*Wheeler Publishing Co. Ltd., New Delhi, India*.
4. Robert, W. D. (2002). Geotechnical Earthquake Engineering Handbook. *NY: McGraw-Hill*
5. Kramer, S. L. (1996). *Geotechnical earthquake engineering* (Vol. 80). Upper Saddle River, NJ: Prentice Hall.
6. Saran, S. (2006). Soil dynamics and machine foundation
7. McCarthy, D. F., & McCarthy, D. F. (1977). *Essentials of soil mechanics and foundations* (p. 505). Reston Publishing Company.
8. Wood, D. M. (1990). *Soil behaviour and critical state soil mechanics*. Cambridge university press.
9. Fredlund, D. G., &Rahardjo, H. (1993). *Soil mechanics for unsaturated soils*. John Wiley & Sons.
10. Helwany, S. (2007). Applied soil mechanics with ABAQUS applications. John Wiley & Sons.
11. Das, B., &Ramana, G. V. (2010). *Principles of soil dynamics*. Cengage Learning.

AML545 WIND EFFECTS ON STRUCTURES (DE)

Credit:	**3**
Contact hours (L-T-P):	**3-0-0**
Pre-requisites:	**AML522**
Overlaps with:	**Nil**

Course Objectives

To introduce concept of wind flow, static and dynamic wind load analysis including exposure to Indian Standard code for wind

Course Outcomes

At the completion of this course, the student shall acquire knowledge and ability,

i. To perform static and dynamic analysis for wind loading
ii. To design a structure for wind induced loadings.

Relationship of Course Outcomes to Program Outcomes

H = 100; M = 75; L = 50

POs → / COs ↓	PO1	PO2	PO3	PO4
CO1	M	L	H	H
CO2	M	L	H	H

Content

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, code 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 aero elastic 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.

Reference Books/Material

1. Simiu, E., &Scanlan, R. H. (1986). Wind effects on structures: an introduction to wind engineering. John Wiley.
2. Scruton, C. (1981). *An introduction to wind effects on structures* (Vol. 3). Oxford: Oxford University Press
3. Sachs, P. (2013). *Wind forces in engineering*. Elsevier.
4. Lawson, T. V. (1980). Wind Effects on Buildings: Design Applications (Vol. 1). Spon Press.
5. Cook, N. J. (1986). Designers guide to wind loading of building structures. Part 1.
6. Simiu, E., &Scanlan, R. H. (1996). *Wind effects on structures*. Wiley.
7. Dyrbye, C., & Hansen, S. O. (1996). *Wind loads on structures*. John Wiley & Sons.
8. Holmes, J. D. (2015). *Wind loading of structures*. CRC Press.
9. Nayfeh, A. H. (2011). *Introduction to perturbation techniques*. John Wiley & Sons
10. Blevins, R. D. (1990). Flow-induced vibration.
11. Holmes, M. H. (2012). *Introduction to perturbation methods* (Vol. 20). Springer Science & Business Media
12. Simiu, E., & Miyata, T. (2006). Design of buildings and bridges for wind: a practical guide for ASCE-7 standard users and designers of special structures

AML546 EARTHQUAKE EFFECTS ON STRUCTURES (DE)

Credit: **3**

Contact hours (L-T-P): **3-0-0**

Pre-requisites: **AML522**

Overlaps with: **Nil**

Course Objectives

To introduce earthquake analysis of various structures using IS and International code, issues related mathematical modelling and analysis techniques special structures viz. Water Tanks, Masonry Structures, Industrial Structures, Chimneys and Dams.

Course Outcomes

At the completion of this course, the student shall acquire knowledge and ability,

i. To develop mathematical models for various special structures and apply various analysis techniques for special structures
ii. To apply the principles and provisions for seismic design and detailing for special structures
iii. To initiate research on water tanks, bridges and masonry structures.

Relationship of Course Outcomes to Program Outcomes

H = 100; M = 75; L = 50

POs → / COs ↓	PO1	PO2	PO3	PO4
CO1	H	H	M	L
CO2	H	M	M	L
CO3	H	H	H	L

Content

Review of all the parts of IS:1893, IS4326, IS13920, IS13827, IS13828, IS13935 and international codes (ASCE 7, Eurocode and Newzealand code) for calculation of earthquake forces

Review of earthquake effect on various structures in past

Earthquake analysis of overhead, underground, ground supported water tanks, single mass and two mass systems, various mathematical modeling, IS code recommendations:

Masonry buildings, Industrial structures, Bridge, Chimneys, Dams and retaining walls

Analysis for non-structural elements

Reference Books/Material

1. Naeim, F. (1989). The seismic design handbook. Springer Science & Business Media.
2. Jaiswal, O. R., Rai, D. C., & Jain, S. K. (2004). Review of code provisions on seismic analysis of liquid storage tanks. *Document No. IITK-GSDMA-EQ04-V1. 0*.
3. Fintel, M. (Ed.). (1974). *Handbook of concrete engineering* (p. 801). New York: Van Nostrand Reinhold
4. Hendry, A. W. (1990). *Structural masonry*. Scholium International.
5. Drysdale, R. G., Hamid, A. A., & Baker, L. R. (1994). *Masonry structures: behavior and design*. Prentice Hall
6. Bozorgnia, Y., &Bertero, V. V. (Eds.). (2004). Earthquake engineering: from engineering seismology to performance-based engineering. CRC press.
7. Gupta, A. K. (1992). Response spectrum method in seismic analysis and design of structures (Vol. 4). CRC press.
8. Beskos, D. E., &Anagnostopoulos, S. A. (1997). Computer analysis and design of earthquake resistant structures: a handbook. WIT Press.

AML547 NUMERICAL METHODS AND PROGRAMMING (DE)

Credit:	**3**
Contact hours (L-T-P):	**3-0-0**
Pre-requisites:	**Nil**
Overlaps with:	**Nil**

Course Objectives

To empower students with programming skill and application of various numerical methods to solve large scale computation heavy problems

Course Outcomes

At the completion of this course, the student shall acquire knowledge and ability,

i. To understand various numerical techniques for solving problems in structural engineering

ii. To develop codes/software for solution using numerical techniques

Relationship of Course Outcomes to Program Outcomes

H = 100; M = 75; L = 50

POs → / COs ↓	PO1	PO2	PO3	PO4
CO1	H	L	H	L
CO2	H	L	H	L

Content

Computer programming Fortran /C/MATLAB–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, Jacobi iteration, Gauss – Seidel method of Iteration,

Numerical Integration – Trapezoidal, Simpson's and other Newton – Cotes formulae, Method of Gauss Quadrature.

Interpolation (Lagrange Interpolation, Taylor series expansion, Extrapolation), curve fitting, regression

Initial and boundary value problem, Euler's, Runge-kutta, Milne's etc, Computer oriented Algorithms.

Solution of nonlinear Equations.

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 (determinant search, subspace iteration and Lanczos method) .

Reference Books/Material

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”, Springer, 2nd Edition, 2002

AML 548 SOIL-STRUCTURE INTERACTION (DE)

Credit: **3**

Contact hours (L-T-P): **3-0-0**

Pre-requisites: **Nil**

Overlaps with: **Nil**

Course Objectives

To provide a basic background on soil-structure interaction (static and dynamic).

Course Outcomes

At the completion of this course, the student shall acquire knowledge and ability,

i. To understand the behavior of structure with soil-structure interaction
ii. To analyse beams on wrinkle foundation and model soil-structure interaction analysis problem

Relationship of Course Outcomes to Program Outcomes

H = 100; M = 75; L = 50

POs → / COs ↓	PO1	PO2	PO3	PO4
CO1	H	L	H	M
CO2	H	L	H	M

Content

General soil-structure interaction problems: Contact pressures and soil-structure interaction for shallow foundations. Concept of sub-grade modulus, effects/parameters influencing subgrade modulus. Analysis of foundations of finite rigidity, Beams on elastic foundation concept, introduction to the solution of beam problems.

Analytical Methods of Analysis of Finite Beams on Wrinkler Foundation: Introduction, analysis of finite and infinite beam on wrinkle foundation, method of super position, method of initial parameters and its application to analysis of regular beams, analysis of continuous beams and frames on wrinkle foundation, analysis of frames on wrinkle foundation, analysis of rigid piles with horizontal and vertical loads.

Analysis of Beams on Elastic Half Space: Introduction, analysis of Rigid Beams, short beam analysis, long beam Analysis, Analysis of Frame on Elastic Half Space.

Dynamic Soil Structure Interaction: Direct and Sub-structure method of Analysis, Equation of Motion for flexible and rigid base, kinematic interaction, inertial interaction and effect of embedment, Temporal and special variation of external loads including seismic loads, continuous models, discrete models and finite element models.

Wave Propagation for SSI: Waves in Semi-Infinite Medium, one two and three dimensional wave propagation, dynamic stiffness matrix for out of plane and in plane motion.

Free Field Response of Site: Control point and control motion for seismic analysis, dispersion and attenuation of waves, half space, single layer on half space, modelling of boundaries, elementary, local, consistent and transmitting boundaries.

Engineering Application of Soil-Structure Interaction: Low rise residential building, multi-storey building, bridges and dams, soil-pile structure interaction.

Reference Books/Material

1. Tsudik, E. (2012). Analysis of Structures on Elastic Foundations. J. Ross Publishing
2. Wolf, J. P. (1985). *Dynamic soil-structure interaction*. Prentice Hall int..
3. Wolf, J. P., & Song, C. (1996). *Finite-element modelling of unbounded media*. Chichester: Wiley.
4. Kramer, S. L. (1996). *Geotechnical earthquake engineering* (Vol. 80). Upper Saddle River, NJ: Prentice Hall.
5. Kellezi, L. (1998). Dynamic Soil-Structure-Interaction
6. Jones, G. (1997). Analysis of beams on elastic foundations: using finite difference theory. Thomas Telford.

AML549 FINITE ELEMENT METHOD (DE)

Credit: **3**

Contact hours (L-T-P): **3-0-0**

Pre-requisites: **Nil**

Overlaps with: **Nil**

Course Objectives

The objectives of this course are to introduce concepts of finite element method for analysis of structures

Course Outcome

At the completion of this course, the student shall acquire knowledge and ability,

i. To develop comprehensive knowledge in the fundamental of basis of FEM,

ii. To build FEM models of physical problems and apply appropriate constraints and boundary conditions along with external loads.

iii. To use professional-level finite element software to solve engineering problems

Relationship of Course Outcomes to Program Outcomes

H = 100; M = 75; L = 50

POs → / COs ↓	PO1	PO2	PO3	PO4
CO1	H		H	L
CO2	H		H	L
CO3	H		H	H

Content

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, Formulation of 1-D elements (BAR, TORSION, BEAM), 2D elements and 3D elements, load vector (1D, Plane stress, Plane strain, Axi-symmetric and 3D elements) using Displacement formulation. Cartesian and Iso-parametric element formulation. Numerical Integration, convergence study, element with drilling DoF and incompatible modes. Plate elements (Kirchoff theory, Mindlin plate element, triangular and rectangular, conforming & nonconforming elements), Shell elements (flat faced triangular and rectangular elements), Axisymmetric plate & shell elements, Ring elements. Introduction to advanced elements-Mixed formulation, Infinite elements.

Formulation for Geometrical Nonlinear problems. Formulation of Dynamic problems, Consistent and lumped mass matrices.

Computer Implementation of FEM procedure for plane truss, Plane stress, plane strain and Axi-symmetric problems. Mathematical modeling of structures.

Constraint Equations (Penalty method, Lagrangian method), Patch test

Reference Books / Material

1. Dhatt, G., Lefrançois, E., &Touzot, G. (2012). *Finite element method*. John Wiley & Sons
2. Bathe, K. J. (2008). *Finite element method*. John Wiley & Sons, Inc.
3. Zienkiewicz, O. C., Taylor, R. L., Zienkiewicz, O. C., & Taylor, R. L. (1977).*The finite element method* (Vol. 3). London: McGraw-hill.
4. Hughes, T. J. (2012). The finite element method: linear static and dynamic finite element analysis. Courier Corporation.
5. Reddy, J. N. (1993). *An introduction to the finite element method* (Vol. 2, No. 2.2). New York: McGraw-Hill.
6. Cook, R. D. (2007). Concepts and applications of finite element analysis. John Wiley & Sons.
7. Cook, R. D. (1994). Finite element modeling for stress analysis. Wiley.
8. Chandrupatla, T. R., Belegundu, A. D., Ramesh, T., & Ray, C. (1997).*Introduction to finite elements in engineering* (pp. 279-300). Upper Saddle River: Prentice Hall.
9. Strang, G., & Fix, G. J. (1973). *An analysis of the finite element method*(Vol. 212). Englewood Cliffs, NJ: Prentice-Hall
10. Prathap, G. (2013). The finite element method in structural mechanics: principles and practice of design of field-consistent elements for structural and solid mechanics (Vol. 24). Springer Science & Business Media.
11. Rao, S. S. (2005). *The finite element method in engineering*. Butterworth-heinemann

AML550 DESIGN OF PRESTRESSED CONCRETE STRUCTURES (DE)

Credit: **3**

Contact hours (L-T-P): **3-0-0**

Pre-requisites: **Nil**

Overlaps with: **Nil**

Course Objectives

To understand the mechanical behavior, analysis and design of prestressed concrete elements.

Course Outcomes

At the completion of this course, the student shall acquire knowledge and ability,

i. to understand basic properties of pre-stressed concrete structures
ii. to analyzed and design pre-stressed concrete structures as per IS codes

Relationship of Course Outcomes to Program Outcomes

H = 100; M = 75; L = 50

POs → / COs ↓	PO1	PO2	PO3	PO4
CO1	M	H	M	M
CO2	M	H	M	M

Content

Introduction to basic concepts and general principles of pre-stressed concrete, materials used in prestressed concrete and methods and techniques of prestressing, prestressing systems.

Analysis of prestressed concrete sections for flexure considering loading stages, computation of sectional properties, critical sections under working loads for pretensioned and post tensioned members, load balancing method of analysis of prestressed concrete beams, losses in prestress, application to simply supported beams and slabs

Design philosophy of prestressed concrete sections, permissible stresses in concrete and steel, design approaches using working stress method as per IS 1143 – 1980, limit state of collapse – flexure and shear as applied to prestressed concrete beams, kern points, choice and efficiency of sections, cable profile and layouts, cable zone, deflection of prestressed concrete sections.

End zone stresses in prestresses concrete members, pretension transfer bond, transmission length, end block of post tensioned members.

Design of simply supported pre-tensioned and post tensioned slabs and beams. Design of bridge girders as per IRC.

Analysis and design of composite prestressed concrete structures

Introduction to application of prestressing to continuous beams, linear transformation and concordancy of cables

Reference Books/Material

1. Raju, N. K. (2006). *Prestressed concrete*. Tata McGraw-Hill Education
2. Lin, T. Y., & Burns, N. H. (1981). Design of prestressed concrete structures.
3. Park, R. (1977). *Design of Prestressed Concrete Structures*. University of Canterbury.

AML551 ANALYSIS AND DESIGN OF FOUNDATIONS (DE)

Credit: 3

Contact hours (L-T-P): 3-0-0

Pre-requisites: Nil

Overlaps with: Nil

Course Objectives

To enhance the understanding of various methods for analyze and design different types of foundations

Course Outcomes

At the completion of this course, the student shall acquire knowledge and ability,

i. To select and design appropriate foundations based on various criteria,
ii. To check the stability of various components of foundations and retaining walls.

Relationship of Course Outcomes to Program Outcomes

H = 100; M = 75; L = 50

POs → / COs ↓	PO1	PO2	PO3	PO4
CO1	M	L	H	L
CO2	M	L	H	L

Content

Introduction geotechnical aspects for foundation design (Bearing capacity, modulus of subgrade reactions etc.) and relevant IS codes

Analysis and design of shallow foundations: Individual and combined footings for axial and bending loads (Uniaxial and biaxial), Loss of contacts and calculation of liftoff

Analysis and design of raft foundations, Annular Footings, Rigid and flexible foundations, Beams and slabs on elastic foundations

Analysis and design of pile and pile cap

Analysis and design of Well foundations

Analysis and design of Retaining walls

Reference Books / Material

1. Hetényi, M. (1971). Beams on elastic foundation: theory with applications in the fields of civil and mechanical engineering. University of Michigan.
2. Bowles, J. E. (1988). Foundation analysis and design.
3. Saran, S. (2006). Soil dynamics and machine foundation.
4. Srinivasulu, P., &Vaidyanathan, C. V. (1976). *Handbook of machine foundations*. Tata McGraw-Hill Education.
5. Kurian, N. P. (1982). Modern foundations: introduction to advanced techniques. Tata McGraw-Hill.
6. Reese, L. C., Isenhower, W. M., & Wang, S. T. (2006). *Analysis and design of shallow and deep foundations* (Vol. 10). Hoboken, NJ: Wiley.
7. Portney, L. G., & Watkins, M. P. (2000). *Foundations of clinical research: applications to practice* (Vol. 2). Upper Saddle River, NJ: Prentice Hall.
8. McCarthy, D. F., & McCarthy, D. F. (1977). *Essentials of soil mechanics and foundations* (p. 505). Reston Publishing Company.

AML552 ANALYSIS AND DESIGN OF INDUSTRIAL STEEL STRUCTURES (DE)

Credit: **3**

Contact hours (L-T-P): **3-0-0**

Pre-requisites: **Nil**

Overlaps with: **Nil**

Course Objectives

To qualify the students to analyze and design of various types of industrial steel structures

Course Outcomes

At the completion of this course, the student shall acquire knowledge and ability,

i. To understand and design industrial buildings with and without crane girders.

ii. To analysis and design various steel structures

Relationship of Course Outcomes to Program Outcomes

H = 100; M = 75; L = 50

POs → / COs ↓	PO1	PO2	PO3	PO4
CO1	H	H	M	H
CO2	H	H	H	H

Content

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 Circular), including supporting systems.

Design of Pressure vessels and storage tanks (Circular)

Introduction to IS 1893 Part IV

Design of PEB structures

Reference Books/Material

1. Subramanian, S. (2010). Steel structures design and practice Oxford.
2. Reimbert, M. L., &Reimbert, A. M. (1987). Silos. Theory and practice. Vertical silos, horizontal silos (retaining walls) (No. Ed. 2). Lavoisier Publishing.
3. Johnson, R. P. (2008). Composite structures of steel and concrete: beams, slabs, columns, and frames for buildings. John Wiley & Sons.
4. Owens, G. W., & KNOWLES, P. R. (1992). Steel designers manual.
5. Faella, C., Piluso, V., &Rizzano, G. (1999). Structural steel semirigid connections: theory, design, and software (Vol. 21). CRC press.

AML553 ANALYSIS AND DESIGN OF BRIDGES (DE)

Credit: **3**

Contact hours (L-T-P): **3-0-0**

Pre-requisites: **Nil**

Overlaps with: **Nil**

Course Objectives

To understand the planning, behavior, analysis and design of bridges and its components

Course Outcomes

At the completion of this course, the student shall acquire knowledge and ability, to plan, analyze and design various components of bridges

Relationship of Course Outcomes to Program Outcomes

H = 100; M = 75; L = 50

POs → / COs ↓	PO1	PO2	PO3	PO4
CO1	H	L	H	L

Content

Types of RC bridge superstructure and introduction to their design, sub-structure, bearings, IRC / IRS codes bridge loadings and other code recommendations, Performance of bridges in past earthquakes.

Design philosophy for bridges (Deck slab, beam-slab and box), State of art modelling of bridges, Design of Substructures including ductile detailing, Design of well and pile foundations, Modelling soil flexibility.

Analysis and design of abutments, dirt wall, pedestals and returns

Design of Bearings (Free, Guided and Restrained)

Introduction of integrated bridges, curved bridges and deck continuous bridges.

Reference Books/Material

1. Chen, W. F., &Duan, L. (Eds.). (2014). Bridge Engineering Handbook: Construction and Maintenance. CRC press.
2. Fintel, M. (Ed.). (1974). Handbook of concrete engineering (p. 801). New York: Van Nostrand Reinhold.
3. Branco, F. A., & De Brito, J. (2004). Handbook of concrete bridge management.
4. Smith, J. W. (1994). Theory and design of bridges: by Petros P. Xanthakos, Wiley Interscience, New York, 1994, ISBN 0-471-57097-4.

AML554 ANALYSIS AND DESIGN OF WATER RETAINING STRUCTURES (DE)

Credit: **3**

Contact hours (L-T-P): **3-0-0**

Pre-requisites: **Nil**

Overlaps with: **Nil**

Course Objectives

To understand the planning, behavior, analysis and design of water retaining structures

Course Outcomes

At the completion of this course, the student shall acquire knowledge and ability,to plan and analyze water retaining structures, .

Relationship of Course Outcomes to Program Outcomes

H = 100; M = 75; L = 50

POs → / COs ↓	PO1	PO2	PO3	PO4
CO1	H	L	H	L

Content

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 tanks using beam on elastic foundation analogy

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 headtanks(SDOF and MDOF model)

Analysis and design of jack well, approach bridge and WTP units etc.

Analysis and design of ESR (container and staging)

Reference Books/Material

1. Jaiswal, O. R., Rai, D. C., & Jain, S. K. (2007). Review of seismic codes on liquid-containing tanks. Earthquake Spectra, 23(1), 239-260.
2. Anchor, R. D. (1981). Design of liquid-retaining concrete structures. Halsted Press.

3. IS 3370(Part-I). (2009). Concrete structures for storage of liquids - code of practice.
4. IS 3370(Part-II). (2009). Concrete structures for storage of liquids - code of practice.
5. IS 3370(Part-III). (1967). Code of practice for concrete structures for the storage of liquids.
6. IS 3370(Part-IV). (1967). Code of practice for concrete structures for the storage of liquids. Design –Tables.
7. Ghali, A. (2014). Circular storage tanks and silos. CRC Press.

AML555 ANALYSIS AND DESIGN OF MACHINE FOUNDATIONS (DE)

Credit: 3

Contact hours (L-T-P): 3-0-0

Pre-requisites: AML522

Overlaps with: Nil

Course Objectives

To understand the behavior and basic concepts for the design of foundation subjected to vibrations

Course Outcomes

At the completion of this course, the student shall acquire knowledge and ability,

i. To understand the basics of vibration, type and principles for machine foundations,
ii. To investigate dynamic soil properties and soil testing methods in laboratory and on field,
iii. To analyse and design machine foundations as per IS codes.

Relationship of Course Outcomes to Program Outcomes

H = 100; M = 75; L = 50

POs → / COs ↓	PO1	PO2	PO3	PO4
CO1	M	L	H	H
CO2	M	L	H	H
CO3	M	L	H	H

Content

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

Reference Books/Material

1. Kramer, S. L. (1996). *Geotechnical earthquake engineering* (Vol. 80). Upper Saddle River, NJ: Prentice Hall.
2. Bowles, J. E. (1988). Foundation analysis and design.
3. Richart, F. E., Hall, J. R., & Woods, R. D. (1970). Vibrations of soils and foundations.
4. Prakash, S. (1981). *Soil dynamics* (pp. 361-7). New York: McGraw-Hill.
5. Wolf, J. P. (1985). *Dynamic soil-structure interaction*. Prentice Hall int.
6. Saran, S. (2006). Soil dynamics and machine foundation.
7. Bhatia, K. G. (2008). Foundations for industrial machines and earthquake effects. *ISET Journal of Earthquake Technology, Paper*, (495), 1-2.
8. Bhatia, K. G. (2009). Foundations for Industrial Machines: Handbook for Practising Engineers. CRC.
9. Major, A. (1962). Vibration analysis and design of foundations for machines and turbines: dynamical problems in civil engineering. Collet's Holdings.

AML556 ANALYSIS AND DESIGN OF MULTISTORIED BUILDINGS (DE)

Credit: **3**

Contact hours (L-T-P): **3-0-0**

Pre-requisites: **Nil**

Overlaps with: **Nil**

Course Objectives

To impart knowledge of analysis and design of multistoried buildings for static and dynamic loading

Course Outcomes

At the completion of this course, the student shall acquire knowledge and ability,

i. to apply methods of static and dynamic analysis of multistoried buildings
ii. to develop mathematical model, perform analysis and design RC and steel buildings
iii. to understand various provisions Indian codes/Standards for RC and steel structures

Relationship of Course Outcomes to Program Outcomes

H = 100; M = 75; L = 50

POs → / COs ↓	PO1	PO2	PO3	PO4
CO1	M	H	M	M
CO2	M	H	M	M
CO3	M	H	M	M

Content

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, Seismic analysis using equivalent static, response spectrum and time history analysis using software.

Special aspects in Multi-storeyed buildings: Effect of torsion, flexible first story, various methods for P-delta analysis, 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.

Reference Books / Material

1. Naeim, F. (1989). *The seismic design handbook*. Springer Science & Business Media.
2. Paulay, T., & Priestly, M. J. N. (2009). *Frontmatter* (pp. i-xxiii). John Wiley & Sons, Inc..
3. Booth, E. D. (1994). *Concrete structures in earthquake regions: design and analysis*. Longman Scientific & Technical; Copublished in the US with J. Wiley.
4. Park, R., &Paulay, T. (1975). *Reinforced concrete structures*. John Wiley & Sons.
5. Fintel, M. (Ed.). (1974). *Handbook of concrete engineering* (p. 801). New York: Van Nostrand Reinhold

AML557 ANALYSIS AND DESIGN OF IRRIGATION STRUCTURES (DE)

Credit: **3**

Contact hours (L-T-P): **3-0-0**

Pre-requisites: **Nil**

Overlaps with: **Nil**

Course Objectives

To understand the planning, behavior, analysis and design of various Irrigation structures

Course Outcomes

At the completion of this course, the student shall acquire knowledge and ability to plan, analyze and design various irrigation structures

Relationship of Course Outcomes to Program Outcomes

H = 100; M = 75; L = 50

POs → / COs ↓	PO1	PO2	PO3	PO4
CO1	H	H	H	H

Content

Introduction to Irrigation structures and relevant IS codes

Gravity Dams – Site selection, Forces, Stability analysis.

Analysis and Design of Diversion Works – Bandhara, Weirs and Barrages

Analysis and Design of Head Regulators and Cross regulators

Design of Canals and Canal Falls

Analysis and Design of Cross Drainage Work

Analysis and Design of cut-fill tunnels

Reference Books/Material

1. Novák, P., Moffat, A. I. B., Nalluri, C., & Narayanan, R. (2007). *Hydraulic structures*. CRC Press.
2. Creager, W. P., Justin, J. D. W., & Hinds, J. (1945). Engineering for dams.
3. Creager, W. P., Justin, J. D., & Hinds, J. (1961). *Engineering for Dams: Earth, Rock-fill, Steel and Timber Dams*. John Wiley & Sons.
4. Linsley, R. K., &Franzini, J. B. Water Resources Engineering. *Chap, 6*, 148-160.

5. Leliavsky, S. (1982). *Design textbooks in civil engineering*. Chapman and Hall
6. BUREAU, O. R. (1977). Design of small dams. *Washington. DC: Govt. Print. Off.*
7. Singh, B. (1979). Fundamentals of Irrigation Engineering: Bharat Singh. Nem Chand & Bros.
8. Arora, K. R. (2002). *Irrigation, water power and water Resources Engineering*. Standard Publisher Distributors.
9. Varshney, R. S., Gupta, S. C., & Gupta, R. L. (1979). *Theory & Design of Irrigation Structures: RS Varshney, SC Gupta, RL Gupta*. Nem Chand & Bros.
10. Garg, S. K. (1987). Irrigation engineering and hydraulic structures. Khanna publishers.
11. IS 6512 (1984). Criteria for Design of Solid Gravity Dams.
12. IS 1893 (1984).Criteria for Earthquake Resistant Design of Structures.
13. IS 4410 (Part-22). (1994). Glossary of terms relating to river valley projects.
14. IS 6966(Part-I). (1989). Guidelines for hydraulic design of barrages and weirs.
15. IS 7349(1989). Guidelines for operation and maintenance of barrages and weirs.
16. IS 7720(1991).Criteria for Investigation, Planning and Layout for Barrages and Weirs.
17. IS 11130 (1984). Criteria for Structural Design of Barrages and Weirs.
18. IS14955 (2001). Guidelines for Hydraulic Model Studies of Barrages and Weirs
19. Novak, P. (2005). *Developments in hydraulic engineering* (Vol. 5). CRC Press

AML558 ANALYSIS AND DESIGN OF COMPOSITE STRUCTURES (DE)

Credit: **3**

Contact hours (L-T-P): **3-0-0**

Pre-requisites: **Nil**

Overlaps with: **Nil**

Course Objectives

The objective of this course is to familiarize the students with analysis and design of steel-concrete composite structure.

Course Outcomes

At the completion of this course, the student shall acquire knowledge and ability,

i. To critically assess various engineering properties of composite member,

ii. To analyzed and design steel-concrete composite member

Relationship of Course Outcomes to Program Outcomes

H = 100; M = 75; L = 50

POs → / COs ↓	PO1	PO2	PO3	PO4
CO1	H	L	H	L
CO2	H	M	H	L

Content

Analysis and design of steel-concrete composite deck floor,

Analysis and design composite Beam, composite beams with solid steel beam, Composite beams with steel beams with web opening,

Analysis and design shear connection between concrete slab and beam, types of shear connectors and its function.

Analysis and design steel-concrete composite column, steel section embedded in concrete, concrete in filled steel tubes.

Analysis and design steel frame structure with concrete in-filled.

Advanced topics and detailing in composite structures.

Reference Books/Material

1. Taranath, B. S. (2011). Structural analysis and design of tall buildings: Steel and composite construction. CRC press.
2. Vinson, J. R., &Sierakowski, R. L. (2006). *The behavior of structures composed of composite materials* (Vol. 105). Springer Science & Business Media.
3. Vinson, J. R., &Sierakowski, R. L. (2012). *The behavior of structures composed of composite materials* (Vol. 5). Springer Science & Business Media.
4. Jones, R. M. (1975). *Mechanics of composite materials* (Vol. 1). New York: McGraw-Hill.
5. Christensen, R. M. (2012). *Mechanics of composite materials*. Courier Corporation.
6. Kaw, A. K. (2005). Mechanics of composite materials. CRC press.
7. Daniel, I. M., Ishai, O., Daniel, I. M., & Daniel, I. (1994). *Engineering mechanics of composite materials* (Vol. 3). New York: Oxford university press.
8. Liang, Q. Q. (2014). Analysis and Design of Steel and Composite Structures. CRC Press.
9. IS 1138 (1985). Code of Practice for Composite Construction in Structural Steel and Concrete, Indian Standard Institution, New Delhi.
10. IS 393 (1966). Code of practice for composite construction, Indian Standard Institution, New Delhi.
11. Narayanan, R. (Ed.). (1988). *Steel-concrete Composite Structures* (Vol. 7). CRC Press.
12. Owens, G. W., & KNOWLES, P. R. (1992). *Steel designers manual*.
13. Davison, B., & Owens, G. W. (Eds.). (2011). *Steel designers' manual*. John Wiley & Sons.

AML559 ANALYSIS AND DESIGN OF MASONRY STRUCTURES (DE)

Credit: **3**

Contact hours (L-T-P): **3-0-0**

Pre-requisites: **Nil**

Overlaps with: **Nil**

Course Objectives

To provide insight into relevant theories, simulation techniques and principles of earthquake resistant design and construction for various types of masonry structures and to introduce various code provisions.

Course Outcomes

At the completion of this course, the student shall acquire knowledge and ability,

i. To critically assess various engineering properties of masonry components,
ii. To analyzed and design masonry structures
iii. To use various retrofitting methods for masonry structures.

Relationship of Course Outcomes to Program Outcomes

H = 100; M = 75; L = 50

POs → / COs ↓	PO1	PO2	PO3	PO4
CO1	H	L	H	M
CO2	H	L	H	L
CO3	M	M	M	L

Content

Behaviour of Masonry Structures During Past Earthquakes: Common modes of failure, effect of unit shapes and mortar type, effect of roof and floor systems; Common deficiencies.

Material Properties: Masonry units- stones, brick and concrete blocks, hollow and solid units; Manufacturing process; Mortar, grout and reinforcement; Various tests and standards.

Masonry Under Compression: Prism strength, Failure mechanism, types of construction and bonds; Eccentric loading; Slenderness – effective length and effective height, effect of openings; Code provisions.

Masonry Under Lateral Loads: In-plane and out-of-plane loads, bending parallel and perpendicular to bed joints; Shear and flexure behaviour of piers; Test and standards; Analysis of perforated shear walls, lateral force distribution for flexible and rigid diaphragms; Arching action; Combined axial and bending actions.

Earthquake Resistant Measures: Analysis for earthquake forces, role of floor and roof diaphragm; Concept and design of bands, bandages, splints and ties; Reinforced masonry; Vertical reinforcement at corners and jambs; Measures in random-rubble masonry; Confined masonry; Code provisions.

Masonry Infills: Effect of masonry infills on seismic behaviour of framed buildings; Failure modes; Simulation of infills – FEM and equivalent strut; Safety of infills in in-plane action – shear, compression and buckling; Out-of plane action, arching; Code provisions.

Retrofitting of Masonry Building: Techniques of repair and retrofitting of masonry buildings; IS: 13935-1993 provision for retrofitting.

Advance Concepts: Strength and ductility; Nonlinear pushover analysis; Performance based design; Vulnerability and fragility analysis.

Reference Books/Material

1. Drysdale, R. G., Hamid, A. A., & Baker, L. R. (1994). *Masonry structures: behavior and design*. Prentice Hall.
2. Schneider, R. R., & Dickey, W. L. (1994). *Reinforced masonry design*. Pearson College Division.
3. Thomas, P., & Priestley, M. J. (1992). Seismic design of reinforced concrete and masonry buildings.
4. Hochwalt, J. M., &Amrhein, J. E. (2012). Reinforced Masonry Engineering Handbook.
5. Hendry, A. W. (1990). *Structural masonry*. Scholium International.
6. Tomazevic, M. (1999). Earthquake-resistant design of masonry buildings. World Scientific.
7. Anderson, D., &Brzev, S. (2009). *Seismic design guide for masonry buildings*. Canadian Concrete Masonry Producers Association.

AML560 ANALYSIS AND DESIGN OF GRAVITY DAMS AND RETAINING WALLS (DE)

Credit: **3**
Contact hours (L-T-P): **3-0-0**
Pre-requisites: **Nil**
Overlaps with: **Nil**

Course Objectives

The objective of this course is to familiarize the students with concepts of analysis and design of gravity dam, embankment and retaining wall.

Course Outcomes

At the completion of this course, the student shall acquire knowledge and ability to plan, analyze and design concrete and earthen dams including embankment.

Relationship of Course Outcomes to Program Outcomes

H = 100; M = 75; L = 50

POs → / COs ↓	PO1	PO2	PO3	PO4
CO1	H	M	H	L

Content

Concrete Dams: Purpose, Scope, Applicability, General Design Considerations, Types of Concrete Gravity Dams. Coordination between disciplines, Construction Materials Site Selection Determining Foundation Strength Parameters, Load Calculations, stability analysis and structural Design.

General design and construction considerations for earth and rock-fill dams:

Applicability, Types of Embankment Dams, Basic Requirements , Selection of Embankment Type, Environmental Considerations, Geological and Subsurface Explorations and Field Tests, Laboratory Testing, Freeboard , Top Width, Alignment, Embankment Performance Parameters, Earthquake Effects, Coordination Between Design and Construction.

Seepage Control: General, Embankment, Earth Foundations, Rock Foundations, Abutments, Adjacent to Outlet Conduits Beneath Spillways and Stilling Basins, Seepage Control Against Earthquake Effects.

Embankment Design: Embankment Materials Zoning, Cracking, Filter Design, Consolidation and Excess Pore-water Pressure, Embankment Slopes and Berms, Embankment Reinforcement, Compaction Requirements, Slope Protection.

Retaining walls: Types of retaining walls, Analysis and design of cantilever type retaining walls, Analysis and design of counterfort and buttress type retaining walls, Analysis and design of Abutments.

Reference Books/Material

1. Bowles, J. E. Foundation analysis and design, 1996.
2. Swami, S. (1999). Soil Dynamics and Machine Foundation.
3. Kurian, N. P. (1982). Modern foundations: introduction to advanced techniques. Tata McGraw-Hill.
4. McCarthy, D. F., & McCarthy, D. F. (1977). *Essentials of soil mechanics and foundations* (p. 505). Reston Publishing Company.

AML561 DESIGN OF PRE-STRESSED STEEL STRUCTURES (DE)

Credit: 3

Contact hours (L-T-P): 3-0-0

Pre-requisites: Nil

Overlaps with: Nil

Course Objectives

To familiarize the students with analysis and design of Pre-stressed steel structures.

Course Outcomes

At the completion of this course, the student shall acquire knowledge and ability,

i. To understand basic properties of pre-stressed steel structures
ii. To analyzed and design pre-stressed steel structures including strengthening of existing steel bridges by external prestressing

Relationship of Course Outcomes to Program Outcomes

H = 100; M = 75; L = 50

POs → / COs ↓	PO1	PO2	PO3	PO4
CO1	M	L	H	H
CO2	M	L	H	H

Content

Basic concepts of steel prestressing, Methods of steel prestressing, prestressing by tendons, by bending and predeflection technique. Types of tendon - steel wires, Strands, Prestressing H.T Steel bars, Types of Anchorages for different tendons, Arrangement of Tendons, Diaphragms, Joints and Anchorages and their corrosion protection procedures.

Losses of prestress - Anchorage slip, due to friction, Relaxation of steel, Controlled Prestress force to optimize losses

Prestressed Steel Plate Girders - Analysis and design, Optimum parameters of a Symmetrical I Beam and Asymmetrical Girder, optimum design of plate girders, check for deflection, Buckling strength of plate girders

Composite Plate Girders - Analysis and design, Creep and shrinkage of concrete slab, loss of prestress due to shrinkage and creep

Structural configuration of Prestressed Steel Trusses, Arches, Box Girders, Cable Truss Bridges, Rehabilitation and strengthening of steel bridges by prestressing.

Reference Books / Material

1. Belenja, E. I. (1977). Prestressed load-bearing metal structures. Mir.
2. Troitsky, M. S. (1990). Prestressed steel bridges: Theory and design.
3. Dunker, K. F., Klaiber, F. W., Beck, B. L., & Sanders Jr, W. W. (1985). Strengthening of existing single-span steel-beam and concrete deck bridges. *Final Report—Part II, Engineering Research Institute Project*, *1536*.
4. Li, G. Q., & Zhang, Q. L. (2005). *Advances in steel structures*. Elsevier.

AML562 INSTRUMENTATION AND REHABILITATION OF STRUCTURES (DE)

Credit: 3

Contact hours (L-T-P): 2-0-2

Pre-requisites: Nil

Overlaps with: Nil

Course Objectives

To impart knowledge on laboratory / field testing of civil engineering structures

Course Outcomes

At the completion of this course, the student shall acquire knowledge and ability,

i. To understand methods of laboratory / field testing of civil engineering structures
ii. To apply techniques for rehabilitation / strengthening of RC, Steel and Masonry structures

Relationship of Course Outcomes to Program Outcomes

H = 100; M = 75; L = 50

POs → / COs ↓	PO1	PO2	PO3	PO4
CO1	M	H	M	M
CO2	M	H	M	M

Content

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.

Non-destructive testing of concrete, steel structures, Various NDT tests, codal provisions, Proof Load testing.

Corrosion of steel and concrete: Theory and prevention.

Cracks in buildings: causes and remedial measures.

Assessment and evaluation for structural stability of existing structures

Special concrete constructions: fibre reinforced concrete; fibre wrapping, Special concrete like lightweight concrete, ferro cement, fly ash concrete, High performance concrete, concrete admixtures.

Techniques for Rehabilitation of RC, Steel and Masonry structures.

Reference Books / Material

1. Singh, S. (1982). *Experimental Stress Analysis*. Khanna publishers.
2. Soisson, H. E. (1975). *Instrumentation in industry*. John Wiley & Sons, Inc.
3. Boomfield, J.P.; Corrosion of Steel in Concrete; E& FN SPON; 1997
4. IS: 13935; Repair and Seismic Strengthening of Bulidings- Guidelines; Bureau of Indian Standard; New Delhi; 1993
5. SP: 25; Causes and Prevention of Cracks in Buildings; Bureau of Indian Standard; New Delhi; 1984

AML563 SEISMIC EVALUATION AND RETROFITTING OF STRUCTURES (DE)

Credit: **3**

Contact hours (L-T-P): **3-0-0**

Pre-requisites: **AML522**

Overlaps with: **Nil**

Course Objectives

To impart the knowledge for assessing and improving the performance of buildings not designed as per seismic codes of practice.

Course Outcomes

At the completion of this course, the student shall acquire knowledge and ability,

i. To understand various methods of seismic evaluation
ii. To apply techniques for rehabilitation / strengthening of RC, Steel and Masonry structures

Relationship of Course Outcomes to Program Outcomes

H = 100; M = 75; L = 50

POs → / COs ↓	PO1	PO2	PO3	PO4
CO1	H	H	H	L
CO2	H	H	H	L

Content

Introduction: Terminology; Basic principles of seismic evaluation and retrofitting.

Qualitative Methods of Seismic Evaluation: Rapid visual screening procedure (RVSP) and simplified evaluation of buildings; Visual inspection method and non-destructive testing (NDT) method.

Quantitative Methods of Seismic Evaluation: Performance based method using nonlinear static push-over analysis (NSP) and non linear dynamic method of analysis (NDP); Estimation of seismic capacity (strength and ductility).

Local and Global Methods of Seismic Retrofitting of RC Buildings: System completion; Strengthening of existing components; RC, Steel and FRP Jacketing; Addition of new components – frames, shear walls and braced frames; Introduction to supplemental energy dissipation and base isolation.

Local and Global Methods of Seismic Retrofitting of Bridges: Seismic evaluation of components of bridges (foundation, pier, deck, bearings), determination of liquefaction potential, modeling issues, strengthening of components.

Re-evaluation of Buildings with Retrofitting Elements: Linear and Non-linear modelling; Modelling of soil and foundations.

Seismic Repair and Retrofitting of Earthquake Damaged RC Buildings: Schemes of temporary shuttering damages; Methods of repair and retrofitting.

Seismic Safety of Equipments and Accessories: Retrofitting solutions against sliding and overturning of equipments and accessories.

Case Studies in Seismic Retrofitting: Case studies RC and masonry buildings.

Reference Books/Material

1. Comartin, C. D., Niewiarowski, R. W., &Rojahn, C. (1996). Seismic evaluation and retrofit of concrete buildings ATC-40. *Applied Technology Council (ATC).: Report No. SSC*, 96-01..
2. Priestley, M. N., Seible, F., &Calvi, G. M. (1996). *Seismic design and retrofit of bridges*. John Wiley & Sons.
3. Thomas, P., & Priestley, M. J. (1992). Seismic design of reinforced concrete and masonry buildings..
4. Kappos, A., &Penelis, G. G. (2010). *Earthquake resistant concrete structures*. CRC Press.
5. FEMA 154 Rapid Visual Screening of Buildings for Potential Seismic Hazards, A Handbook,.
6. FEMA273, F. (1996). NEHRP Commentary on the guidelines for the rehabilitation of building. *Washington DC: Federal Emergency Management Agency*.
7. *FEMA-356*. (2000). Commentary for the Seismic Rehabilitation of Buildings., *Federal Emergency Management Agency, Washington, DC*.
8. FEMA-440, A. (2005)., Improvement of nonlinear static seismic analysis procedures. *FEMA-440, Redwood City*.
9. FEMA, P-695 (2009). Quantification of Building Seismic Performance Factors, Federal Emergency Management Agency.
10. ASCE 41. (2006). Seismic Rehabilitation of Existing Buildings.
11. ASCE 7. (1994). Minimum design loads for buildings and other structures (Vol. 7). American Society of Civil Engineers.

AML564 SEISMIC RISK AND HAZARD ASSESSMENT (DE)

Credit: **3**

Contact hours (L-T-P): **3-0-0**

Pre-requisites: **Nil**

Overlaps with: **Nil**

Course Objectives

To introduce assessment methods of seismic hazard and risk.

Course Outcomes

At the completion of this course, the student shall acquire knowledge and ability to understand various assessment methods for seismic hazard and risk.

Relationship of Course Outcomes to Program Outcomes

H = 100; M = 75; L = 50

POs → / COs ↓	PO1	PO2	PO3	PO4
CO1	H	H	M	L

Content

Seismic Sources, Earthquake Magnitude and Magnitude Scales, Magnitude Distributions, Fault Rupture Characteristics

Importance of earthquake shaking, Empirical ground motion equations, Stochastic Methods of Estimating ground motion, Ground motion uncertainties.

roduction to seismic hazard, Basic seismic hazard calculations, Fault hazard, Hazard from area sources, Effect of Local site conditions

Hazard curve, hazard maps

Vulnerability assessment, fragility curve

Seismic risk assessment, Methods of damage estimation, comparisons of Damage estimates, integrating seismic hazard to seismic risk

Reference Books/Material

1. McGuire, R. K. (2004). *Seismic hazard and risk analysis*. Earthquake engineering research institute.

2. Dowrick, D. J. (2009). Earthquake resistant design and risk reduction. John Wiley & Sons.
3. Anderson, J. G., Biasi, G., &Brune, J. N. (2014). Earthquake Hazard, Risk and Disasters.
4. Tesfamariam, S., &Goda, K. (Eds.). (2013). Handbook of seismic risk analysis and management of civil infrastructure systems. Elsevier.
5. Ranganathan, R. (1999). *Structural reliability analysis and design*. Jaico Publishing House.
6. Schenk, V. (Ed.). (2012). *Earthquake hazard and risk* (Vol. 6). Springer Science & Business Media.

AML565 STRUCTURAL RELIABILITY ANALYSIS (DE)

Credit: **3**
Contact hours (L-T-P): **3-0-0**
Pre-requisites: **Nil**
Overlaps with: **Nil**

Course Objectives

The objective of this course is to familiarize the students with concepts of structural safety and reliability.

Course Outcomes

At the completion of this course, the student shall acquire knowledge and ability to understand the concepts of structural safety and reliability.

Relationship of Course Outcomes to Program Outcomes

H = 100; M = 75; L = 50

POs → / COs ↓	PO1	PO2	PO3	PO4
CO1	H	M	H	L

Content

Introduction of Structural Reliability, Basic Statistics, Theory of Probability, Probability Distributions (Continuous & Discrete), Random Variables.

Level-1 and Level-2 Reliability Methods, Failure Surface & Definition of Reliability in Std. Normal Space (Cornell's Reliability Index), First Order Reliability Method (FORM), Hasofer-Lind's Definition of Reliability, Rackwitz-Fiessler Algorithm, Asymptotic Integral, Second Order Reliability Method (SORM).

Monte-Carlo Methods, Latin Hypercube Sampling, Variance Reduction Technique, Importance Sampling and Adaptive Sampling, Subset Simulation.

Implicit Performance Function, Polynomial Response Surface Method (RSM), Stochastic Response Surface Method (SRSM), Stochastic Model of Loads.

Code Calibration, Partial Safety Factors, LRFD Format, System Reliability, Time Varying Reliability Analysis, Reliability Based Optimization, Introduction to Stochastic FEM.

Case Studies Using MATLAB &ANSYS in Batch Mode

Reference Books/Material

1. Ranganathan, R. (1999). *Structural reliability analysis and design*. Jaico Publishing House.
2. Robert E. Melchers. (1999). *Structural reliability analysis and prediction*. John Wiley & Son Ltd.
3. Ang, A. H. S., & Tang, W. H. (1984). Probability concepts in engineering planning and design.
4. Choi, S. K., Grandhi, R., & Canfield, R. A. (2006). *Reliability-based structural design*. Springer Science & Business Media.
5. Haldar, A., &Mahadevan, S. (2000). Reliability assessment using stochastic finite element analysis. John Wiley & Sons.

AML566 RANDOM VIBRATION ANALYSIS (DE)

Credit: **3**

Contact hours (L-T-P): **3-0-0**

Pre-requisites: **AML522**

Overlaps with: **Nil**

Course Objectives

This course covers the basic principles of random variables and stochastic processes and applications to the response of systems subjected to random vibrations.

Course Outcomes

At the completion of this course, the student shall acquire knowledge and ability to random variables and stochastic processes and applications to the response of systems subjected to random loading

Relationship of Course Outcomes to Program Outcomes

H = 100; M = 75; L = 50

POs → / COs ↓	PO1	PO2	PO3	PO4
CO1	H	H	M	L

Content

Basic Theory: Meaning and axiom of probability, events, random variables, discrete and continuous distribution, some examples; Functions of random variables, expectations, characteristic functions; Orthogonality principles, sequence of random variables.

Stochastic Processes: Counting process, random walk, Markov chain, Gaussian process, filtered point process, Markov process and non-stationary Gaussian process; Stochastic continuity and differentiation, integral, time average, ergodicity; Correlation and power spectrum; Threshold crossing, peak, envelope distribution and first passage problem.

Response of Linear Systems to Random Vibrations: Linear response of single and multiple-degree of freedom systems subjected to random inputs; Linear response of continuous systems.

Response of Non-linear Systems to Random Vibrations: Response of nonlinear systems to random inputs; Equivalent linearization and Gaussian closure technique.

Reference Books/Material

1. Nigam, N. C., & Saunders, H. (1986). Introduction to Random Vibration.
2. Preumont, A. (2013). Random Vibration and Spectral Analysis/Vibrations aléatoiresetanalyse spectral (Vol. 33). Springer Science & Business Media.
3. Lin, Y. K., &Cai, G. Q. (2004). *Probabilistic structural dynamics: advanced theory and applications*. Mcgraw-hill Professional Publishing.
4. C. W. (2011). Nonlinear random vibration: Analytical techniques and applications. CRC Press.
5. Wirsching, P. H., Paez, T. L., & Ortiz, K. (2006). *Random vibrations: theory and practice*. Courier Corporation.
6. Robson, J. D. (1964). *An introduction to random vibration,* Edinburgh University Press.

AML567 STRUCTURAL VIBRATION CONTROL (DE)

Credit: **3**

Contact hours (L-T-P): **3-0-0**

Pre-requisites: **AML522**

Overlaps with: **Nil**

Course Objectives

To provide insight into the concepts and theories of devices used to control dynamic response of structures for their seismic protection and to introduce techniques to simulate the dynamic response of structures using control devices

Course Outcomes

At the completion of this course, the student shall acquire knowledge and ability,

i. To understand concepts and theory of dynamic response control
ii. To apply techniques for vibration to various structures

Relationship of Course Outcomes to Program Outcomes

H = 100; M = 75; L = 50

POs → / COs ↓	PO1	PO2	PO3	PO4
CO1	H	H	H	L
CO2	H	H	H	L

Content

Structural Control: Historical development of structural control and base isolation, active control, passive control, hybrid control, semi active control; Application to new and existing buildings.

Theory of Vibration Isolation: Principle of base isolation; Theory of vibration isolation; Components of base isolation; Advantages and limitations; General Design Criteria; Linear and Nonlinear procedures of isolation design; Application of theory to multiple degree of freedom system.

Isolation Devices: Laminated rubber bearing, lead rubber bearing, high damping rubber bearing, PTFE sliding bearing, friction pendulum system and sleeved pile system; Modelling of isolation bearings; Design process for multilayered elastomeric bearings and buckling behaviour of elastomeric bearings; Isolation system testing.

Energy Dissipation Devices: General requirements; Implementation of energy dissipation devices; Metallic yield dampers, friction dampers, viscoelastic dampers, tuned mass dampers, tuned liquid dampers; Shape memory alloy dampers; Modelling, linear and nonlinear procedures; Detailed system requirements; Application to multistorey buildings; Testing of energy dissipation devices.

Reference Books/Material

1. Datta, T. K. (2010). *Seismic analysis of structures*. John Wiley & Sons.
2. Soong, T. T., &Costantinou, M. C. (Eds.). (2014). *Passive and active structural vibration control in civil engineering* (Vol. 345). Springer.
3. Mead, D. J. (1999). *Passive vibration control*. John Wiley & Sons Inc.
4. Dowding, C. H. (1985). *Blast vibration monitoring and control* (Vol. 297). Englewood Cliffs: Prentice-Hall.
5. Ou, J. (2003). Structural Vibration Control: Active, Semi-active and Intelligent Control.
6. Mead, D. J. (1999). *Passive vibration control*. John Wiley & Sons Inc.
7. Skinner, R., Robinson , W.H., Mc Verry, G. H., “An Introduction to Seismic Isolation”, John Wiley and Sons.

AML568 ADVANCED CONCRETE TECHNOLOGY (DE)

Credit: **3**

Contact hours (L-T-P): **3-0-0**

Pre-requisites: **Nil**

Overlaps with: **Nil**

Course Objectives

To impart knowledge on advanced concrete materials and technology

Course Outcomes

At the completion of this course, the student shall acquire knowledge and ability,

i. To understand various techniques for mix design with various admixtures
ii. To understand and design structures with fibre reinforced concrete

Relationship of Course Outcomes to Program Outcomes

H = 100; M = 75; L = 50

POs → / COs ↓	PO1	PO2	PO3	PO4
CO1	H	H	H	L
CO2	H	L	H	L

Content

Importance of Bogue's compounds, Structure of a Hydrated Cement Paste, Volume of hydrated product, porosity of paste and concrete, transition Zone, Elastic Modulus, factors affecting strength and elasticity of concrete, Rheology of concrete in terms of Bingham's parameter.

Chemical Admixtures- Mechanism of chemical admixture, Plasticizers and super Plasticizers and their effect on concrete property in fresh and hardened state, Marsh cone test for optimum dosage of super plasticizer, retarder, accelerator, Air-entraining admixtures, new generation superplasticiser.

Mineral Admixture-Fly ash, Silica fume, GCBS, and their effect on concrete property in fresh state and hardened state.

Mix Design - Factors affecting mix design, design of concrete mix by BIS method using IS10262 and current American (ACI)/ British (BS) methods. Provisions in revised IS10262-2004.

RMC - manufacture, transporting, placing, precautions, Methods of concreting- Pumping, under water concreting, shotcrete, mass concreting, hot and cold weather concreting

Special concrete - High volume fly ash concrete - concept, properties, typical mix. Fiber reinforced concrete - Fibers types and properties, Behavior of FRC in compression, tension including pre-cracking stage and post-cracking stages, behavior in flexure and shear, self compacting concrete concept, materials, tests, properties, application and Typical mix. Ferro cement - materials, techniques of manufacture, properties and application Light weight concrete - materials properties and types. Typical light weight concrete mix High density concrete and high performance concrete-materials, properties and applications, typical mix. Reactive Powder Concrete and Bendable Concrete and Polymer concrete, Pumpable concrete - materials, properties and applications

Durability of Concrete - Introduction, Permeability of concrete, chemical attack, acid attack, efflorescence, Corrosion in concrete. Thermal conductivity, thermal diffusivity, specific heat. Alkali Aggregate Reaction, IS456-2000 requirement for durability.

Test on Hardened concrete-Effect of end condition of specimen, capping, H/D ratio, rate of loading, moisture condition. Compression, tension and flexure tests. Tests on composition of hardened concrete-cement content, original w/c ratio. NDT tests concepts-Rebound hammer, pulse velocity methods. Recycling & re-use of industrial waste material.

Reference Books/Material

1. Neville, A. M. (1995). *Properties of concrete*.
2. Shetty, M. S. (2005). *Concrete Technology (ME)*. S. Chand.
3. Santhakumar, A. R. (2007). *Concrete Technology*. oxford university press.
4. Mehta, P. K. (1986). Concrete. Structure, properties and materials.
5. ACI 211, Code for Mix Design.
6. IS 10262-2009, Concrete Mix Proportioning – Guidelines.
7. Raju, N. K. (1983). *Design of concrete mixes*. CBS Publishers &Distrirutors.
8. Gambhir, M. L. (1992). *Concrete manual*. Dhanpat Rai.
9. Newman, J., & Choo, B. S. (Eds.). (2003). *Advanced concrete technology 3: processes*. Butterworth-Heinemann.
10. Prasad, J., & Nair, C. K. (2008). *Non-Destructive Test and Evaluation of Materials*. Tata McGraw-Hill Education.
11. Aïtcin, P. C. (2011). *High performance concrete*. CRC Press.
12. Powers, T. C. (1969). The properties of fresh concrete.

AML569 DISASTER MANAGEMENT AND MITIGATION (DE)

Credit: **3**

Contact hours (L-T-P): **3-0-0**

Pre-requisites: **Nil**

Overlaps with: **Nil**

Course Objectives

To impart knowledge towards the assessment of various hazards, disasters and their mitigation

Course Outcomes

At the completion of this course, the student shall acquire knowledge and ability,

i. To understand hazard identification and mitigation techniques for primary hazards such as earthquakes, tsunamis, landslides, and floods (with an emphasis on the Indian Subcontinent).

ii. To apply design principles for disaster-resistant community.

Relationship of Course Outcomes to Program Outcomes

H = 100; M = 75; L = 50

POs → / COs ↓	PO1	PO2	PO3	PO4
CO1	M	H	H	H
CO2	M	H	H	H

Content

Introduction to various hazard, vulnerability and risk, hazard estimation, hazard mapping, effect of site conditions on structures, event monitoring, processing and integration of data.

Damages: Grade of damages, direct and indirect damages, damage to structures, lessons learnt

Management and mitigation of earthquake: earthquake risk and vulnerability in India, traditional housing construction in rural and urban areas, critical areas of concern in earthquake management, past and present initiative in India, disaster management plan, approaches to seismic risk mitigation, seismic strengthening and retrofitting methods, awareness and preparedness, capacity building

Management and mitigation of tsunamis: Tsunami Risk Assessment and Vulnerability Analysis, Coastal Zone Management, Tsunami Preparedness, Structural Mitigation Measures, Regulation and Enforcement of Techno-Legal Regime

Management and mitigation of cyclones: Understanding cyclone and wind hazard in India, vulnerability and risk assessment, early warning systems, structural mitigation measures, management of coastal zones, disaster risk management and capacity development

Management and mitigation of flood (including urban flooding): The Flood Hazard, Flash Floods, urban flooding, structural measures for flood management, design and management of urban drainage system, urban flood disaster risk management, early warning system and communication, capacity development

Management and mitigation of landslide: Introduction to landslide hazard, Landslide Vulnerability and Risk in India, Hazard Zonation Mapping, Geological and Geotechnical Investigations, Landslide Risk Treatment, Landslide Monitoring and Forecasting, Capacity building

Disaster Management Act : Disaster management policy; Techno legal aspect: Techno-Legal and Techno-Financial work; Model Town and country planning legislation land use zoning regulation, development control regulations and building bye-laws registration, qualification and duties of professionals, disaster response policy.

Reference Books/Material

1. Chester, D. K. (1993). Natural hazards by EA Bryant. Cambridge University Press, 1991. No. of pages: 294. Price:£ 40 (hardback);£ 14.95 (paperback). ISBN 0 521 37295 X (hardback); 0 521 37889 3 (paperback).
2. Blaikie, P., Cannon, T., Davis, I., & Wisner, B. (2014). *At risk: natural hazards, people's vulnerability and disasters*. Routledge.
3. National Disaster Management Agency Documents, www. http://ndma.gov.in
4. FEMA Documents, http://www.fema.gov
5. Bommer, J. J. (2003). earthquake protection: Andrew Coburn and Robin Spence, John Wiley & Sons, Ltd., Chichester, England, 420 pages,£ 39.95 (paperback), ISBN 0-470-84923-1.
6. Dowrick, D. J. (2003). *Earthquake risk reduction*. John Wiley & Sons.
7. Reiter, L. (1991). *Earthquake hazard analysis: issues and insights*. Columbia University Press.
8. Aki, K., & Richards, P. G. 1980: Quantitative Seismology: Theory and Methods. *Volume I: WH Freeman & Co*.
9. Mileti, D. (1999). Disasters by Design:: A Reassessment of Natural Hazards in the United States. Joseph Henry Press.
10. Bryant, E. A. (2005). Natural Hazards, © Cambridge University Press.*Cambridge, New York, Melbourne*.

AML570 DESIGN OF BLAST RESISTANT STRUCTURES (DE)

Credit: **3**

Contact hours (L-T-P): **3-0-0**

Pre-requisites: **Nil**

Overlaps with: **Nil**

Course Objective

The main objective of this course is to expose the students to the basic concepts of blast analysis of structures and to acquaint them with well-established design and analysis procedures used nationally and internationally so as to evaluate the structures subjected to blast/explosions.

Course Outcomes

i. Students will be able to understand basic concepts of blast resistant design.
ii. Students will be able to understand and apply the design codes for blast resistant design of various structures.
iii. Students will be able to analyze and design the simple structures subjected to blast loading.

Relationship of Course Objective to Program Outcome

H = 100; M = 75; L = 50

POs → / COs ↓	PO1	PO2	PO3	PO4
CO1	H	M	H	H
CO2	H	M	H	M
CO3	H	L	H	L

Content

Basic Concepts of Blast Engineering: Blast waves and blast loading, blast wavefront parameters, blast wave pressure profile

Blast Analysis: Blast wave external loading on structures, Internal blast loading, Underwater blast, Ground shock loading of structures

Stress Wave: Reflection and transmission of stress waves, X-T diagrams

Structural Response: pressure-impulse diagrams

Protective Design: Protection against ballistic attack

Dynamic Material Properties: Materials behaviour under blast loading and their application in blast analysis

Design of Structures Against Blast: Introduction to various standards (IS and DoD) and their application, Design of steel and reinforced concrete structures/components against blast

Reference Books/Material

1. Smith, P. D. and Hetherington, J. G. (1994), "Blast and Ballistic Loading of Structures", Butterworth-Heinemann Ltd.Boston, USA.
2. Dusenberry, D. O. (2010),"Handbook for Blast-Resistant Design of Buildings", John-Wiley & Sons, Inc., Hoboken, New Jersey, USA.
3. Bangash, M.Y.H. (1993), "Impact and Explosion Analysis and Design", Boca Raton, FL: CRC Press, Inc.
4. Bangash, M.Y.H. and Bangash, T. (2006), "Explosion-Resistant Buildings Design, Analysis and Case Studies", Springer, Berlin, Germany.
5. ASCE Standard (2009), "Blast Protection of Buildings", American Society of Civil Engineers, Reston, VA, USA.
6. Henrych, J. (1979), "The Dynamics of Explosion and Its Use", Elsevier, Amsterdam, Netherlands.
7. Kinney, G.F. and Graham, K.J. (1985), "Explosive Shocks in Air." Springer, Berlin, Germany.
8. Krauthammer, T. (2008), "Modern Protective Structures", CRC Press, Boca Raton, FL, USA.
9. Mays G.C. and Smith, P.D. (1995), "Blast Effects on Buildings", Thomas Telford Publications, London, UK.
10. Meyers, M.A. (1994), "Dynamic Behavior of Materials", Wiley, New York, USA.
11. Cole, R. H.(1948), "Underwater Explosions", Princeton University Press, Princeton, New Jersey, USA.
12. IS: 4991-1968, "Criteria for Blast Resistant Design of Structures for Explosions above Ground, Bureau of Indian Standards (BIS), New Delhi, India.
13. IS 6922-1973,"Criteria for Safety and Design of Structures Subject to Underground Blasts", Bureau of Indian Standards (BIS), New Delhi, India.
14. UFC 3-340-02 (2014), "Structures to Resist the Effects of Accidental Explosions", DoD, USA.
15. FEMA-426 (2003), "Reference Manual to Mitigate Potential Terrorist Attacks against Buildings", Federal Emergency Management Agency, Washington, DC, USA.
16. FEMA-427 (2003),"Primer for Design of Commercial Buildings to Mitigate Terrorist Attacks", Federal Emergency Management Agency, Washington, DC, USA.

AMD501 PROJECT PHASE I (DC)

Credit: 3

Contact hours (L-T-P): -

Pre-requisites: Nil

Overlaps with: Nil

Course Objectives

The objective is to make student able to perform critical review of the state-of-the-art literature and current practice on the chosen research topic, to develop research plan and perform the research.

Course Outcomes

Students shall be able to

i. Demonstrate advanced theoretical & experimental knowledge in the core & allied area of structural engineering in which they have chosen to undertake their dissertation.

ii. Formulate hypotheses and design a research method to suitably test the hypotheses

iii. Competently present and defend the research to the supervisor, research progress committee, peers and other dissertation students.

Relationship of Course Outcomes to Program Outcomes

H = 100; M = 75; L = 50

POs → / COs ↓	PO1	PO2	PO3	PO4
CO1	H	H	H	M
CO2	H	H	H	M
CO3	H	H	H	M

Content

Not Applicable

AMD502 PROJECT PHASE II (DC)

Credit: **9**

Contact hours (L-T-P): **-**

Pre-requisites: **Nil**

Overlaps with: **Nil**

Course Objectives

The objective is to make student able to perform critical review of the state-of-the-art literature and current practice on the chosen research topic, to develop research plan and perform the research.

Course Outcomes

Students shall be able to

i. Demonstrate advanced theoretical & experimental knowledge in the core & allied area of structural engineering in which they have chosen to undertake their dissertation.
ii. Formulate hypotheses and design a research method to suitably test the hypotheses
iii. Competently present and defend the research to the supervisor, research progress committee, peers and other dissertation students.

Relationship of Course Outcomes to Program Outcomes

H = 100; M = 75; L = 50

POs → / COs ↓	PO1	PO2	PO3	PO4
CO1	H	H	H	M
CO2	H	H	H	M
CO3	H	H	H	M

Content

Not Applicable