

Existing

Master of Technology in Structural Engineering (CES)

I Semester (18)	II Semester (18)	Summer (0)	III Semester (12)	IV Semester (12)
Advance Structural Analysis (3)	Structural Engg. Lab. (3)	Off	Programme Elective (≥ 3)	Major Project Part II (12)
Structural Dynamics (3)	Earthquake Analysis and Design (3)		Open Elective (≥ 3)	
FEM in Structural Engg. (3)	Solid Mechanics in Structural Engg. (3)		Major Project Part I (6)	
Design of Concrete Structures (3)	Design of Steel Structures (3)			
Programme Elective (≥ 3)	Programme Elective (≥ 3)			
Programme Elective (≥ 3)	Open Elective (≥ 3)			
Total Credits	60			

Proposed

Master of Technology in Structural Engineering (CES)

I Semester (15)	II Semester (15)	Summer (0)	III Semester (15)	IV Semester (9)
Advance Structural Analysis (3)	Structural Engg. Lab. (3)		Major Project Part I * (9)	Major Project Part II (9)
Structural Dynamics (3)	Earthquake Analysis and Design (3)		Programme Elective (≥ 3)	
FEM in Structural Engg. (3)	Design of Concrete Structures (3)		Programme/ Open Elective** (≥ 3)	
Solid Mechanics in Structural Engg. (3)	Design of Steel Structures (3)			
Programme Elective (≥ 3)	Programme Elective (≥ 3)			* One evaluation in first week of 3 rd semester; and two other as currently done
Credits	Core Courses (8) = 24 Programme Electives (4) = 12 M. Tech. Project (MTP) = 18			** Only on Supervisor's recommendation
Total Credits	54			

CES Programme Core Courses

Existing Course (L-T-P Structure)

1. 717 Advanced Structural Analysis (3-0-0 = 3)
2. 719 Structural Dynamics (3-0-0 = 3)
3. 722 Solid Mechanics in Structural Engineering (3-0-0 = 3)
4. 733 Finite Element Method in Structural Engineering (2-1-0 = 3)
5. 721 Design of Concrete Structures (2-1-0 = 3)
6. 718 Design of Steel Structures (2-1-0 = 3)
7. 724 Earthquake Analysis and Design (3-0-0 = 3)
8. CEP726 Structural Engineering Laboratory (0-0-6 = 3)

1. CED821 Major Project Part-I (0-0-12 = 6)
2. CED822 Major Project Part-II (0-0-24 = 12)

Modified Course (L-T-P Structure)

- Finite Element Methods in Structural Engineering (2-0-2 = 3)
 Theory of Concrete Structures (3-0-0 = 3)
 Theory of Steel Structures (3-0-0 = 3)

- CED821 Major Project Part-I (0-0-18 = 9)
 CED822 Major Project Part-II (0-0-18 = 9)

CES Programme Elective Courses

1. 727 Design of Industrial Structures (2-1-0 = 3)
2. 729 Advanced Design of Bridges (2-1-0 = 3)
3. 731 Prestressed/Composite Structures (3-0-0 = 3)
4. 734 Mathematical and Numerical Methods (2-1-0 = 3)
5. 771 Civil Engineering Materials (3-0-0 = 3)
6. 817 Structural Safety and Reliability (3-0-0 = 3)
7. 818 Design of Plates and Shells (2-1-0 = 3)
8. 819 Concrete Mechanics (3-0-0 = 3)
9. 822 Stability Theory in Structural Engineering (3-0-0 = 3)
10. 824 Design of Offshore Structures (2-1-0 = 3)
11. 826 Advanced Finite Element Method and Programming (2-0-2 = 3)
12. 828 Wind Resistant Design of Structures (3-0-0 = 3)
13. 832 Design of Tall Buildings (2-1-0 = 3)
14. 836 Structural Health Monitoring (2-0-2 = 3)
15. CES820 Independent Study (3-0-0 = 3)
16. CED*** Minor Project in Structural Engineering (0-0-6 = 3)
17. CEL*** Structural Vibration Control (3-0-0 = 3)
18. CEL*** Design of Fiber Reinforced Composite Structures (3-0-0 = 3)
19. CEL*** Analysis and Design of Machine Foundations (2-0-2 = 3)
20. CEL*** Blast Resistant Design of Structures (2-0-2 = 3)
21. CEL*** Fire Engineering and Design (3-0-0 = 3)
22. CEL*** General Continuum Mechanics (3-0-0 = 3)
23. CEL*** Design of Masonry Structures (3-0-0 = 3)
24. CEL*** Formwork for Concrete Structures (3-0-0 = 3)
25. CEL*** Strengthening and Retrofitting of Struct. (3-0-0 = 3)
26. CEP*** Construction Technology Laboratory (0-0-3 = 1.5)

- Design of Industrial Structures (3-0-0 = 3)
 Design of Bridge Structures (3-0-0 = 3)
 Prestressed and Composite Structures (2-0-2 = 3)
 Analytical and Numerical Methods for Struct. Engg. (2-1-0 = 3)
 Advanced Concrete Technology (3-0-0 = 3)
 Theory of Plates and Shells (3-0-0 = 3)
 Theory of Structural Stability (3-0-0 = 3)
 Design of Offshore Structures (3-0-0 = 3)
 Design of Tall Buildings (3-0-0 = 3)
 CES820 Independent Study (0-3-0 = 3)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	ADVANCED STRUCTURAL ANALYSIS
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	CEL * * *
6.	Status (<i>category for program</i>)	PC

7.	Pre-requisites (course no./title)	Nil
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supercedes any existing course	Nil

9.	Not allowed for (indicate program names)	Nil
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10.	Frequency of offering	☐ Every sem ☒ 1 st sem ☐ 2 nd sem ☐ Either sem
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11.	Faculty who will teach the course Dr. Suresh Bhalla, Dr. D. R. Sahoo, Prof. Ashok Gupta	
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12.	Will the course require any visiting faculty?	No
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13.	Course objective (<i>about 50 words</i>): To teach state-of-the art techniques for analysis of skeletal structures and computational techniques.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Matrix methods for 3-D skeletal structures: force and displacement methods including analysis using substructures, static condensation. Computational aspects including in plane rigidity of slab, non-prismatic members, and shear deformation effects. Non-linear analysis: second order and elastoplastic analysis. Energy approaches. Analysis of plates and singly curved shells.	
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introductory concepts of structural analysis	01
2	Matrix displacement method for 3D skeletal structures	08
3	Method of substructures, in-plane rigidity of slab, non-prismatic members, effect of shear deformations	06
4	Static condensation, computational aspects	04
5	Matrix force method for 3D skeletal structures	05
6	Second order analysis. Elast-plastic analysis for beams and frames	08
7	Energy approaches	02
8	Analysis of plates and singly curved shells	08
9		
10		
11		
12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

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17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

Text Books:

1. Jenkins, W. M. Matrix and Digital Computer Methods in Structural Analysis, Mc Graw Hill, London.
2. Ghali, A. and Neville, A. M., Structural Analysis (Unified Classical and Matrix Approach), Chapman and Hall Ltd.
3. Bhavikatti, S. S. Theory of Plates and Shells, New Age International Publishers, New Delhi.
4. Todd, J., D., Structural Theory and Analysis, The Mac Millan Press Ltd., New York.
5. Menon, D., Advanced Structural Analysis, Narosa Publishing House, New Delhi.
6. Mc Carmac, J. and Eling, R. E., Structural Analysis: A classical and Matrix Approach, Harper and Row Publishers.
7. Yuan Yu Hsieh, Elementary Theory of Structures, 3rd edition, Prentice Hall.
8. Kinney, J. S. Indeterminate Structural Analysis, Oxford IBH Publishing Company.

9. Megson, T. H. G. (2013). Strucural and Stress Analysis, Butterworth-Heinemann
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19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	Yes
19.2	Hardware	
19.3	Teaching aides (videos, etc.)	Yes
19.4	Laboratory	Yes
19.5	Equipment	Yes
19.6	Classroom infrastructure	Yes
19.7	Site visits	

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	Nil
20.2	Open-ended problems	20%
20.3	Project-type activity	20%
20.4	Open-ended laboratory work	Nil
20.5	Others (please specify)	Nil

Date: 11th February 2015

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	STRUCTURAL DYNAMICS
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	CEL * * *
6.	Status (<i>category for program</i>)	PC

7.	Pre-requisites (course no./title)	None
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	NIL
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	NONE

9.	Not allowed for (<i>indicate program names</i>)	Not Applicable
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10.	Frequency of offering	☐ Every sem ☒ 1 st sem ☐ 2 nd sem ☐ Either sem
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11.	Faculty who will teach the course Dr. Vasant Matsagar; Dr. Dipti Ranjan Sahoo; Dr. Abhijit Ganguli; Prof. A. Madan; Prof. A. K. Jain	
12.	Will the course require any visiting faculty?	NO

13.	Course objective (<i>about 50 words</i>): Introducing dynamic loadings and fundamentals of structural dynamics. Dynamic analyses of single degree of freedom (SDOF) systems. Numerical evaluation of dynamic response. Dynamic analyses of multi degree of freedom (MDOF) systems. Obtaining natural frequencies and mode shapes of MDOF systems. Free and forced vibration of continuous systems. Introduction to advanced topics in structural dynamics.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Theory of structural dynamics and vibration analysis. Free and forced vibration of single degree of freedom (SDOF) systems, load regimes and response to harmonic, periodic, impulsive, and general dynamic loading. Response of SDOF to earthquake and response spectrum concept. Damping in structures and its evaluation. Free and forced vibration of lumped multi degree of freedom (MDOF) structures. Methods for obtaining natural frequencies and	
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	mode shapes. Normal mode theory; mode combination rules; dynamic response evaluation. Force excited and base excited dynamical systems. Time domain analysis using numerical integration scheme. Free and forced vibration of continuous systems. Frequency domain analysis of dynamical systems. Introduction to advanced topics in structural dynamics.
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Sources of Structural Vibration; Dynamic Loadings/ Regimes; Basics of Vibration/ Oscillation; Fundamentals of Structural Dynamics; Equation of Motion	3
2	Free Vibration of Single Degree of Freedom (SDOF) Systems; Structural Damping; Damped and Undamped Dynamic Response	4
3	Forced Vibration of Single Degree of Freedom (SDOF) Systems; Response to Harmonic; Periodic; Impulsive; and General Dynamic Loading; Response of SDOF to Earthquake	5
4	Numerical Evaluation of Dynamic Response	2
5	Free Vibration of Lumped Multi Degree of Freedom Systems; Modal Analysis	3
6	Analysis of two degree of freedom system; Concept of Tuned Mass Dampers	3
7	Approximate Methods for Obtaining Natural Frequencies and Mode Shapes	2
8	Numerical Evaluation for Dynamic Response of Multi Degree of Freedom System; Frequency Domain Analysis of Lumped Multi Degree of Freedom System using Normal Mode Theory	6
9	Force Excited and Base Excited Dynamical Systems	4
10	Dynamic Analysis of Non-Linear System; Numerical Scheme for Response Evaluation	4
11	Free and Forced Vibration of Continuous Systems	3
12	Introduction to Advanced Topics in Structural Dynamics; Offshore Structures	3
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

NIL

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
3		
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COURSE TOTAL (14 times 'P')		0

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

Text Books:

1. Anil Kumar Chopra (2009), "Dynamics of Structures: Theory and Applications to

- Earthquake Engineering", Prentice Hall / Pearson Education, India.
2. Ray W. Clough and Joseph Penzien (2003) "Dynamics of Structures", 3rd Edition, Computers & Structures Inc., California, USA.
 3. Jagmohan L. Humar (2012) "Dynamics of Structures", 3rd Edition, CRC Press, ISBN: 978-0415620864, Florida, USA.
 4. Mario Paz (1979) "Structural Dynamics: Theory and Computation", 2nd Edition, Van Nostrand Reinhold, New York, USA.
 5. Mario Paz and William Leigh (2006) "Structural Dynamics: Theory and Computation", 5th Edition, Springer, Berlin, Germany.
 6. Leonard Meirovitch (2001) "Fundamentals of Vibrations", McGraw-Hill, ISBN: 0070413452, 9780070413450.
 7. Roy R. Craig and Andrew J. Kurdila (2006) "Fundamentals of Structural Dynamics" (2nd Edition), John Wiley & Sons, ISBN: 978-0471430445, New Jersey, USA.
 8. Konstantin Meskouris (2000) "Structural Dynamics: Models, Methods, Examples", Ernst & Sohn, ISBN: 978-3433013274, Berlin, Germany.
 9. Franklin Y. Cheng (2000) "Matrix Analysis of Structural Dynamics: Applications and Earthquake Engineering", CRC Press, ISBN: 978-0824703875, Florida, USA.

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	SAP-2000, MATLAB
19.2	Hardware	NIL
19.3	Teaching aides (videos, etc.)	Microsoft (MS) Powerpoint and Videos
19.4	Laboratory	NIL
19.5	Equipment	NIL
19.6	Classroom infrastructure	LCD Projector and PA System
19.7	Site visits	No

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	40%
20.2	Open-ended problems	40%
20.3	Project-type activity	10%
20.4	Open-ended laboratory work	Nil
20.5	Others (please specify)	10% (Class Assignments and Quizzes)

Date: 13th February 2015

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	SOLID MECHANICS IN STRUCTURAL ENGINEERING
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	CEL * * *
6.	Status (<i>category for program</i>)	PC

7.	Pre-requisites (course no./title)	UG/ Dual – 120 credits; PG / Ph.D. - Nil
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	10% AML 140, 180, 731
8.3	Supercedes any existing course	CEL722

9.	Not allowed for (indicate program names)	Nil
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10.	Frequency of offering	☐ Every sem ☒ 1 st sem ☐ 2 nd sem ☐ Either sem
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11.	Faculty who will teach the course Dr. Gurmail S. Benipal and Dr. Abhijit Ganguli	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): The objective of the course is to present the mathematical foundations of mechanics of elastic, elastoplastic, and viscoelastic structural materials. Constitutive equations for finite elasticity, and hyper/ hypoelasticity will be derived. Methods for solution of boundary/ initial value problems of interest to civil engineers will be presented.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Introduction; Historical developments; Theory of stress; Kinematics; Isotropic/ anisotropic linear elastic solids; Axioms of constitutive equations; Finite isotropic elasticity; Hypo/ hyperelasticity; Hardening plasticity; Viscoelasticity; Boundary Value Problems (BVPs); Plane elasticity; Polar coordinates Torsion and bending of prismatic bars with general section; Elastic wave propagation; Current trends.	
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15. Lecture Outline (*with topics and number of lectures*)

Module no.	Topic	No. of hours
1	Introduction; Historical developments Theory of stress; Kinematics;	3
2	Isotropic/ anisotropic linear elastic solids	6
3	Axioms of constitutive equations; Finite isotropic elasticity; Hyper/ hypoelasticity	6
4	Hardening Plasticity; Viscoelasticity	6
5	Boundary Value Problems; Plane Elasticity	6
6	Torsion of prismatic bars with general section	6
7	Bending of prismatic bars	3
8	Elastic wave propagation	6
9		
10		
11		
12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

NIL

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
3		
4		
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6		
7		
8		
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10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Sonntag, R. E., Borgnakke, C., and Van Wylen, G. J., *Fundamentals of Thermodynamics*, 5th Ed., John Wiley, 2000.

Text Books:

Malvern, L.E., *Introduction to the Mechanics of a Continuous Medium*, Prentice Hall, Inc. 1969.

Singh, A. K., *Mechanics of Solids*, Prentice Hall of India Pvt. Ltd., New Delhi, 2007

Love, A.E.H., *The Mathematical Theory of Elasticity*, Dover Publications, London, 1897, 1934.

Sokolnikoff, I. S., *Mathematical Theory of Elasticity*, McGraw Hill Book Co., 1956.

Fung, Y.C., *Foundations of Solid Mechanics*, Prentice Hall of India, 1968.

Timoshenko S. P. and Goodier, J. N., *Theory of Elasticity*, McGraw Hill, 1970.

Saada, Adel S., *Elasticity: Theory and Applications*, Pergamon Press, 1974.

Reference Material:

Wang, C.C. and Truesdell, C., Rational Elasticity, Springer Verlag, 1977.

Jog, C. S., Foundations and Applications of Solid Mechanics, Norosa Publishers, 2002.

Sadd, Martin H., Elasticity: Theory, Applications and Numerics, Elsevier Inc., Oxford, 2005.

Lekhnitskii, S. G., Theory of Elasticity of an Anisotropic Body, Mir Publishers, Moscow, 1981.

Haddad, Y. M., Viscoelasticity of Engineering Materials, Chapman and Hall, London, 1995.

Bland, D.R., The Theory of Linear Viscoelasticity, Pergamon Press, 1960.

Rabotnov, Yu. N., Elements of Hereditary Solid Mechanics, Mir Publishers, Moscow, 1980.

Arutyunyan, N.K. H., Some Problems in the Theory of Creep in Concrete, Pergamon Press Ltd., 1966.

Luberda, V. A., Elastoplasticity Theory, CRC Press, London, 2002.

Chen, W. F. And Saleeb, A. F., Constitutive Equation for Engineering Materials, Vol. I : Elasticity and Modeling, Vol. II: Plasticity and Modeling, Elsevier Pub., Amsterdam, 1994.

Bertram, A., Elasticity and Plasticity of Large Deformations: An Introduction, Springer Verlag, Berlin, 2008 2/e.

Boley, B. A. And Weiner, J. H., Theory of Thermal Stresses, John Wiley, New York, 1960.

Caussey, O., Mechanics of Porous Continua, John Wiley & Sons, New York, 1995.

Truesdell, C., Rational Thermodynamics, Springer Verlag, Berlin, 1984 2/e.

Muhlhaus, H. B., Continuum Models for Materials with Microstructure, John Wiley & Sons, New York, 1995.

Timoshenko S. P., History of Strength of Materials, Dover Publications, New York, 1953, 1983.

Truesdell, C. A., Essays on the History of Mechanics, Springer Verlag, 1968.

Truesdell, C. A., An Idiot's Fugitive Essays on Science, Springer Verlag, 1984.

Achenbach, J. D., Wave Propagation in Elastic Solids, North-Holland, 1984.

Aki, K. And Richards, P. G., Quantitative Seismology, University Science Books, 2002.

19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	
19.2	Hardware	
19.3	Teaching aides (videos, etc.)	
19.4	Laboratory	
19.5	Equipment	
19.6	Classroom infrastructure	LCD Projector
19.7	Site visits	

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	Nil
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20.2	Open-ended problems	<20%
20.3	Project-type activity	Nil
20.4	Open-ended laboratory work	Nil
20.5	Others (please specify)	Nil

Date: 13th February 2015

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	FINITE ELEMENT METHODS IN STRUCTURAL ENGINEERING
3.	L-T-P structure	2 - 0 - 2
4.	Credits	3
5.	Course number	CEL * * *
6.	Status (<i>category for program</i>)	PC

7.	Pre-requisites (course no./title)	Nil
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supercedes any existing course	Nil

9.	Not allowed for (indicate program names)	Not Applicable
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10.	Frequency of offering	☐ Every sem ☒ 1 st sem ☐ 2 nd sem ☐ Either sem
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11.	Faculty who will teach the course Dr. Vasant Matsagar; Dr. Dipti Ranjan Sahoo	
12.	Will the course require any visiting faculty?	NO

13.	Course objective (<i>about 50 words</i>): Fundamentals of finite element (FE) techniques with emphasis on the underlying principles, theories, assumptions, and modeling in structural engineering. The accuracy of finite element results compared to other analytical methods. Practical use of finite element method in the analyzing the civil structures. Providing hands-on-experience using finite element software to model, analyze, and visualise the results for engineering problems.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Review of principles of virtual work and minimum potential energy. Elements of theory of elasticity. Finite element (FE) techniques for linear and static problems. Developing various types of finite elements: 1-D, 2-D, and 3-D. Formulating displacement and shape functions. Variational and weighted residual techniques. Higher order/ isoparametric formulation for truss, beam, frame, plate, and shell elements. Numerical solution procedures and computational aspects. Applications to structures such as dams, frames, shear	
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	walls, grid floors, rafts etc. Algorithms for FE problem solving and commercial software modeling issues. Application of FE methods to solve thermal problems.
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Review of principles of virtual work.	2
2	Review of minimum potential energy.	2
3	Elements of theory of elasticity.	2
4	Finite element (FE) techniques for linear and static problems. Finite element one-dimensional (1-D) elements. Concept and analysis of assembling of elements. Formulating displacement and shape functions	3
5	Finite element two-dimensional (2-D) elements; their concept and analysis. 2-D plane stress and plane strain elements, 2-D bending element. Formulating displacement and shape functions	2
6	Finite element three-dimensional (3-D) elements; their concept and analysis. Formulating displacement and shape functions. Variational and weighted residual techniques	3
7	Higher order/ isoparametric formulation for truss, beam, frame elements	2
8	Higher order/ isoparametric formulation for plate, and shell elements	3
9	Numerical solution procedures used for finite element analysis	2
10	Application to structures such as dams, frames, shear walls, grid floors rafts etc. Concept and analysis.	3
11	Algorithms for FEM problem solving, and commercial software modeling issues such hour glass and shear locking	2
12	Application to thermal problems	2
COURSE TOTAL (14 times 'L')		28

16. Brief description of tutorial activities

NIL

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	Examples on 1-D elements (prismatic and non-prismatic) and compare with analytical solutions; convergence studies	2
2	Different types of elements used in finite element (FE) software and their modelling issues	2
3	Simulation using finite element (FE) software and compare the results with the analytical methods for 1-D elements	3
4	Effect of mesh size (mesh density) and element shapes on the results and compare the effect on the convergence and compatibility of results	3
5	Simulation of 2-D elements and compare the results with the analytical methods	3
6	Simulation of various types of trusses and comparing the results with the analytical methods using finite element (FE) software	3
7	Simulation of beams for various supports and loading conditions using finite element (FE) software and comparing the results for different element sizes	3
8	Simulation of frame structures for different support and loading conditions using finite element (FE) software	3
9	Simulation of various types of plate and shell elements and comparing	3

	the results with the analytical methods using finite element (FE) software	
10	Simulation of 3-D elements using finite element (FE) software such as dams, frames, shear walls, grid floors, rafts etc.	3
COURSE TOTAL (14 times 'P')		28

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

Text Books:

1. Dawe D. J., "Matrix and Finite Element Displacement Analysis of Structures", Clarendon Press, Oxford, UK (1984).
2. Zienkiewicz O. C. and Robert Leroy Taylor, "The Finite Element Method", Butterworth-Heinemann, Oxford, UK (2000).
3. Bathe K., "Finite Element Procedures", Prentice Hall, Englewood Cliffs (1996).
4. Reddy J. N., "An Introduction to the Finite Element Method", 3rd edition, McGraw-Hill (2005).
5. Cook R. D., "Finite Element Modeling for Stress Analysis", John Wiley & Sons (1995).
6. Weaver W. Jr. and Gere J. M., "Matrix Analysis of Framed Structures", van Nostrand Reinhold, (1980).
7. Logan D. L., "A First Course in the Finite Element Method", 5th edition, Thomson (2010).
8. Chappelle D. and Bathe K., "The Finite Element Analysis of Shells - Fundamentals" Springer, Berlin Heidelberg, Germany (2011).
9. Zienkiewicz O. C., Taylor R. L. and Zhu Z. J. "The Finite Element Method: Its Basis and Fundamentals" Butterworth-Heinemann Ltd.; 7th revised edition (2013).
10. Rao S. S., "The Finite Element Method in Engineering", Butterworth-Heinemann, UK (2005).

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	ABAQUS, ANSYS
19.2	Hardware	Nil
19.3	Teaching aides (videos, etc.)	Microsoft (MS) Powerpoint and Videos
19.4	Laboratory	Computational Laboratory
19.5	Equipment	Computer Systems/ Workstations
19.6	Classroom infrastructure	LCD Projector and PA System
19.7	Site visits	No

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	40%
20.2	Open-ended problems	10%
20.3	Project-type activity	30%
20.4	Open-ended laboratory work	10%
20.5	Others (please specify)	10% (Class Assignments and Quizzes)

Date: 13th February 2015

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	THEORY OF CONCRETE STRUCTURES
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	CEL * * *
6.	Status (<i>category for program</i>)	PC

7.	Pre-requisites (course no./title)	Nil
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supercedes any existing course	Nil

9.	Not allowed for (indicate program names)	Nil
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☒ 2 nd sem ☐ Either sem
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11.	Faculty who will teach the course Dr. Gurmail S. Benipal, Dr. D. R. Sahoo	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): The objective is to present the methods of analysis of concrete structures under service and ultimate loads. The design of structural members for safety, serviceability, and durability under internal forces using limit state design method is discussed in detail. Historical developments and current trends in theory of concrete structures are presented.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Introduction: Historical developments, Material properties; Cracked concrete members under flexural moment and axial force; Deformations and collapse; M-P interaction. Beams without stirrups under flexural and torsional shear: Morsch and Regan theories; Skew- bending theory. Beams with stirrups under flexural and torsional shear: Plane and space truss analogies, Modified compression field theory, Unified theory, P-M-V-T interaction; Strut and tie model; Cracking: Bond slip, Development length, Tension stiffening, Durability detailing; Serviceability: Elastic, creep and shrinkage deformations; Elastic	
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	analysis: Redistribution of moments; Plastic analysis: Inelastic and hysteretic behaviour, Limit design, Confined concrete: Ductility detailing requirements; Buckling of columns; Concrete slabs: Yield line theory, Strip Theory; Reliability and safety: Limit state design method, Target reliability; Current trends: Constitutive modelling, Capacity design, Finite element analysis.
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15. Lecture Outline (*with topics and number of lectures*)

Module no.	Topic	No. of hours
1	Introduction: Historical developments; Material properties	3
2	Cracked concrete members under flexural moment and axial force; Deformations and collapse; M-P interaction	3
3	Concrete beams with/ without stirrups under flexural and torsional shear; Morsch and Regan theories; Skew-bending theory; Plane and space truss analogies	6
4	Modified compression field theory; Unified theory; PMVT interaction Strut and tie model	3
5	Cracking: Bond slip; Development length; Tension stiffening; Durability detailing	3
6	Serviceability: Elastic, creep and shrinkage deformations	3
7	Elastic analysis; Redistribution of moments Plastic analysis: Inelastic and hysteretic behaviour; Plastic hinges; Limit design	5
8	Confined concrete; Ductility detailing for OMR and SMR frames; Inelastic buckling of columns	6
9	Concrete slabs; Yield line theory, Strip Theory	4
10	Reliability and safety: Limit state design method; Target reliability	3
11	Current trends: Constitutive modelling; Capacity design, Finite element analysis	3
12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

NIL

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Sonntag, R. E., Borgnakke, C., and Van Wylen, G. J., *Fundamentals of Thermodynamics*, 5th Ed., John Wiley, 2000.

Text Books:

Baker, A. L. L., *Ultimate Load Theory applied to Design of Reinforced and Prestressed Concrete Structures*, Concrete Publications, London, 1956.
Benipal, G. S., *Theoretical Concrete Mechanics*, Ready for publication.

ASCE-ACI, Symposium on Flexural Mechanics of Reinforced Concrete, Florida, 1964.

Kong, F. K., Evans, R. H., Cohen, E. and Roll, H. (Editors), Handbook of Structural Concrete, Pitman Adv. Pub. Program, 1983

Bangash, M. Y. H., Concrete and Concrete Structures, Elsevier Applied Science, 1989.

Bresler, Boris, Reinforced Concrete Engineering, John Wiley & Sons, 1974.

Collins, M. P. and Mitchell, D. Prestressed Concrete Structures, Prentice Hall, Inc., 1991.

Hsu, T. T. C. and Mo, Y.L., Unified Theory of Concrete Structures, John Wiley & Sons, 2010.

Chen, W. F., Constitutive Equations for Engineering Materials, Vol. I: Elasticity and Modelling, Elsevier Publications, 1994.

Chen, W. F. and Saleeb, A.F., Constitutive Equations for Engineering Materials, Vol. II: Plasticity and Modelling, Elsevier Publications, 1994.

Gilbert, R. I., Time Effects in Concrete Structures, Elsevier App. Sc., Amsterdam, 1998.

Maekawa, K., Pimanmas, A. and Okamura, H., Nonlinear Mechanics of Reinforced Concrete, Taylor and Francis, London, 2003.

Neville, A. M., Creep of Concrete: Plain, Reinforced and Prestressed, Construction Press, London, 1970, 1983.

Mo, Y. L., Dynamic Behaviour of Concrete Structures, Development in Civil Engineering, Vol. 44, Elsevier Science Pub., Amsterdam, 1994.

Hughes, B. P., Limit State Theory of Reinforced Concrete, Pitman Publishing Co., London, 1971

Park, P. and Paulay, T., Reinforced Concrete Structures, John Wiley & Sons Inc., New York, 1981.

Ranganathan R., Reliability Analysis and Design of Structures, Tata McGraw-Hill, 1990.

Fintel, Mark, Handbook of Concrete Engineering, Springer, 1985.

Rajagopalan N., Prestressed Concrete, Narosa Publishing House Pvt. Ltd, 2005.

Hoyer, T. G. and Hansen, L. Z., Stability of Concrete Columns, Tech. Univ., Denmark, 2002.

Bazant, Z. P. and Planas, J., Fracture and size Effect in Concrete and other Quasi-Brittle Materials, CRC Press, London, 1998.

Subramanian, N. Design of Reinforced Concrete Structures, Oxford Higher Education, 2013.

Ghali, A., Favre, R. and Elbadry, M., Concrete Structures: Stresses and Deformations: Analysis and Design for Serviceability, Spon Press, London and New York, 2012.

IS: 456 (2000) Code of Practice for Plain and Reinforced Concrete, BIS, New Delhi.

SP: 23 (1983) Explanatory Handbook for IS: 456 (1978), BIS New Delhi.

IS: 1893 (2002) Criteria for Earthquake Resistant design of Structures, BIS, New Delhi.

19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	Yes
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19.2	Hardware	Yes
19.3	Teaching aides (videos, etc.)	Yes
19.4	Laboratory	Yes
19.5	Equipment	Yes
19.6	Classroom infrastructure	Yes
19.7	Site visits	Yes

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	30
20.2	Open-ended problems	20
20.3	Project-type activity	30
20.4	Open-ended laboratory work	10
20.5	Others (please specify)	10

Date: 13th February 2015

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	THEORY OF STEEL STRUCTURES
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	CEL * * *
6.	Status (<i>category for program</i>)	PC

7.	Pre-requisites (course no./title)	Nil
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supercedes any existing course	Nil

9.	Not allowed for (indicate program names)	Nil
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☒ 2 nd sem ☐ Either sem
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11.	Faculty who will teach the course Dr. Dipti Ranjan Sahoo, Dr. Vasant Matsagar, Dr. Gurmail S. Benipal	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): The objective is to teach the behaviour and design of structural steel components, an educational and comprehensive experience in the design of steel structures, and to introduce inelastic analysis of steel structures, issues of strength and stability and its application to design for cases of extreme loading, and related code provisions.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Structural steel: Classifications, Grades, Behavioural characteristics, Plasticity and hardening; Material models: Simple, Rigid, Power function, Smooth hysteretic; Design methodology: Allowable, Limit state, Ultimate; Methods of analysis including second-order effects; Plastic design: Plate instabilities, Local buckling, Section classifications; Structural stability: Global buckling, Member and frames under axial and combined loading; Sway and non-sway frames; Design of members under combined bending, shear and torsion; Connections: Simple, Semi-rigid, Rigid; Plates girders: Simple post-critical theory, Tension-	
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	field theory, Section design, Stiffener requirements; Gantry girder; Grillage foundation; Earthquake-resistant design and detailing; Fire-resistant design; Fatigue-resistant design
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15. Lecture Outline (*with topics and number of lectures*)

Module no.	Topic	No. of hours
1	Structural steel: Classifications, Grades, Behavioural characteristics, Plasticity and hardening;	3
2	Material models: Simple, Rigid, Power function, Smooth hysteretic;	3
3	Design methodology: Allowable, Limit state, Ultimate;	2
4	Methods of analysis including second-order effects;	3
5	Plastic design: Plate instabilities, Local buckling, Section classifications;	2
6	Structural stability: Global buckling, Member and frames under axial and combined loading; Sway and non-sway frames;	4
7	Design of members under combined axial, bending, shear and torsion; Connections design and detailing;	8
8	Plates girders: Simple post-critical theory, Tension-field theory, Design, Stiffener requirements;	3
9	Earthquake-resistant design and detailing;	7
10	Fire-resistant design;	3
11	Fatigue-resistant design;	2
12	Gantry girder and grillage foundation.	2
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

NIL

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Sonntag, R. E., Borgnakke, C., and Van Wylen, G. J., *Fundamentals of Thermodynamics*, 5th Ed., John Wiley, 2000.

Text Books:

- Engelkirk, R. (1995). *Steel Structures*, Prentice Hall.
- Galambos, T.V. and Surovek, A.E. (2005). *Structural Stability of Steel*, Wiley
- Segui, W.T. (2007). *Design of Steel Structures*, Cengage Learning.
- Bruneau, M., Uang, C.M. and Sabeli, R. (2011), *Ductile Design of Steel Structures*, Second Edition, McGraw Hill Companies, Inc.

- Chen and Sohal, Plastic Design and Second-Order Analysis of Steel Frames, , Springer-Verlag.
 - Horne and Morris, Plastic Design of Low-Rise Frames, MIT Press
 - Subramanian, N. (2008). Design of Steel Structures, Oxford University Press.
 - Chajes, A., (1974). Principles of Structural Stability Theory, Prentice Hall.
 - McCormac, J.C. (1995). Structural Steel Design: LRFD Method, Harper Collins Publishers.
 - Salmon, C.G. and Johnson, J.E. (1996). Steel Structures: Design and Behaviour, Prentice Hall.
- References:
- Trahair, N.S. (2008). Behaviour and Design of Steel Structures to EC3, Taylor and Frances.
 - Relevant Indian Standard codes and handbooks
 - AISC publications and other international codes of practice

19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	Yes
19.2	Hardware	Yes
19.3	Teaching aides (videos, etc.)	Yes
19.4	Laboratory	Yes
19.5	Equipment	Yes
19.6	Classroom infrastructure	Yes
19.7	Site visits	Yes

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	30
20.2	Open-ended problems	20
20.3	Project-type activity	30
20.4	Open-ended laboratory work	10
20.5	Others (please specify)	10

Date: 13th February 2015

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	EARTHQUAKE ANALYSIS AND DESIGN
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	CEL * * *
6.	Status (<i>category for program</i>)	PC

7.	Pre-requisites (<i>course no./title</i>)	None
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	NIL
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	NONE

9.	Not allowed for (<i>indicate program names</i>)	Not Applicable
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☒ 2 nd sem ☐ Either sem
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11.	Faculty who will teach the course Dr. Dipti Ranjan Sahoo; Dr. Vasant Matsagar; Prof. A. Madan; Prof. A. Gupta	
12.	Will the course require any visiting faculty?	NO

13.	Course objective (<i>about 50 words</i>): To impart knowledge regarding background of earthquake engineering. Teach seismology and seismic hazard to structures; seismic input for earthquake analysis of structures. Further, teaching various methods for earthquake analysis of structures; earthquake resistant design philosophy and design guidelines. Edify on seismic vibration control technologies and retrofitting.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Seismology, Seismic Risk and Hazard; Soil Dynamics and Seismic Inputs to Structures; Response Spectrum Analysis (RSA); Spectral Analysis; Nonlinear and Push-Over Analysis; Dynamic Soil-Structure Interaction (SSI); Earthquake Resistant Design Philosophy; Performance Based Earthquake Engineering; Code Provisions for Seismic Design of Structures; Retrofitting and Strengthening of Structures; Concept of Base Isolation Design and Structural Vibration Control; Advanced Topics in Earthquake Engineering.	
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction to Plate Tectonics; Sources of Earthquake; Seismic Waves; Earthquake Magnitude and Intensity	4
2	Seismic Instrumentation; Ground Motion Characteristics and Evaluation; Attenuation Relationships; Seismic Inputs to Structures	4
3	Concept of Response Spectrum; Development of Response Spectrum for a Given Earthquake; Elastic and In-Elastic Design Response Spectrum	4
4	Concept of Ductility and In-Elastic Design Response Spectrum	2
5	Concepts and Philosophies of Seismic Resistant Design; Seismic Design Parameters; Performance Based Earthquake Engineering	3
6	Seismic Coefficient Methods; Computation of Design Base Shear; Codal Provisions; Response Spectrum Method of Analysis; Load Combinations	6
7	Capacity Design Concept; Factors Affecting Ductility; Strategies to Improve Ductility; Strong Column-Weak Beam Concept for Building Frame	3
8	Design Guidelines and Codal Provisions for Design of Structural Members; Ductility Detailing	2
9	Non-Linear Analysis of Structures Subjected to Earthquake; Push-Over Analysis; Development of Capacity Demand Diagram	4
10	Seismic Retrofitting and Strengthening of Structures; Failure Mode Identification and Retrofitting Strategies for Reinforced Concrete and Masonry Structures	2
11	Introduction to Seismic Control of Structures; Passive, Active and Hybrid Control; Passive Base Isolation Technique; Linear Theory of Seismic Base Isolation	4
12	Consideration of Soil-Structure Interaction in Seismic Analysis; Advanced Topics in Earthquake Engineering	2
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

NIL

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
3		
4		
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7		
8		
9		
10		
COURSE TOTAL (14 times 'P')		0

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

Text Books:

1. Anil Kumar Chopra (2009), "Dynamics of Structures: Theory and Applications to Earthquake Engineering", 3rd Edition, Prentice Hall / Pearson Education, India
2. Datta, T.K. (2010). "Seismic Analysis of Structures", John Wiley & Sons (Asia) Pte Ltd. Singapore.

Reference Books:

3. Roberto Villaverde (2009), "Fundamental Concepts of Earthquake Engineering", Taylor & Francis.
4. Tom Paulay and M.J. Nigel Priestley (1991), "Seismic Design of Reinforced Concrete and Masonry Buildings", John Wiley & Sons, Inc.
5. Agrawal, P. and Shrikhande, M. (2006), "Earthquake Resistant Design of Structures", Prentice Hall of India, Inc.
6. Filiatrault, A., Tremblay, R.; Christopoulos, C.; Folz, B.; Pettinga, D. (2013), "Elements of Earthquake Engineering and Structural Dynamics", Presses Internationales Polytechnique, ISBN 97-82-553-016-493.
7. Kramer, S.L. (1996), "Geotechnical Earthquake Engineering", Prentice Hall, ISBN 81-317-0718-0.
8. Mazzolani, Federico M. (2000), "Seismic Resistant Steel Structures", Springer-Wien, New York (NY), USA.
9. Connor, Jerome J. (2000), "Structural Control", Massachusetts Institute of Technology (MIT), Cambridge, Massachusetts (MA), USA.
10. Naeim, F. and Kelly, J.M. (1999), "Design of Seismic Isolated Structures: From theory to practice", John Wiley and Sons, Inc., New York (NY), USA.
11. Wolf, J.P. (1985), "Dynamic Soil-Structure Interaction", Prentice Hall, Englewood Cliffs, New Jersey (NJ), USA.
12. R. S. Jangid, "NPTEL : National Program on Technology Enhanced Learning: Introduction to Earthquake Engineering", <http://nptel.ac.in/courses/105101004>.
13. NICEE Publications, "National Information Centre of Earthquake Engineering: EQ Tips", <http://www.nicee.org>.

19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	SAP-2000, MATLAB
19.2	Hardware	NIL
19.3	Teaching aides (videos, etc.)	Microsoft (MS) Powerpoint and Videos
19.4	Laboratory	Yes
19.5	Equipment	Yes
19.6	Classroom infrastructure	LCD Projector and PA System
19.7	Site visits	NIL

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	25%
20.2	Open-ended problems	25%
20.3	Project-type activity	20%
20.4	Open-ended laboratory work	NIL
20.5	Others (please specify)	30% (Class Assignments and Quizes)

Date: 13th February 2015

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	STRUCTURAL ENGINEERING LABORATORY
3.	L-T-P structure	0 - 0 - 6
4.	Credits	3
5.	Course number	CEP* * *
6.	Status (<i>category for program</i>)	PC

7.	Pre-requisites (course no./title)	Nil
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supercedes any existing course	Nil

9.	Not allowed for (indicate program names)	Nil
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☒ 2 nd sem ☐ Either sem
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11.	Faculty who will teach the course Dr. Dipti Ranjan Sahoo, Dr. S. Gupta, Dr. Suresh Bhalla, Dr. Vasant Matsagar, Prof. A.K. Jain	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): The objective is to study behaviour of conventional and advanced construction materials, response to extreme events, vibration characteristics of members, evaluation and their health monitoring techniques.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Concrete: Concrete mix-design; Evaluation of stress-strain response of plain, self-compacting and high-performance concrete; Behavior of RC members under axial, flexure, shear, torsion, and interaction; Behavior of slabs, Non-destructing testing. Response of structures and its elements against extreme loading events. Model testing: Models, of plates, shells, and frames; Free and forced vibrations; Evaluation of dynamic modulus; Beam vibrations; Vibration isolation; Shear wall building model; Time and frequency-domain study. Smart materials; Photogrammetry for Displacement Measurement; Vibration Characteristics of RC Beams using Piezoelectric Sensors etc.	
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
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2		
3		
4		
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9		
10		
11		
12		
COURSE TOTAL (14 times 'L')		

16. Brief description of tutorial activities

NIL

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	Concrete mix-design; Evaluation of stress-strain response of plain, self-compacting and high-performance concrete;	12
2	Behavior of RC members under axial, flexure, shear, torsion, and interaction; response under extreme loading events;	15
3	Behavior of slabs, Non-destructing testing;	09
4	Model testing: Models, of plates, shells, and frames; Free and forced vibrations; Evaluation of dynamic modulus;	15
5	Beam vibrations; Vibration isolation; Shear wall building model; Time and frequency-domain study.	12
6	Introduction to smart materials and structures concept and its relevance to structural dynamics; Comparison of Vibration Characteristics of Structures acquired using Accelerometers and Surface Bonded Piezoelectric Sensors; Identification of High Frequency Modes of a Beam in "Free-Free" Condition using Electro-mechanical Impedance (EMI) Technique;	12
7	Forced Excitation of Large Structure Using Electrodynamical Shaker for Dynamic Characteristics using Piezoelectric Sensors ; Photogrammetry for Displacement Measurement; Vibration Characteristics of RC Beams using Embedded Piezoelectric Sensors; Derivation of Modes of Vibration of a simply Supported beam	09
8		
9		
10		
COURSE TOTAL (14 times 'P')		84

18. Suggested texts and reference materials

STYLE: Sonntag, R. E., Borgnakke, C., and Van Wylen, G. J., *Fundamentals of Thermodynamics*, 5th Ed., John Wiley, 2000.

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19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	As needed
19.2	Hardware	As needed
19.3	Teaching aides (videos, etc.)	As needed
19.4	Laboratory	DAQ, Sensors, Manual help
19.5	Equipment	UTM, CTM, Mixer machines,
19.6	Classroom infrastructure	As needed
19.7	Site visits	As needed

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	
20.2	Open-ended problems	
20.3	Project-type activity	
20.4	Open-ended laboratory work	
20.5	Others (please specify)	Laboratory Activities

Date: 13th February 2015

(Signature of the Head of the Department)

MAJOR PROJECT TEMPLATE

1.	Department /Centre proposing the course	CIVIL ENGINEERING
2.	Course Title (<i>< 45 characters</i>)	MAJOR PROJECT I
3.	L-T-P structure	0 - 0 - 18
4.	Credits	9
5.	Course number	CED * * *
6.	Status (<i>category for program</i>)	PC

7.	Pre-requisites (course no./title)	Earned programme core credits and minimum of 24 credits by the end of first year.
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8.	Supersedes any existing course	
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9.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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10.	FACULTY WHO WILL SUPERVISE PROJECT STUDY STRUCTURAL ENGINEERING FACULTY MEMBERS	
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11.	Will the PROJECT SUPERVISION require any visiting faculty?	May be invited on request by faculty supervisor/ student
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12.	PROJECT objective (<i>about 50 words</i>): (1) To initiate students into research on well-defined or open ended problems; (2) To foster/ promote understanding of identified problem domains based on laboratory and/or numerical modeling based approaches; (3) To develop theoretical formulations of specific contextual physical processes; (4) To develop improved design methodologies in the area of structural engineering .	
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13. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	Specific to the problem taken up for the study	Open

14. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

Relevant, contextual research articles, reports and books

15. Resources required for the STUDY (*itemized & student access requirements, if any*)

19.1	Software	Yes
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19.2	Hardware	Yes
19.3	PRESENTATION aides (videos, etc.)	Yes
19.4	Laboratory	Yes
19.5	Equipment	Yes
19.6	Classroom infrastructure	No
19.7	Site visits	May be required as part of the study

Date: 13th March 2015

(Signature of the Head of the Department)

MAJOR PROJECT TEMPLATE

1.	Department /Centre proposing the course	CIVIL ENGINEERING
2.	Course Title (<i>< 45 characters</i>)	MAJOR PROJECT II
3.	L-T-P structure	0 - 0 - 18
4.	Credits	9
5.	Course number	CED* * *
6.	Status (<i>category for program</i>)	PC

7.	Pre-requisites (course no./title)	CED*** : Major Project - Part 1 must be passed.
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8.	Supersedes any existing course	
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9.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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10.	FACULTY WHO WILL SUPERVISE PROJECT STUDY STRUCTURAL ENGINEERING FACULTY MEMBERS	
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11.	Will the PROJECT SUPERVISION require any visiting faculty?	May be invited on request by faculty supervisor/ student
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12.	PROJECT objective (<i>about 50 words</i>): (1) To initiate students into research on well-defined or open ended problems; (2) To foster/ promote understanding of identified problem domains based on laboratory and/or numerical modeling based approaches; (3) To develop theoretical formulations of specific contextual physical processes; (4) To develop improved design methodologies in the area of structural engineering .	
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13. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	Specific to the problem taken up for the study	Open

14. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

Relevant, contextual research articles, reports and books

15. Resources required for the STUDY (*itemized & student access requirements, if any*)

19.1	Software	Yes
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19.2	Hardware	Yes
19.3	PRESENTATION aides (videos, etc.)	Yes
19.4	Laboratory	Yes
19.5	Equipment	Yes
19.6	Classroom infrastructure	No
19.7	Site visits	May be required as part of the study

Date: 13th March 2015

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	ADVANCED CONCRETE TECHNOLOGY
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	CEL * * *
6.	Status (<i>category for program</i>)	PE for CES

7.	Pre-requisites (course no./title)	None
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	15% with Durability
8.2	Overlap with any UG/PG course of other Dept./Centre	No
8.3	Supercedes any existing course	No

9.	Not allowed for (indicate program names)	None
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10.	Frequency of offering	☐ Every sem ☒ 1 st sem ☐ 2 nd sem ☐ Either sem
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11.	Faculty who will teach the course Dr. S. Bishnoi, Prof. B. Bhattacharjee, Dr. S. Gupta	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): This course will cover the advanced aspects of concrete technology building the knowledge of the student beyond what is taught at the undergraduate level.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Hydration of cements and microstructural development, Mineral additives, Chemical admixtures, Rheology of concrete, Creep and relaxation, Shrinkage, cracking and volume stability, deterioration processes, special concretes, Advanced characterisation techniques, sustainability issues in concreting, Modelling properties of concrete	
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction to cement and concrete	1
2	Composition of cement and hydration of cement phases	3
3	Microstructural development	4
4	Supplementary cementitious materials and chemical admixtures	6
5	Rheology of concrete	3
6	Creep, relaxation and volume stability of concrete	4
7	Deterioration processes	6
8	Special concretes	4
9	Advanced characterisation techniques	4
10	Sustainability issues in concreting	3
11	Modelling properties of concrete	4
12		
COURSE TOTAL (14 times 'L')		42

16. 1Brief description of tutorial activities

No tutorials planned

17. 2Brief description of laboratory activities

Moduleno.	Experiment description	No. of hours
1	No laboratories planned.	
2		
3		
4		
5		
6		
7		
8		
9		
10		
COURSE TOTAL (14 times 'P')		

18. 3Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

Text Books: Mehta P.K. and Monteiro P.J.M., Concrete Microstructure Properties and Materials, Third Edition, Tata McGraw Hill, 2006 Neville A.M., Properties of Concrete, Fourth Edition, Pearson, 2006 Reference Books: HFW Taylor, Cement Chemistry, Thomas Telford, 1997 Bensted J. and Barnes P. (Ed.), "Structure and Performance of Cements", Second Edition, Spon Press, 2002 Newman J. and Choo B.S., Advanced Concrete Technology - Processes, Elsevier, 2003

Newman J. and Choo B.S., Advanced Concrete Technology - Testing and Quality, Elsevier, 2003
 Jahren P. and Tongbo S., Concrete and Sustainability, CRC Press, 2014
 Sarja A. and Vesikari, E., Durability Design of Concrete Structures E & FN Spon. 1996.
 Brandt, A. M., Cement-Based Composites: Materials, Mechanical Properties and Performance, E & FN SPON. 1995
 Bentur, A. and Mindes, S., Fibre Reinforced Cementitious Composites, E & FN Spon 1990

19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	
19.2	Hardware	
19.3	Teaching aides (videos, etc.)	
19.4	Laboratory	
19.5	Equipment	
19.6	Classroom infrastructure	LCD Projector
19.7	Site visits	

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	10%
20.2	Open-ended problems	20%
20.3	Project-type activity	10%
20.4	Open-ended laboratory work	20%
20.5	Others (please specify)	Nil

Date: 13th February 2015

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	ADVANCED FEM AND PROGRAMMING
3.	L-T-P structure	2 - 0 - 2
4.	Credits	3
5.	Course number	CEL * * *
6.	Status (<i>category for program</i>)	PE

7.	Pre-requisites (<i>course no./title</i>)	CEL733 Finite Element Methods in Structural Engineering
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supercedes any existing course	Nil

9.	Not allowed for (<i>indicate program names</i>)	Not Applicable
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☒ 2 nd sem ☐ Either sem
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11.	Faculty who will teach the course Dr. Vasant Matsagar, Dr. Dipti Ranjan Sahoo, Dr. Abhijit Ganguli	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): To teach finite element (FE) application to advanced topics such as dynamics, vibration and buckling problems. FE methods used for analysis, design, and optimization of structural engineering problems. Various nonlinearities (geometric/ material) in structural problems, their mathematical and numerical aspects. Exposure to computer programming and use of commercial finite element (FE) programs for solving these problems and computational aspects.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Finite element method (FEM) to solve complex structural engineering problems. Various types of finite elements (FE) considering nonlinear material models; constitutive laws; hybrid elements. Strong and weak form representation and solutions. FEM for dynamic problems: consistent mass matrix, vibration of bars, beams, and plate elements. FEM for buckling problems: geometric matrix, buckling of struts, and plate elements. FE modeling and analysis of complex structures: 3-D frames, shear walls, bridges,	
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	cooling towers, continua etc. Computational aspects: meshing, convergence, singularity, etc. Interpretation of results. Comparison with other methods.
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Reviewing of basic finite element (FE) concept.	2
2	Various types of finite elements (FE) considering nonlinear material models.	2
3	Constitutive laws; hybrid elements.	3
4	Strong and weak form representation and solutions.	2
5	FEM for dynamic problems: consistent mass matrix, vibration of bars, beams plate elements.	3
6	FEM for dynamic problems: consistent mass matrix, vibration of plate elements.	2
7	FEM for buckling problems: geometric matrix, buckling of struts element. Concept and analysis.	3
8	FEM for buckling problems: geometric matrix, buckling of element. Concept and analysis.	2
9	Computational aspects: meshing, convergence, singularity, etc.	3
10	Interpretation of results. Comparison with other methods.	2
11	FE modeling and analysis of complex structures: 3-D frames, shear walls.	2
12	FE modeling and analysis of complex structures: bridges, cooling towers, continua etc.	2
COURSE TOTAL (14 times 'L')		28

16. Brief description of tutorial activities

Nil

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	Reviewing of different types of elements used in finite element (FE) software and related computational schemes	2
2	Simulation of vibration of bar element with nonlinearities using finite element (FE) software. Comparing the results for different mesh sizes for vibration of bars with analytical solutions	2
3	Simulation of vibration of beam element with nonlinearities using finite element (FE) software and comparing the results for different mesh sizes	3
4	Simulation of vibration of plate element using finite element (FE) software and comparing the results for different mesh sizes	3
5	Simulation of buckling of strut and plate element using finite element (FE) software.	3
6	Develop finite element (FE) programs for analysis of vibration, and buckling of bar and beam elements.	3
7	Develop finite element (FE) programs for analysis of vibration, and buckling of plate and shell elements.	3
8	Constitutive model for concrete; use of damaged plasticity models in FE, and smeared crack model for concrete	3
9	Simulation of shear wall and bridge using finite element (FE) software	3
10	Simulation of cooling tower using finite element (FE) software	3
COURSE TOTAL (14 times 'P')		28

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

Text Books:

1. Dawe D. J., "Matrix and Finite Element Displacement Analysis of Structures", Clarendon Press, Oxford (1984).
2. Zienkiewicz O. C. and Robert Leroy Taylor, "The Finite Element Method", Butterworth-Heinemann, Oxford (2000).
3. Bathe K., "Finite Element Procedures", Prentice Hall, Englewood Cliffs (1996).
4. Reddy J. N., "An Introduction to the Finite Element Method", 3rd McGraw-Hill (2005).
5. Cook R. D., "Finite Element Modeling for Stress Analysis", John Wiley & Sons (1995).
6. Reddy J. N., "An Introduction to Nonlinear Finite Element Analysis", Oxford University Press, Oxford (2004).
7. Ted Belytschko, Wing Kam Liu, Brian Moran, Khalil Elkhodary, "Nonlinear Finite Elements for Continua and Structures", John Wiley & Sons (2013).
8. Nakasone Y., Yoshimoto S., Stolarski T. A., "Engineering Analysis with ANSYS Software", Elsevier, Burlington, (2006).
9. Thomas J. R. Hughes, "The Finite Element Method- Linear Static and Dynamic Finite Element Analysis", Dover Publication, Inc., New York, (2000).
10. Smith I. M., Griffiths D. V., and Margetts L., "Programming the Finite Element Method", John Wiley and Sons Ltd. UK (2013).

19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	MATLAB, C++, ABAQUS, ANSYS
19.2	Hardware	Nil
19.3	Teaching aides (videos, etc.)	Microsoft (MS) PowerPoint and Videos
19.4	Laboratory	Computational Laboratory
19.5	Equipment	Computer Systems/ Workstations
19.6	Classroom infrastructure	LCD Projectors and PA Systems
19.7	Site visits	No

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	40%
20.2	Open-ended problems	10%
20.3	Project-type activity	30%
20.4	Open-ended laboratory work	10%
20.5	Others (please specify)	10% (Class Assignments and Quizzes)

Date: 13th February 2015

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	CIVIL ENGINEERING
2.	Course Title (<i>< 45 characters</i>)	ANALYSIS AND DESIGN OF MACHINE FOUNDATIONS
3.	L-T-P structure	2 – 0 – 2
4.	Credits	3
5.	Course number	CEL * * *
6.	Status (<i>category for program</i>)	PE

7.	Pre-requisites (course no./title)	CEL 719 (Structural Dynamics)
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	5% (CEL 727)
8.2	Overlap with any UG/PG course of other Dept./Centre	NO
8.3	Supercedes any existing course	NO

9.	Not allowed for (indicate program names)	Nil
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☒ 2 nd sem ☐ Either sem
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11.	Faculty who will teach the course Dr. Suresh Bhalla, Prof. Alok Madan, Prof. Ashok Gupta	
12.	Will the course require any visiting faculty?	NO

13.	Course objective (<i>about 50 words</i>): This course aims to make the student well-versed in theoretical, design, and practical aspects, including field measurements, of all types of machine foundations.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): General design requirements, general dynamics of machine foundations for rotating and reciprocating machines, determination of soil properties, modelling, analysis and design of block/ frame type foundations, specific details for machines applying impulsive loads, compressors and turbo-generators, detailed dynamic analysis and modes of vibration for frame type foundations, techniques for vibration isolation, practical case studies, code requirements, construction aspects of machine foundations. Laboratory: Instrumentation aspects in terms of sensors and data acquisition systems, measurement of dynamic soil parameters, measurement of vibration related parameters, vibration isolation, computational aspects related to frame	
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	type foundations including dynamic analysis
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction to machine types and general design requirements	01
2	General dynamics of machine foundations	02
3	Soil parameters for analysis and design	01
4	Modelling, analysis and design of block type machine foundations	07
5	Modelling, analysis and design of frame type foundations	07
6	specific details for machines applying impulsive loads, compressors and turbo-generators	05
7	Techniques for vibration isolation	02
8	Construction aspects of machine foundations	02
9	Case studies	01
10		
11		
12		
COURSE TOTAL (14 times 'L')		28

16. Brief description of tutorial activities

Not Applicable

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	Vibration sensing systems for machine foundations - including sensors and DAQs	02
2	Measurement of soil stiffness parameters	04
3	Vibration response measurement on operational machine foundations	06
4	Vibration isolation	06
5	FE analysis of frame type machine foundations including detailed dynamic analysis using line elements	04
6	FE analysis of frame type machine foundations including detailed dynamic analysis using 3D brick type elements	04
7		
8		
9		
10		
COURSE TOTAL (14 times 'P')		28

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. Srinivasulu, P. and Vaidyanathan, C. V. (2007), Handbook of Machine Foundations, Tata McGraw Hill Publishing Company Ltd., New Delhi.
2. Bhatia, K. G. (2011), Foundations for Industrial Machines: Handbook for Practising Engineers, D-Cad Publishers, New Delhi.

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	MATLAB, STAAD PRO, ANSYS, COMSOL
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19.2	Hardware	Geophones, accelerometers, oscilloscopes, multi-channel DAQ systems, excitation systems
19.3	Teaching aides (videos, etc.)	POWERPOINT
19.4	Laboratory	SMART STRUCTURES AND DYNAMICS LAB (V 211), STRUCTURAL SIMULATION LAB (V 216), CONCRETE STRUCTURES LAB (IV 112)
19.5	Equipment	Geophones, accelerometers, oscilloscopes, multi-channel DAQ systems, excitation systems
19.6	Classroom infrastructure	LCD PROJECTOR
19.7	Site visits	YES

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	40%
20.2	Open-ended problems	
20.3	Project-type activity	30%
20.4	Open-ended laboratory work	30%
20.5	Others (please specify)	

Date: 9th February 2015

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	ANALYTICAL AND NUMERICAL METHODS IN STRUCT. ENGG.
3.	L-T-P structure	2 - 1 - 0
4.	Credits	3
5.	Course number	CEL * * *
6.	Status (<i>category for program</i>)	PE

7.	Pre-requisites (course no./title)	Nil
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supercedes any existing course	Nil

9.	Not allowed for (indicate program names)	Nil
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course Dr. Gurmail S. Benipal, Dr. Abhijit Ganguli, Dr. Vasant Matsagar	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): Analysis of civil engineering structures requires the solution of different boundary/ initial value problems. The objective of this course is to equip the students with the required mathematical and numerical methods. Applications of these methods to: • Static, • Dynamic, and • Stability analysis of structures	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Introduction: Mathematical foundations of structural theory. Linear algebra: vector spaces and linear transformations. Linear differential equations and function spaces. Partial differential equations; Elliptic, parabolic and hyperbolic PDEs. Nonlinear differential equations. Gaussian Elimination; Factorization Techniques - LU, Cholesky; Iterative Methods of Solution of Linear Simultaneous Equations. Properties of Eigenvalues and Eigenvectors;	
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	Similarity Transforms; Diagonalization and Numerical Techniques to Compute Eigenvalues - Vector Iteration, QR algorithm, Jacobi Method. Time Marching Schemes (Step by Step Solutions); Euler's Method; Runge Kutta Method; Newmark Beta Method. Numerical Solution of Boundary Value Problems - Finite Difference Method, Explicit and Implicit Approaches; Method of Weighted Residuals, Galerkin's Method. Numerical Integration: Gauss-Legendre Method, Newton-Cotes Method. Regression Analysis and Curve Fitting. Applications of mathematical and numerical methods to static, dynamic and stability analysis of elastic structures and cables.
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15. Lecture Outline (*with topics and number of lectures*)

Module no.	Topic	No. of hours
1	Introduction: Mathematical foundations of structural theory	1
2	Linear algebra: vector spaces and linear transformations	4
3	Linear differential equations and function spaces	4
4	Partial differential equations; Elliptic, parabolic and hyperbolic PDEs	4
5	Nonlinear differential equations	2
6	Gaussian Elimination; Factorization Techniques – LU, Cholesky; Iterative Methods of Solution of Linear Simultaneous Equations.	2
7	Properties of Eigenvalues and Eigenvectors; Similarity Transforms; Diagonalization and Numerical Techniques to Compute Eigenvalues - Vector Iteration, QR algorithm, Jacobi Method.	4
8	Time Marching Schemes (Step by Step Solutions); Euler's Method; Runge Kutta Method; Newmark Beta Method.	2
9	Numerical Solution of Boundary Value Problems - Finite Difference Method, Explicit and Implicit Approaches; Method of Weighted Residuals, Galerkin's Method	2
10	Solution of Non-linear Simultaneous Equations; Numerical Integration – Gauss Legendre Method, Newton-Cotes Method	2
11	Regression Analysis and Curve Fitting	1
12	Applications of mathematical and numerical methods to static, dynamic and stability analysis of elastic structures and cables	
COURSE TOTAL (14 times 'L')		28

16. Brief description of tutorial activities

Tutorial problems or take home project assignments will be allotted to enable the student to understand the various numerical techniques associated with: 1. solution of linear or non-linear simultaneous equations 2. computation of eigenvalues 3. time marching schemes to solve ODEs 4. solution of PDEs using Finite Difference Techniques. Total duration of instruction for this exercise will be 14 hours.

17. Brief description of laboratory activities

Moduleno.	Experiment description	No. of hours
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Sonntag, R. E., Borgnakke, C., and Van Wylen, G. J., *Fundamentals of Thermodynamics*, 5th Ed., John Wiley, 2000.

Mathematical Methods:

Text Books:

Krieder, D. L., Kuller, R. G., Ostberg, D. R., Perkins, F. W., An Introduction to Linear Analysis, Addison-Wesley Publishing Co., Ontario, Canada, 1966.

Reference Material:

Thompson, E. G., Introduction to Finite Element Method, John Wiley & Sons, Singapore, 2005.

Hartmann, F., The Mathematical Foundation of Structural Mechanics, Springer-Verlag, USA, 1985.

Hoffman, K., Kunze, R., Linear Algebra, Prentice Hall, India, 1998.

Kelly, S. G., Advanced Engineering Mathematics, CRC Press, UK, 2009.

Martin, R. H., Elementary Differential Equations with Boundary Value Problems, McGraw-Hill Ryerson Ltd., New York, USA, 1984.

Michel, A. N., Herget, C. J., Algebra and Analysis for Engineers and Scientists, Birkhäuser Publishing Inc., Boston, USA, 2007.

McCamy, R. C., Mizel, V. J., Linear Analysis and Differential Equations, MacMillan, New York, USA, 1969.

Simmons, G. F., Differential Equations with Applications and Historical Notes, Tata McGraw-Hill, New Delhi, India, 2009.

Zill, D. G., Cullen, M. R., Advanced Engineering Mathematics, 3rd Edition, Narosa, Publishing House, 2009.

Zuckerberg, H. L., Linear Algebra, Charles E. Merrill Publishing Company, Columbus, Ohio, USA, 1972.

Numerical Methods:

Text Books:

Chapra, S. C., Canale, R. P., Numerical Methods for Engineers, 5th Edition, McGraw-Hill, 2005.

Conte, S. D., Boor, C. D., Elementary Numerical Analysis: An Algorithmic Approach, McGraw-Hill, 1980.

Reference Material:

Gupta, A., Bose, S. C., "Introduction to Numerical Analysis", Academic Publishers, Kolkata, India, 1989.

Hildebrand, F. B., Introduction to Numerical Analysis, 2nd Edition, Dover Publications Inc., New York, USA, 1987.

Maron, M. J., Lopez, R. J., Numerical Analysis: A Practical Approach, 3rd Edition, Wadsworth Publishing Company, USA, 1991.

Niyogi, P., Numerical Analysis and Algorithms, Tata McCraw Hill, New Delhi, India, 2003.

Salvadori, M. G., Baron, M. L., Numerical Methods in Engineering, Prentice-Hall Inc., USA, 1961.

Scheid, F., Numerical Analysis, 2nd Edition, Tata McGraw-Hill, New Delhi, India, 2008.

Zienkiewicz, O. C., Taylor, R. L., Zhu, J. Z., The Finite Element Method: Its Basic and Fundamentals, Butterworth-Heinemann, UK, 2005.

Chapman, S. J., MATLAB Programming for Engineers, 3rd Edition, Cenage Learning, USA, 2008.

19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	
19.2	Hardware	
19.3	Teaching aides (videos, etc.)	
19.4	Laboratory	
19.5	Equipment	
19.6	Classroom infrastructure	LCD Projector
19.7	Site visits	

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	Nil
20.2	Open-ended problems	Nil
20.3	Project-type activity	<20%
20.4	Open-ended laboratory work	Nil
20.5	Others (please specify)	Nil

Date: 11th February 2015

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department/Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	BLAST RESISTANT DESIGN OF STRUCTURES
3.	L-T-P structure	2 – 0 – 2
4.	Credits	3
5.	Course number	CEL * * *
6.	Status (<i>category for program</i>)	PE

7.	Pre-requisites (course no./title)	None
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	NIL
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supersedes any existing course	New Course

9.	Not allowed for (indicate program names)	Not Applicable
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course Dr. Vasant Matsagar; Dr. Dipti Ranjan Sahoo	
12.	Will the course require any visiting faculty?	NO

13.	Course objective (<i>about 50 words</i>): To teach fundamentals of blast engineering and related blast dynamics; theoretical and practical aspects of the recent technological advancements made in blast resistant and anti-terrorism design of structures and facilities. To teach concepts of high strain-rate material behaviour, blast analysis, and design of structures; blast resistant structural design using of available commercial finite element (FE) packages. To provide complete guidelines on how to design blast resistant structure for intended level of threat scenario from chosen materials.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Blast Engineering: Explosion Phenomena, Shock Front, Fragmentation, Waves, Ground Shock, and Interaction with Structures; Structural Analysis for Impulsive Loading; Pressure-Impulse (PI) Diagrams; Material Behaviour under High Strain-Rate of Loadings; Blast Resistant Design of Structures; Performance-Based Blast Design; Progressive Collapse; Anti-Terrorism	
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	Planning and Design of Facilities; Blast Retrofitting; Indian/ International Standards and Codes of Practice; Numerical Analysis Tools for Blast Analysis using Finite Element (FE) Software and Hydrocodes.
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Blast Engineering; Nuclear Explosions; Blast Phenomena.	2
2	Ground Shock; Wave Propagation; Interaction with Structures; Fragmentation.	2
3	Load Regimes; Impulse Loading; Shock/ Response Spectra; Pressure-Impulse (P-I) Diagrams; Analysis Concepts.	3
4	Blast Load Calculations; Conventional Weapons Effects (ConWep); Jones-Wilkins-Lee (JWL); Equations of State (EoS).	2
5	High Strain-Rate Response of Materials; Modelling and Simulations.	2
6	Structural Materials: Testing, Effects, and Behaviour; SHPB and Shock Tube Tests.	2
7	Performance Based Blast Design; Ductility; Support Rotation; Progressive Collapse.	3
8	Blast Analysis of Steel/ Concrete Members in Finite Element (FE) Software and Hydrocodes.	2
9	Blast-Resistant Design Concepts and Member Detailing: Steel, Concrete, Masonry etc.	2
10	Design of Steel/ Concrete Buildings: Elastic and Inelastic Behaviours; Ductility Requirements and Reinforcement Detailing.	4
11	Indian Standard (IS) Codes of Practice; American Codes and Standards; Technical Manuals; Unified Facilities Criteria (UFC).	2
12	Anti-Terrorism Planning and Design of Facilities; Blast Retrofitting.	2
COURSE TOTAL (14 times 'L')		28

16. Brief description of tutorial activities

Nil

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	Hand calculations for blast loadings and empirical approaches	2
2	Simulations in finite element (FE) software and hydrocodes for blast loadings	2
3	Structural response calculation for idealized structures	3
4	Progressive collapse analysis simulation	3
5	Design examples for steel members and structures	3
6	Design examples for concrete members and structures	3
7	Design examples for masonry units and structures	3
8	Simulations in finite element (FE) software and hydrocodes for blast response evaluation of steel members and structures	3
9	Simulations in finite element (FE) software and hydrocodes for blast response evaluation of concrete members and structures	3
10	Simulations in finite element (FE) software and hydrocodes for blast response evaluation of masonry units and structures	3
COURSE TOTAL (14 times 'P')		28

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

Text Books:

1. Dusenberry, D.O. (2010). "Handbook for Blast Resistant Design of Buildings", John Wiley and Sons, New Jersey (NJ), USA.
2. Krauthammer, T. (2008). "Modern Protective Structures", CRC Press, Boca Raton, Florida (FL), USA.
3. Bangash, M.Y.H. and Bangash, T. (2006). "Explosion-Resistant Buildings Design, Analysis and Case Studies", Springer, Berlin, Germany.
4. Mays, G.C. and Smith, P.D. (1995). "Blast Effects on Buildings", Thomas Telford Publications, London, UK.
5. Smith, P.D. and Hetherington, J.G. (1994). "Blast and Ballistic Loading of Structures", Oxford, Butterworth-Heinemann.

Reference Texts:

6. Goel, M.D. and Matsagar, V.A. (2014). "Blast Resistant Design of Structures", Practice Periodical on Structural Design and Construction, American Society of Civil Engineers (ASCE), Vol. 19, No. 2, Article Number 04014007.
7. Meyers, M.A. (1994). "Dynamic Behavior of Materials", Wiley, New York (NY), USA.
8. Kinney, G.F. and Graham, K.J. (1985). "Explosive Shocks in Air", Springer, Berlin, Germany.
9. Henrych, J. (1979). "The Dynamics of Explosion and Its Use", Elsevier, Amsterdam, Netherlands.
10. Zukas, J.A. (2004). "Introduction to Hydrocodes", Oxford, Elsevier.
11. IS 4991: 1968 Criteria for blast resistant design of structures for explosions above ground.
12. IS 6922: 1973 Criteria for safety and design of structures subject to underground blasts.

Publications by: (1) the Department of Defense (DoD), Unified Facilities Criteria (UFC) Program, Washington, DC, USA; (2) the Federal Emergency Management Agency (FEMA), Washington, DC, USA; (3) the American Society of Civil Engineers (ASCE), Reston, Virginia (VA), USA.

19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	SAP-2000, ABAQUS, ANSYS-AutoDyn, LS-Dyna
19.2	Hardware	NIL
19.3	Teaching aides (videos, etc.)	Microsoft (MS) Powerpoint and Videos
19.4	Laboratory	Computational Laboratory
19.5	Equipment	Computer Systems/ Workstations
19.6	Classroom infrastructure	LCD Projector and PA System
19.7	Site visits	As per need (defense laboratories)

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	40%
20.2	Open-ended problems	10%
20.3	Project-type activity	30%
20.4	Open-ended laboratory work	10%
20.5	Others (please specify)	10% (Class Assignments and Quizzes)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	CONCRETE MECHANICS
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	CEL * * *
6.	Status (<i>category for program</i>)	PE for CES, CET, and CEC

7.	Pre-requisites (course no./title)	None
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supercedes any existing course	Nil

9.	Not allowed for (indicate program names)	Nil
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course Dr. Shashank Bishnoi, Dr. Abhijit Ganguli, Dr. Gurmail S. Benipal	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): The objective of this course is to develop the concepts of the continuum mechanical behaviour of fresh and hardened concrete. The macroscopic mechanical and physical properties of concrete will be built upon from the microstructural level. This will help in achieving a deeper understanding of the physical, mechanical, and the long-term performance of concrete structures.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Introduction; Rheological modelling of fresh concrete; Flowing concrete; Mechanics of hardened concrete: Failure criteria; Constitutive equations; Elasto- plasticity, creep, damage mechanics and fracture; Mechanics of hydrating concretes, Durability mechanics, Transport processes; Shrinkage; Micromechanics , Numerical and analytical homogenisation, poromechanics , Crystalline growths and internal microstresses	
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15. Lecture Outline (*with topics and number of lectures*)

Module no.	Topic	No. of hours
1	Introduction	2
2	Rheological modelling of fresh concrete; Flowing concrete	4
3	Failure criteria	3
4	Constitutive equations, Elasto-plasticity	6
5	Visco-elasticity	3
6	Damage mechanics and fracture	3
7	Mechanics of hydrating concrete	3
8	Durability mechanics	3
9	Transport processes, Drying shrinkage	6
10	Micromechanics	3
11	Numerical and analytical homogenisation, Poromechanics	3
12	Crystalline growths and internal microstresses	3
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

NIL

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Sonntag, R. E., Borgnakke, C., and Van Wylen, G. J., *Fundamentals of Thermodynamics*, 5th Ed., John Wiley, 2000.

Text Book:

Benipal, G. S., Theoretical Concrete Mechanics, Ready for Publication.

Reference Texts:

Chen, W. F. Constitutive Equations for Engineering Materials Vol. I: Elasticity and Modelling, Elsevier Publications, 1994

Chen, W. F. and Saleeb, A.F. Constitutive Equations for Engineering Materials Vol. II: Plasticity and Modelling, Elsevier Publications, 1994

Neville, A. M. Creep of Concrete: Plain, Reinforced and Prestressed, Construction Press, London, 1983.

Hauggard, A. B. Mathematical Modelling and Analysis of Early Age Concrete, Department of Structural Engineering and Materials, Technical University of

Denmark, Dk-2800 Lyngby, Denmark, 1997
 Tattersall, G. H. and Banfill, P. F. G. Rheology of Fresh Concrete, Pitman Adv. Pub. Program, 1983
 Singh, Arbind K., Mechanics of Solids, Prentice Hall of India Pvt. Ltd., New Delhi, 2007

19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	Yes
19.2	Hardware	Nil
19.3	Teaching aides (videos, etc.)	Yes
19.4	Laboratory	Nil
19.5	Equipment	Nil
19.6	Classroom infrastructure	Yes
19.7	Site visits	Nil

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	Nil
20.2	Open-ended problems	<20%
20.3	Project-type activity	Nil
20.4	Open-ended laboratory work	Nil
20.5	Others (please specify)	Nil

Date: 11th February 2015

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	CONSTRUCTION TECHNOLOGY LABORATORY
3.	L-T-P structure	0 - 0 - 3
4.	Credits	1 . 5
5.	Course number	CEP * * *
6.	Status (<i>category for program</i>)	PE for CES

7.	Pre-requisites (course no./title)	None
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	None
8.2	Overlap with any UG/PG course of other Dept./Centre	No
8.3	Supercedes any existing course	No

9.	Not allowed for (indicate program names)	None
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☒ 2 nd sem ☐ Either sem
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11.	Faculty who will teach the course Dr. S. Bishnoi, Dr. A. Ganguli, Dr. S. Gupta	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): This laboratory course will offer knowledge on the use and testing of construction materials and site tests for quality control.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Tests related to quality control at site, in-situ tests, tests related to damage and deterioration assessment, performance monitoring of structures.	
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1		
2		
3		
4		
5		
6		
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10		
11		
12		
COURSE TOTAL (14 times 'L')		

16. Brief description of tutorial activities

No tutorials planned

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	Testing of cements and supplementary cementitious materials	6
2	Testing of chemical admixtures	3
3	Mixture design of special concretes	6
4	Moisture profile and acoustic measurements	3
5	Non destructive tests, half-cell potential, pH measurement, carbonation depth, water and air permeability	6
6	Effect of high temperature on concrete	3
7	Calorimetry and shrinkage	6
8	Alkali Silica Reaction	3
9	Advanced characterisation of construction materials	3
10	Behaviour of construction joints, water-proofing and precast joints	3
COURSE TOTAL (14 times 'P')		42

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

Richardson M.G., Fundamentals of Durable Reinforced Concrete, First Edition, Spon Press, 2002 Comite Euro-international du Beton, Durable concrete structures: design guide, Second Edition, Thomas Telford Services Ltd., 1989 Mehta P.K. and Monteiro P.J.M., Concrete Microstructure Properties and Materials, Third Edition, Tata McGraw Hill, 2006 Bohni H (Ed.), Corrosion in reinforced concrete structures, CRC Press, 2005 Bensted J. and Barnes P. (Ed.), "Structure and Performance of Cements", Second Edition, Spon Press, 2002
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Newman J. and Choo B.S., Advanced Concrete Technology - Processes, Elsevier, 2003
 Newman J. and Choo B.S., Advanced Concrete Technology - Testing and Quality, Elsevier, 2003
 Neville A.M., Properties of Concrete, Fourth Edition, Pearson, 2006

19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	Yes
19.2	Hardware	Yes
19.3	Teaching aides (videos, etc.)	Yes
19.4	Laboratory	Yes
19.5	Equipment	Yes
19.6	Classroom infrastructure	LCD Projector
19.7	Site visits	Yes

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	20%
20.2	Open-ended problems	20%
20.3	Project-type activity	20%
20.4	Open-ended laboratory work	20%
20.5	Others (please specify)	NIL

Date: 13th February 2015

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	DESIGN OF BRIDGE STRUCTURES
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	CEL * * *
6.	Status (<i>category for program</i>)	PE

7.	Pre-requisites (course no./title)	None
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supercedes any existing course	Nil

9.	Not allowed for (indicate program names)	Not Applicable
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course Dr. Dipti Ranjan Sahoo, Dr. Vasant Matsagar	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): To teach fundamentals of bridges and their importance; theoretical and practical aspects of the recent technologies in bridge construction and design of bridge structures. Introduce Indian Roads Congress (IRC) codes and American Association of State Highway and Transportation Officials (AASHTO) recommendations for design of bridges. Teach design of various types of bridges using available commercial software. Provide complete guidelines on how to design bridge structures from chosen materials.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Introduction, historical/ magnificent bridges; Site Selection, Planning, and Type of Bridges, Loads and Forces; Code Provisions for Design of Steel and Concrete Bridges; Analysis Methods, Grillage Analogy; Theories of Lateral Load Distribution and Design of Superstructure: Slab Type, Beam-Slab, and Box Type; Distribution of Externally Applied and Self-Induced Horizontal Forces among Bridge Supports in Straight, Curved, and Skewed Decks;	
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	Continuous Type and Balanced Cantilever Type Superstructure; Temperature Stresses in Concrete Bridge Deck; Different Types of Foundations: Open, Pile, and Well Foundations; Choice of Foundation for Abutments and Piers; Design of Abutments, Piers, Pile/ Pier Caps; Effect of Differential Settlement of Supports; Bridge Bearings; Expansion Joints for Bridge Decks; Vibration of Bridge Decks; Parapet and Railings for Highway Bridges; Construction Methods; Segmental Construction of Bridges; Inspection and Maintenance of Bridges; Health Monitoring and Evaluation of Existing Bridges; Bridge Failure: Case Studies.
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction, historical/ magnificent bridges; Site Selection, Planning, and Type of Bridges, Loads and Forces	4
2	Code Provisions for Design of Steel and Concrete Bridges; Analysis Methods, Grillage Analogy	4
3	Theories of Lateral Load Distribution and Design of Superstructure: Slab Type, Beam-Slab, and Box Type	3
4	Distribution of Externally Applied and Self-Induced Horizontal Forces among Bridge Supports in Straight, Curved, and Skewed Decks	3
5	Continuous Type and Balanced Cantilever Type Superstructure	3
6	Temperature Stresses in Concrete Bridge Deck	2
7	Different Types of Foundations: Open, Pile, and Well Foundations; Choice of Foundation for Abutments and Piers	4
8	Design of Abutments, Piers, Pile/ Pier Caps	4
9	Effect of Differential Settlement of Supports	3
10	Bridge Bearings; Expansion Joints for Bridge Decks; Vibration of Bridge Decks; Parapet and Railings for Highway Bridges	4
11	Construction Methods; Segmental Construction of Bridges; Inspection and Maintenance of Bridges; Health Monitoring and Evaluation of Existing Bridges	4
12	Bridge Failure: Case Studies	4
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

NIL

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

Text Books:

1. Raina V.K. (2014) "Concrete Bridge Practice Analysis, Design and Economics", 4th Edition, Shroff Publishers and Distributors Private Limited, Nawi Mumbai, India.
2. Ponnuswamy S. (2011) "Bridge Engineering", 2nd Edition, Tata McGraw Hill Education Private Limited, New Delhi, India.
3. Victor D.J. (2011) "Essentials of Bridge Engineering", Oxford and IBH Publishing Co.

Private Limited, New Delhi, India.

Reference Texts:

4. IRC-5 (1998) "Standard Specifications and Code of Practice for Road Bridges, Section I - General Features of Design", Indian Road Congress, New Delhi, India.
5. IRC-6 (2000) "Standard Specifications and Code of Practice for Road Bridges, Section II – Loads and Stresses", Indian Road Congress, New Delhi, India.
6. IRC-112 (2011) "Code of Practice for Concrete Road Bridges", Indian Road Congress, New Delhi, India.
7. IS-456 (2000) "Plain and Reinforced Concrete - Code of Practice", Bureau of Indian Standards, New Delhi, India.
8. IS-800 (2007) "General Construction in Steel - Code of Practice", Bureau of Indian Standards, New Delhi, India.
9. IS-1893 (2002) "Indian Standard Criteria for Earthquake Resistant Design of Structures", Bureau of Indian Standards, New Delhi, India.
10. AASHTO LRFD Bridge Design Specifications (2007) American Association of State Highway and Transportation Officials - Load and Resistance Factor Design, Fourth Edition, Washington DC, USA.

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	STAAD.Pro, SAP-2000, LARSA 4D, Midas Civil, RM Bridge
19.2	Hardware	Nil
19.3	Teaching aides (videos, etc.)	Microsoft (MS) Powerpoint and Videos
19.4	Laboratory	Computational Laboratory
19.5	Equipment	Computer Systems/ Workstations
19.6	Classroom infrastructure	LCD Projector and PA System
19.7	Site visits	Yes

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	40%
20.2	Open-ended problems	25%
20.3	Project-type activity	30%
20.4	Open-ended laboratory work	0%
20.5	Others (please specify)	5%

Date: 13th February 2015

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	DESIGN OF FIBER REINFORCED COMPOSITE STRUCTURES
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	CEL * * *
6.	Status (<i>category for program</i>)	PE for CES, CET, and CEC Programmes

7.	Pre-requisites (course no./title)	Nil
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supercedes any existing course	Nil

9.	Not allowed for (indicate program names)	Nil
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course Dr. Dipti Ranjan Sahoo, Dr. Vasant Matsagar, Dr. Shashank Bishnoi, Prof. B. Bhattacharjee	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): The objective is to teach the basic concepts, behavior and design techniques for fiber reinforced composite (FRC) structures	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Introduction; Types of structural fibers: matrix, fiber and interface; Fiber reinforced concrete (FRC); High-performance concrete; Stress transfer, Bond, Pull-out, Toughening mechanism; Fracture mechanics; Modeling of tensile and flexural behaviours; Behaviour under compression; Shear failure theory; Behaviour under seismic loading; Composite structural design: Design spirals, Criteria, Selection configurations; Laminate design; Mathematical analysis of laminates; Design of single skin panels, Design of composite stiffeners.	
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15. Lecture Outline (*with topics and number of lectures*)

Module no.	Topic	No. of hours
1	Introduction to fiber reinforced composites	2
2	Types of structural fibers; Matrix, Fiber and Interface	3
3	Fiber reinforced concrete (FRC); High-performance concrete; Stress Transfer, Bond, Pull-out, Toughening mechanism	6
4	Behaviour under compression; Shear failure theory; Fracture mechanics	6
5	Modeling of tensile and flexural behaviour; Behaviour under seismic loading, Continuous reinforcement	5
6	Composite structural design: Design spirals, Criteria, Selection configurations	4
7	Laminate design	3
8	Mathematical analysis of laminates	3
9	Design of single skin panels	3
10	Design of composite stiffeners	5
11	Recent trends	2
12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

NIL

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Sonntag, R. E., Borgnakke, C., and Van Wylen, G. J., *Fundamentals of Thermodynamics*, 5th Ed., John Wiley, 2000.

Text Books:

- Hannant, D. J., *Fibre cements and fibre concretes*, Wiley, 1978.
- Mukhopadhyay, M., *Mechanics of composite materials and structures*, Universities Press, 2012.
- Johnston, C. D., *Fiber-reinforced cements and concretes*, CRC Press, 2010.
- Neville, A. M., *Fibre reinforced cement and concrete*, Construction Press, 1975.
- Portland Cement Association, *Fiber reinforced concrete*, Portland Cement

Association, 1990.

- Wight, J. K., and MacGregor, J. G., Reinforced concrete-Mechanics and Design, Pearson, 2005.

- Balaguru, P., Nanni, A., and Giancaspro, J., FRP Composites for Reinforced and Prestressed Concrete Structures, Taylor and Francis, 2009.

-Bentur, A., and Mindess, S., Fibre Reinforced Cementitious Composites, Second Edition, Modern Concrete Technology Series, 2007.

19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	Yes
19.2	Hardware	Yes
19.3	Teaching aides (videos, etc.)	Yes
19.4	Laboratory	Yes
19.5	Equipment	Yes
19.6	Classroom infrastructure	Yes
19.7	Site visits	Yes

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	Nil
20.2	Open-ended problems	10
20.3	Project-type activity	20
20.4	Open-ended laboratory work	Nil
20.5	Others (please specify)	Nil

Date: 13th February 2015

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	DESIGN OF MASONRY STRUCTURES
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	CEL * * *
6.	Status (<i>category for program</i>)	PE

7.	Pre-requisites (<i>course no./title</i>)	Nil
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	None
8.2	Overlap with any UG/PG course of other Dept./Centre	None
8.3	Supersedes any existing course	None

9.	Not allowed for (<i>indicate program names</i>)	Nil
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course Dr. Dipti Ranjan Sahoo, Prof. Alok Madan, Dr. Shashank Bishnoi	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): To develop the techniques required for the design, analysis, and assessment of masonry structures. Particular emphasis will be placed on limit-state design, strength design and seismic design requirements	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Introduction and Historical Perspective; Masonry Materials; Masonry Design Approaches; Overview of Load Conditions; Compression Behavior of Masonry; Masonry Wall Configurations; Distribution of Lateral Forces; Flexural Strength of Reinforced Masonry Members: In-plane and Out-of-plane Loading, Interactions; Structural Wall; Columns and Pilasters; Retaining Wall; Pier and Foundation; Shear Strength and Ductility of Reinforced Masonry Members; Prestressed Masonry; Stability of Walls; Coupling of Masonry Walls, Openings, Columns, Beams; Elastic and inelastic analysis; Modelling Techniques; Static Push-Over Analysis and use of Capacity Design Spectra	
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction and Historical Perspective	01
2	Masonry Materials	02
3	Masonry Design Approaches	03
4	Overview of Load Conditions	02
5	Compression Behavior of Masonry	04
6	Masonry Wall Configurations; Distribution of Lateral Forces	04
7	Flexural Strength of Reinforced Masonry Members: In-plane and Out-of-plane Loading, Interactions	06
8	Structural Wall; Columns and Pilasters; Retaining Wall; Pier and Foundation;	04
9	Shear Strength and Ductility of Reinforced Masonry Members	04
10	Prestressed Masonry; Stability of Walls;	02
11	Coupling of Masonry Walls, Openings, Columns, Beams;	04
12	Elastic and inelastic analysis; Modelling techniques; Static Push-Over Analysis and use of Capacity Design Spectra	06
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

Nil

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
3		
4		
5		
6		
7		
8		
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10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

Text Books:

- Narendra Taly, Design of Reinforced Masonry Structures, McGraw Hill Professional, 21-Jun-2010- 752 pp.
- Robert R. Schneider, Walter L. Dickey, Reinforced Masonry Design, Prentice Hall, 1994, 729 pp.
- T. Paulay and M. J. N. Priestley, Seismic Design of Reinforced Concrete and Masonry Buildings, John Wiley & Sons, Inc. 1992.
- The Masonry Society. (2007). Masonry Designers' Guide (MDG-5), Fifth Edition, The Masonry Society.
- Hendry, A.W., Sinha, B. P., Davies, S. R., Design of Masonry Structures, CRC

Press; 3rd edition, 1997.
 -All relevant IS codes and handbooks and International codes of practices

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	Yes
19.2	Hardware	Yes
19.3	Teaching aides (videos, etc.)	Yes
19.4	Laboratory	Yes
19.5	Equipment	Yes
19.6	Classroom infrastructure	Yes
19.7	Site visits	Yes

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	20%
20.2	Open-ended problems	Nil
20.3	Project-type activity	20%
20.4	Open-ended laboratory work	Nil
20.5	Others (please specify)	Nil

Date: 13th February 2015

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	DESIGN OF OFFSHORE STRUCTURES
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	CEL * * *
6.	Status (<i>category for program</i>)	PE

7.	Pre-requisites (<i>course no./title</i>)	Structural Dynamics (CEL719)
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supercedes any existing course	Nil

9.	Not allowed for (<i>indicate program names</i>)	Not Applicable
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☒ 2 nd sem ☐ Either sem
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11.	Faculty who will teach the course Prof. A.K. Jain, Prof. Ashok Gupta, Dr. Vasant Matsagar	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): To teach fundametals of offshore engineering. Fundamentals of both the theory and application of the relevant procedures of structural and geotechnical design of offshore structures. A thorough understanding of the interaction of waves, wind, and currents with offshore structures and fluid-structure interaction (FSI). Analytical background in modeling of wind, wave, and current forces on the structures. Dynamic analysis of floating structures. Stochastic dynamics of offshore structures. Offshore pipeline design concepts. Seabed pile/ gravity foundation analysis and design concepts.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Rudiments of offshore engineering; sea spectra; wave theories; wave-structure interation. Design of offshore platforms: introduction, fixed and floating platforms. Buoyed structures/ articulated towers; tension-leg platform (TLP); Marine risers; compliant and non-compliant structures; offshore pipelines and risers; Steel, concrete, and hybrid platforms. Buoys and mooring system	
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	design; Design criteria and code provisions. Environmental loading. Wind, wave, and current loads. Loads and stability during handling and towing. Introduction to stochastic dynamics of ocean structures considering different sea spectra. Soil-structure interaction (SSI): beam on Winkler foundation foundation (p-y curve approach). Dynamic analysis of SPAR platforms. Fatigue analysis of fixed and floating offshore structure: stress concentration, S-N curves. Foundations: site investigations, gravity, jacket platforms, hybrid platforms. Piled foundation and behavior under dynamic loading. Static and dynamic analysis of platforms and components. Dynamic analysis using software: response of fixed type offshore structures, articulated towers, single leg- and multi-legged towers.
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction to different types of offshore platforms (compliant and non-compliant)	2
2	Loads on offshore structures (wind, waves, and currents)	3
3	Dynamic analysis of fixed offshore structures. Stability analysis of offshore structures. Formulation and analysis of solid-fluid interaction problems. Fluid-structure interaction (FSI) effect using simulations	4
4	Dynamic analysis of large floating structures: buoyant leg supported - tension-legged platforms (TLPs), articulated towers. Analysis and design of steel-framed and base-supported offshore structures (platforms). Finite element applications for framed steel offshore platforms. Modeling and dynamic analysis of tension legged platforms (TLPs) using simulations. Dynamic analysis of submarine pipelines and risers using software	9
5	Dynamic analysis of SPAR platforms. Fatigue analysis of fixed and floating offshore structure: stress concentration, S-N curves. Structural response calculation for jacket type platforms. Finite element modeling and analysis of SPAR type platforms. Analysis and design of gravity platforms subjected to wind and wave loads. Steel tubular joint design for static and cyclic Loads, ultimate capacity of tubular joints	7
6	Introduction to stochastic dynamics of ocean structures (JONSWAP and Pierson-Moskowitz spectrum)	2
7	Foundation design: site investigation, gravity and jacket type platforms, behavior under static as well as dynamic loading,	3
8	Offshore pipeline design, modeling of clump weights for subsea pipelines, design of risers, route selection and diameter / wall thickness calculations; pipeline stability, free span calculations	3
9	Buoys and mooring system design, mooring configurations	2
10	Dynamic analysis using software: response of fixed type offshore structures, articulated towers, single leg- and multi-legged towers. Simulations in finite element (FE) software for dynamic analysis of fixed type offshore structures, articulated towers, single leg and multi-legged towers	3
11	Code and standard provisions for design of offshore structures	1
12	Soil-structure interaction: Beam on Winkler foundation foundation (p-y curve approach). Code-based foundation design for pile supported offshore structures. Design of pile foundations for offshore platforms	3
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

Nil

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
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COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

Text Books:

- 1) Chakrabarti, S. K., "Hydrodynamics of Offshore Structures", Springer, 1987.
- 2) Sarpkaya, T. and Isaacson, M., "Mechanics of Wave Forces on Offshore Structures", Van Nostrand Reinhold Co., 1981.

Reference Texts:

- 3) American Petroleum Institute, "Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms", API Recommended Practice 2A (RP 2A), 1991.
- 4) Wilson, J. F., "Dynamics of Offshore Structures", Wiley, 2003.
- 5) Brebbia, C. A., Walker, S., "Dynamic Analysis of Offshore Structures", Butterworth's, 1979.
- 6) Patel, H., "Dynamics of Offshore Structures", Butterworth-Heinemann Ltd., 1989.
- 7) Hooft, J. C., "Advanced Dynamics of Marine Structures", New York John Wiley and Sons, 1978.
- 8) Sorenson, R. M., (1978) "Basic Coastal Engineering", A Wiley-Interscience Publication, 1978.
- 9) Newman, N., "Marine Hydrodynamics", MIT Press, 1977.
- 10) Lamb, H., "Hydrodynamics", 6th Edition, Cambridge University Press, 1995.

19. Resources required for the course (itemized & student access requirements, if any)

19.1	Software	SACS, MOSES, Ansys, Ansys-Aqwa, Sesam HydroD
19.2	Hardware	Nil
19.3	Teaching aides (videos, etc.)	Microsoft (MS) Powerpoint and Videos
19.4	Laboratory	Computational Laboratory
19.5	Equipment	Computer Systems/ Workstations
19.6	Classroom infrastructure	LCD Projector
19.7	Site visits	No

20. Design content of the course (Percent of student time with examples, if possible)

20.1	Design-type problems	40%
20.2	Open-ended problems	30%
20.3	Project-type activity	30%
20.4	Open-ended laboratory work	0
20.5	Others (please specify)	0

Date: 13th February 2015

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	DESIGN OF TALL BUILDINGS
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	CEL * * *
6.	Status (<i>category for program</i>)	PE

7.	Pre-requisites (course no./title)	None
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supercedes any existing course	Nil

9.	Not allowed for (indicate program names)	Nil
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course Prof. Ashok Gupta, Dr. Dipti Ranjan Sahoo, Dr. Shashank Bishnoi	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): To make students familiar with different types of structural and foundation systems in practice for tall buildings. Further, the course will focus on various methods of structural analysis of tall buildings. The course will also cover the effects of shear wall, asymmetrical geometry, differential shortening, and openings.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Structural systems and general concepts of tall buildings; Various methods of structural analysis; Gravity systems for steel, concrete, and composite buildings; Lateral systems for steel, concrete, and composite buildings; Interaction of frames and shear walls; Simultaneous and sequential loading; Differential shortening of columns; P-Δ effects; Effect of openings; Foundations and foundation-superstructure interaction; Wind/ earthquake effects and design for ductility; Damping systems; Asymmetric structures and twisting of frames.	
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Structural systems and general concepts of tall buildings	2
2	Various methods of structural analysis	6
3	Gravity systems for steel, concrete, and composite buildings	5
4	Lateral systems for steel, concrete, and composite buildings	6
5	Interaction of frames and shear walls	3
6	Simultaneous and sequential loading	2
7	Differential shortening of columns	1
8	P- Δ effects	2
9	Effect of openings	1
10	Foundations and foundation-superstructure interaction	5
11	Wind/ earthquake effects, design for ductility and damping systems	7
12	Asymmetric structures and twisting of frames	2
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

Nil

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
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COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

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| <ol style="list-style-type: none"> 1. Taranath, B. S., Structural Analysis and Design of Tall Building, Mcgraw-Hill, 1988. 2. Smith, B.S. and Coull, A., Tall Building Structures: Analysis and Design, John Wiley & Sons, 1991. 3. Taranath, B. S., Structural Analysis and Design of Tall Buildings: Steel and Composite Construction, CRC Press, 2011. 4. Taranath, B. S., Reinforced Concrete Design of Tall Buildings, CRC Press, 2009. |
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19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	STAAD.Pro; SAP-2000, STRUDS
19.2	Hardware	Nil

19.3	Teaching aides (videos, etc.)	LCD Projector and videos
19.4	Laboratory	Nil
19.5	Equipment	Nil
19.6	Classroom infrastructure	General
19.7	Site visits	Nil

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	20%
20.2	Open-ended problems	20%
20.3	Project-type activity	30%
20.4	Open-ended laboratory work	Nil
20.5	Others (please specify)	30% (Simulations)

Date: 13th February 2015

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	FIRE ENGINEERING AND DESIGN
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	CEL * * *
6.	Status (<i>category for program</i>)	PE for CES, CET, and CEC programmes

7.	Pre-requisites (course no./title)	None
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supercedes any existing course	Nil

9.	Not allowed for (indicate program names)	Not Applicable
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course Dr. Vasant Matsagar, Dr. Shashank Bishnoi, Prof. B. Bhattacharjee	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): Teaching theoretical and practical aspects of fire engineering and safety including recent technological advancements. Essentials of fire engineering; structural fire engineering; mechanics of structures under fire. Fundamentals of heat transfer in solids and structures; heat transfer mechanisms, thermo-mechanical properties of construction materials and fire growth. Analyzing thermal effects of fires on buildings and designing members for adequate strengths, protection measures, and hazard mitigation. Response evaluation of members such as beams, columns etc. and structures such as frames under simultaneous mechanical and fire loads.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): (A) Fire engineering: fundamentals of fire science, fire dynamics, hazard mitigation, and safety; codes, standards, rules and fire safety regulations; thermodynamics, thermofluids, heat and mass transfer; human behavior in fire and urban planning; fire testing methods for materials; large-scale fire testing.	
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	"Fire protection" - current methods in fire safety engineering; mechanics of repair; mitigation of fire damage by due design, and construction; industrial fire safety. Passive fire protection: analyzing the thermal effects of fires on buildings and designing structural members. Introduction to active fire protection. (B) Structural fire engineering: fire behavior and scenarios, heat transfer to the structure, structural response and stability under thermo-mechanical loads; fire safety design; mechanical properties of structural materials at elevated temperatures; fire response of steel, concrete, fiber reinforced polymers, high-performance materials etc.; computational procedures to predict structural behavior under fire conditions; structural fire resistance based on theoretical/empirical relationships; performance-based fire engineering; strengthening/repair of structures.
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Fire engineering: fundamentals of fire science, fire dynamics.	4
2	Thermodynamics, thermofluids, heat and mass transfer. Human behavior in fire and urban planning.	4
3	Fire hazard mitigation, and safety provisions; codes, standards, rules, fire safety regulations.	3
4	Fire protection: current methods in fire safety engineering; mechanics of repair; mitigation of fire damage by due design, and construction; industrial fire safety.	4
5	Passive fire protection: analyzing thermal effects of fires on buildings and designing structural members. Introduction to active fire protection.	3
6	Fire testing methods for materials; large-scale fire testing; mechanical properties of the construction materials at elevated temperatures.	3
7	Structural fire engineering: fire behavior and scenarios, heat transfer to the structure.	4
8	Fire safety design; fire response of steel, concrete, fiber reinforced polymers, high performance materials etc.	3
9	Structural response and stability under fire with other loads; member and structure behaviors.	3
10	Computational procedures to predict structural behavior under fire conditions and scenarios.	4
11	Structural fire resistance based on the theoretical/ empirical relationships.	3
12	Performance-based fire engineering; strengthening/ repair of structures against fire.	4
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

Nil

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
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COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

Text Books:

1. Buchanan, Andrew H. (2001) "Structural Design for Fire Safety", John Wiley and Sons", New York (NY), USA, ISBN 0-471-89060.
 2. Kodur, Venkatesh; Franssen, Jean-Marc; Zaharia, Raul (2009) "Designing Steel Structures for Fire Safety", CRC Press, New York (NY), USA.
 3. Wang, Yong; Burgess, Ian; Wald, Frantisek; Gillie, Martin (2014) "Performance-Based Fire Engineering of Structures", CRC Press, Taylor and Francis Group.
 4. Purkiss, John A. (2007) "Fire Safety Engineering - Design of Structures", Butterworth-Heinemann Publications, Oxford, UK.
 5. Malhotra, H.L. (1982) "Design of Fire-Resisting Structures", Surrey University Press, UK.
 6. Li, Guo Qiang; Wang, Peijun (2013) "Advanced Analysis and Design for Fire Safety of Steel Structures", Springer, USA.
 7. Wang, Y.C. (2002) "Steel and Composite Structures - Behaviour and Design for Fire Safety", Spon Press, UK.
 8. Jain, V.K. (2007) "Fire Safety in Buildings", Taylor & Francis, UK.
- References:
9. Proceedings of the "Structures in Fire (SiF)" Conferences.

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	SAFIR, Abaqus, Vulcan
19.2	Hardware	Nil
19.3	Teaching aides (videos, etc.)	Microsoft (MS) Powerpoint and Videos
19.4	Laboratory	Nil
19.5	Equipment	Computer Systems/ Workstations
19.6	Classroom infrastructure	LCD Projector and PA System
19.7	Site visits	Nil

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	50%
20.2	Open-ended problems	10%
20.3	Project-type activity	15%
20.4	Open-ended laboratory work	10%
20.5	Others (please specify)	15% (Design problems and simulation)

Date: 16th February 2015

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	FORMWORK FOR CONCRETE STRUCTURES
3.	L-T-P structure	3-0-0
4.	Credits	3
5.	Course number	CEL * * *
6.	Status (<i>category for program</i>)	PE for CET, CEC, and CES

7.	Pre-requisites (course no./title)	NO
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Yes, CEL 774 (PG Course) about 12% overlap based on keywords count. Some minor overlap with CEL 778 also.
8.2	Overlap with any UG/PG course of other Dept./Centre	NO
8.3	Supercedes any existing course	NO

9.	Not allowed for (indicate program names)	Students not from Civil Engineering
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course K. N. Jha, B. Bhattacharjee, A. K. Jain	
12.	Will the course require any visiting faculty?	NO

13.	Course objective (<i>about 50 words</i>): Formwork is an important constituent of RC Construction, though often neglected thereby resulting into poor quality of concrete, higher cost, and accidents at work places. The course is envisaged to equip students with the basic concepts of different types of formwork and scaffolding, and the issues involved in their design, implementation, and management.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Introduction to Formwork , Requirements and selection for Formwork, Formwork Materials, such as Timber, Plywood, Steel, Aluminum Form,	
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	Plastic Forms, and Accessories, Horizontal and Vertical Formwork Supports; Formwork Design Concepts, Illustration of Formwork system for Foundations, walls, columns, slab and beams and their design, Formwork for Shells, Domes, Folded Plates, Overhead Water Tanks, Natural Draft Cooling Tower. Formwork for Bridge Structures, Flying Formwork such as Table form, tunnel form. Slipform, Formwork for Precast Concrete, Formwork Management Issues pre award and post award, Formwork failures-causes and Case Studies in Formwork Failure, Formwork issues in multi-story building construction.
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction to Formwork as a Temporary Structure, Requirements, Selection, and Classification (Types) of Formwork	02
2	Formwork Materials, Shoring Towers, and Scaffolds	04
3	Formwork Design Concepts	04
4	Conventional and Proprietary Foundation Formwork	02
5	Conventional and Proprietary Wall Formwork	03
6	Conventional and Proprietary Column Formwork	03
7	Slab and Beam Formwork	03
8	Formwork for Special Structures such as Shells, Domes, Folded Plates, Overhead Water Tanks, Natural Draft Cooling Tower, Nuclear Reactor, Tunnel, and Lift Shaft	02
9	Formwork for Bridge Structures, Cases in Failure of Temporary Support Structures of Bridges	02
10	Flying Formworks such as Table Forms, Tunnel Formwork System, Column Mounted Shoring System, Gang Forms	03
11	Slipform, Formwork for Precast Concrete, Formwork Failure	07
12	Pre-Award and Post –award Formwork Management Issues, Formwork Issues in Multi-Story Building Construction	07
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

Not Applicable

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
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COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

Text books:

- 1 Jha, K.N., Formwork for Concrete Structures, First Edition, McGraw Hill. 2012.
- 2 Peurifoy, R.L. and Oberlender, G.D., Formwork for concrete structures, McGraw Hill. 2011.

References:

- 3 Robinson, J.R., Piers, abutments, and formwork for bridges. Library Accn No. 29797
- 4 Austin, C.K., Formwork to concrete Library Accn No. 87018
- 5 Moore, C.E., Concrete Form Construction Library Accn No. 79825

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19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	Yes
19.2	Hardware	Nil
19.3	Teaching aides (videos, etc.)	POWERPOINT, VIDEO
19.4	Laboratory	Nil
19.5	Equipment	Nil
19.6	Classroom infrastructure	LCD PROJECTOR
19.7	Site visits	YES

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	15%
20.2	Open-ended problems	Nil
20.3	Project-type activity	60%
20.4	Open-ended laboratory work	Nil
20.5	Others (please specify)	Nil

Date: 13th February 2015

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	GENERAL CONTINUUM MECHANICS
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	CEL * * *
6.	Status (<i>category for program</i>)	PE UG & PG: Open Category (OC) Elective

7.	Pre-requisites (<i>course no./title</i>)	120 UG Credits
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	10% AML803
8.3	Supercedes any existing course	New Course

9.	Not allowed for (<i>indicate program names</i>)	Nil
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course Dr. Gurmail S. Benipal, Dr. Abhijit Ganguli, Dr. Shashank Bishnoi	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): Continuum mechanics, a field theory of deformable materials, constitutes a basic engineering science. The objective is to present its historical and conceptual development. The focus is on its fundamental concepts and principles, and still open problems. The constitutive equations proposed to simulate the diverse physical phenomena exhibited by materials are presented. Methods and realism in continuum mechanics are discussed in the context of other basic physical sciences.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Introduction: Field and particle theories in physics. Historical development of continuum mechanics; A basic engineering science. Classical theories: Stress and kinematics. Elasticity, viscoelasticity and elastoplasticity; Newtonian fluids. Continuum thermomechanics; Classius- Duhem Inequality; Thermodynamics with internal variables. Constitutive equations; Axioms for simple materials; Frame indifference; Finite elasticity; Hyper/ hypoelasticity; Non- Newtonian	
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	fluids. Polar and nonlocal materials; Materials of differential/ gradient type; Configurational mechanics; Biomechanics; Nanomechanics. Theories of conduction and diffusion; Electromagnetism . Coupled fields: Thermoelasticity and electromagnetoelasticity; MHD; Chemomechanics. Intermediate problems; Statistical continuum theories; Relativistic continuum mechanics; Materials models for luminiferous Aether. Rational methodology and realism; Current trends.
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15. Lecture Outline (*with topics and number of lectures*)

Module no.	Topic	No. of hours
1	Introduction: Field and particle theories in physics; Historical development of continuum mechanics; A basic engineering science	3
2	Classical theories: Stress and kinematics; Elasticity, viscoelasticity and elastoplasticity; Newtonian fluids	6
3	Continuum thermomechanics: Classius-Duhem inequality; Thermodynamics with internal variables	3
4	Constitutive equations; Axioms for simple materials; Frame indifference; Finite elasticity; Hyper/ hypoelasticity; Non-Newtonian fluids	6
5	Polar and non-local materials; Materials of differential/ gradient type; Configurational mechanics; Biomechanics; Nanomechanics	6
6	Theories of conduction and diffusion; Electromagnetism	3
7	Coupled fields: Thermoelasticity and electromagnetoelasticity; MHD; Chemomechanics	6
8	Intermediate problems; Statistical continuum theories; Relativistic continuum mechanics; Elastic luminiferous Aether	6
9	Methods and realism in continuum mechanics; Current trends	3
10		
11		
12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

NIL

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
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COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Sonntag, R. E., Borgnakke, C., and Van Wylen, G. J., *Fundamentals of Thermodynamics*, 5th Ed., John Wiley, 2000.

Text Books:

Chung, T. J., General Continuum Mechanics, Camb. Univ. Press, 2010.
 Melvern, L. E., Introduction to the Mechanics of a Continuous Medium, Prentice-Hall, 1969.

Maugin, G. A. and Metrikine, A. V., Mechanics of Generalized Continua, Springer, 2010.

Reference Material:

Barenblatt, G. I. and Joseph, D. D. (Ed) Collected Works of R. S. Rivlin, Vol. I and II, Springer- Verlag, Berlin, 1997

Benipal, Gurmail S. On the Truesdell School in Continuum Mechanics and Thermodynamics, Proc., Natl. Conf., Recent Trends in Theo and Appl Mechanics, Kurukshetra, 1997

Bobbio, S. Electrodynamics of Materials, Academic Press, 2000

Boley, B. A. and Weiner, J. H. Theory of Thermal Stresses, Dover, 1960

Chen, W. Q. The Renaissance of Continuum Mechanics, Appl Pys & Eng, 15(4), 2014

Coleman, B. D., Markovitz, H. and Noll, W. (1966) Viscometric Flows of Non-Newtonian Flows, Springer

Epstein, M., The Geometrical Language of Continuum Mechanics, Camb. Univ. Press, 2010.

Epstein, M., The Elements of Continuum Biomechanics, John Wiley & Sons, 2012

Eringen, A. C. and Maugin, G. A., Electrodynamics of Continua, Springer, 1989.

Hertel, P., Continuum Physics, Springer, Berlin, 2012.

Ignatieff, Y. A., The Mathematical World of Walter Noll, Springer, Berlin, 1986.

Jog, C. S., Foundations and Applications of Mechanics, Vol. I: Continuum Mechanics, Vol. II: Fluid Mechanics, Norosa, New Delhi, 2002.

Love, A. E. H., A Treatise on the Mathematical Theory of Elasticity, Dover, 1892.

Lavenda, B. H., Thermodynamics of Irreversible Processes, Dover Pub., New York, 1978.

Man, C.- S. and Fosdick, R. L., The Rational Spirit in Modern Continuum Mechanics, Kluwer Academic, Dordrecht, 2004.

Maugin, G. A., Continuum Mechanics through the Twentieth Century, Springer, 2013.

Maugin, G. A., Continuum Mechanics through the Eighteenth and Nineteenth Centuries, Springer, Switzerland, 2014.

Maugin, G. A., The Thermodynamics of Nonlinear Irreversible Behaviours: An Introduction, World Scientific, Singapore, 1999.

Muhlhaus, H.- B. (Ed), Continuum Models for Materials with Microstructure, John Wiley & Sons, 1995.

Muller, W. H., An Expedition to Continuum theory, Springer, 2014.

Murdoch, A. I., Physical Foundations of Continuum Mechanics, Camb. Univ. Press, 2012.

Sih, G. C., Michopoulos, J. and Chou, S.- C., Hygrothermoelasticity, Springer, 2011.

Truesdell, C., Mechanical Foundations of Elasticity and Fluid Dynamics, J Rat Mech Ana, 1(1):125- 300, 1952.

Truesdell, C. and Toupin, Classical Field Theories, Springer, 1960.

Truesdell, C. and Noll, W., The Nonlinear Field Theories of Mechanics, Springer, 1965.

Truesdell, C., Essays in the History of Mechanics, Springer, 1968.

Truesdell, C. and C.-C. Wang, Rational Thermodynamics, Springer, New York, 1984.

Truesdell, C., An Idiot's Fugitive Essays on Science, Springer, New York, 1984.

Truesdell, C. and Rajagopal, K. R., An Introduction to the Mechanics of Fluids, Birkhouser, Boston, 2000.

Wang, C.- C. and Truesdell, C., Introduction to Rational Elasticity, Springer, 1973.

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19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	
19.2	Hardware	
19.3	Teaching aides (videos, etc.)	
19.4	Laboratory	
19.5	Equipment	
19.6	Classroom infrastructure	
19.7	Site visits	

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	Nil
20.2	Open-ended problems	<20%
20.3	Project-type activity	Nil
20.4	Open-ended laboratory work	Nil
20.5	Others (please specify)	Nil

Date: 13th February 2015

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	INDEPENDENT STUDY
3.	L-T-P structure	0 - 3 - 0
4.	Credits	3
5.	Course number	CES820
6.	Status (<i>category for program</i>)	PE

7.	Pre-requisites (course no./title)	None
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	NIL
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	NIL

9.	Not allowed for (indicate program names)	Not Applicable
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course STRUCTURAL ENGINEERING FACULTY MEMBERS	
12.	Will the course require any visiting faculty?	NO

13.	Course objective (<i>about 50 words</i>): To study an independent research area and prepare a report on state of the art. To develop students' capability for advanced analysis, design, and research in a selected topic or area. Also, his/her ability to carry out independent investigation, design, or development.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Course content will be decided by the concerned faculty member of structural engineering.	
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1		
2		
3		
4		
5		
6		
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9		
10		
11		
12		
COURSE TOTAL (14 times 'L')		

16. Brief description of tutorial activities

Specific to the problem taken up for the study.

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

The texts and references will be dependent on the syllabus of the independent study course: relevant, contextual research articles, reports and books.

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	Yes
19.2	Hardware	Yes
19.3	Teaching aides (videos, etc.)	Yes
19.4	Laboratory	Yes
19.5	Equipment	Yes
19.6	Classroom infrastructure	No

19.7	Site visits	Yes
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20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	
20.2	Open-ended problems	
20.3	Project-type activity	
20.4	Open-ended laboratory work	
20.5	Others (please specify)	

Date: 13th February 2015

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	MINOR PROJECT IN STRUCTURAL ENGINEERING
3.	L-T-P structure	0 - 0 - 6
4.	Credits	3
5.	Course number	CES * * *
6.	Status (<i>category for program</i>)	PE

7.	Pre-requisites (course no./title)	None
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	NIL
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supersedes any existing course	NIL

9.	Not allowed for (indicate program names)	Not Applicable
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course STRUCTURAL ENGINEERING FACULTY SUPERVISOR	
12.	Will the course require any visiting faculty?	NO

13.	Course objective (<i>about 50 words</i>): (1) To explore a prescribed problem based on laboratory and/or numerical modelling based approaches (2) To explore design methodologies in the area of water resources engineering The objective of the minor project course is to develop the research carrying capabilities of the students and to improve capabilities of the students for application of scientific knowledge to the solution of technical and scientific problems in structural engineering.	
14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): The course content will be decided by the concerned faculty member (supervisor) who will be assigning the research project to the students registered for this course.	

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Specific to the problem taken up for the study	Open
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
COURSE TOTAL (14 times 'L')		

16. Brief description of tutorial activities

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17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

The texts and references will be dependent on the scope and objective of the research project assigned to the registered student: relevant, contextual research articles, reports and books.

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	Yes
19.2	Hardware	Yes
19.3	Teaching aides (videos, etc.)	Yes
19.4	Laboratory	Yes
19.5	Equipment	Yes

19.6	Classroom infrastructure	No
19.7	Site visits	Yes

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	NA
20.2	Open-ended problems	NA
20.3	Project-type activity	100%
20.4	Open-ended laboratory work	NA
20.5	Others (please specify)	NA

Date: 13th February 2015

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	PRESTRESSED AND COMPOSITE STRUCTURES
3.	L-T-P structure	2 - 0 - 2
4.	Credits	3
5.	Course number	CEL * * *
6.	Status (<i>category for program</i>)	PE

7.	Pre-requisites (course no./title)	None
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	NIL
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	NIL

9.	Not allowed for (indicate program names)	NOT APPLICABLE
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course Dr. Vasant Matsagar, Dr. Dipti Ranjan Sahoo, Dr. Shashank Bishnoi	
12.	Will the course require any visiting faculty?	NO

13.	Course objective (<i>about 50 words</i>): To teach fundamentals of prestress concrete and its application; theoretical and practical aspects of the recent technologies in prestressed concrete and design of prestressed concrete structures. To explain Indian Roads Congress (IRC) code and AASHTO recommendations for design of prestressed concrete bridges. Teach prestressed concrete structural design using of available commercial software. To provide complete guidelines on how to design prestressed concrete structures from chosen materials. To teach steel-concrete composite structures: analysis and design.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Introduction; Need, Advantages, and Disadvantages; High Strength Materials; Pretensioning and Post-Tensioning Methods; Prestressing Methods; Prestressing Systems and Devices; Camber, Deflections, and Cable Profiles/ Layouts; Load-Balancing; Codes and Standards; Prestressed Concrete Members - Flexure, Shear, Torsion Behaviors; Design Methods and Code	
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	Provisions; Strain Compatibility Method; Pressure/ Thrust Line; Pre-Tensioning; Grouted/ Bonded and Ungrouted/ Unbonded Post-Tensioning; Partial Prestressing; Bursting Stresses; Anchorage Zone (End Block Design); Transmission and Transfer Length; De-Bonding and Draping of Prestressing Tendons; Camber, Deflection, and Ductility; External Prestressing; De-Compression; Losses in Prestress; Bearing and Bond Stresses; Case Studies of Prestressed Concrete Bridge Design and Practices. Need of Composite Construction; Analysis of Indeterminate and Composite Structures; Design Methods for Composite Beams, Slabs, Columns, Box-girders, Shear Studs etc.
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction; Need, Advantages, and Disadvantages; High Strength Materials; Pretensioning and Post-Tensioning Methods; Prestressing Methods; Prestressing Systems and Devices	3
2	Camber, Deflections and Cable Profiles/ Layouts; Load-Balancing; Codes and Standards	2
3	Prestressed Concrete Members - Flexure Behavior; Design methods; Strain Compatibility Method; Pressure/ Thrust Line	4
4	Pre-Tensioning; Grouted/ Bonded and Ungouted/ Unbonded Post-Tensioning; Partial Prestressing	2
5	Bursting Stresses; Anchorage Zone (End Block Design)	2
6	Transmission and Transfer Length; De-Bonding and Draping of Prestressing Tendons; Camber, Deflection and Ductility	3
7	Prestressed Concrete Members - Shear and Torsion Behaviors; Code Provisions; External Prestressing; De-Compression	4
8	Losses in Prestress; Bearing and Bond Stresses	2
9	Case Studies of Prestressed Concrete Bridge Design and Practices	2
10	Need of Composite Construction; Analysis of Indeterminate Structures; Design Methods for Composite Beams, Slabs, Columns, Box-Girders, Studs etc.	4
11		
12		
COURSE TOTAL (14 times 'L')		28

16. Brief description of tutorial activities

NIL

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	Design Examples of Prestressed Beams	2
2	Design Examples of Prestress Losses	2
3	Pretensioning Beams: Flexure, Shear and Torsion Governing	3
4	Post-Tensioning Beams: Flexure, Shear and Torsion Governing	3
5	Anchorage Slip of Post-Tensioned Beams	2
6	Computational Aspects and Modeling Interactions in Prestressed Concrete Members and Simulating Real Behavior	6
7	Simulating Behavior of Prestressed Beams in Software Including Prestress Losses	3
8	Failure Studies in Prestressed Concrete Members	2
9	Design Examples of Composite Structures	2
10	Flexural Behaviour of Composite Beams	3
COURSE TOTAL (14 times 'P')		28

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

Text Books:

1. Michael P. Collins and Denis Mitchell (1994) "Prestressed Concrete Structures", Prentice Hall, New Jersey, USA.

2. Tung Yen Lin and Ned Hamilton Burns (2004) "Design of Prestressed Concrete Structures", Third Edition, John Wiley and Sons Private Limited, Singapore.
3. N. Krishna Raju (2009) "Prestressed Concrete", Fourth Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi, India.
4. Pasala Dayaratnam (1996) "Prestressed Concrete Structures", India Book House Limited, Mumbai, India.
5. N. Rajagopalan (2008) "Prestressed Concrete", Second Edition, Narosa Publishing House, New Delhi, India.
6. Edward G. Nawy (2005) "Prestressed Concrete - A Fundamental Approach", Fifth Edition, Prentice Hall International.
7. Antoine E. Naaman (2004) "Prestressed Concrete Analysis and Design - Fundamentals", Second Edition, Techno Press, Korea.

References:

8. IS-1343 (1980) "Code of Practice for Prestressed Concrete", Bureau of Indian Standards, New Delhi, India.
9. IRC-18 (2000) "Design Criteria for Prestressed Concrete Road Bridges (Post-Tensioned Concrete)" Second Revision, Indian Roads Congress, New Delhi, India.
10. IRS Concrete Bridge Code (1997) Indian Railway Standard Code of Practice for Plain, Reinforced and Prestressed Concrete for General Bridge Construction, India.
11. PCI Design Handbook (2004) Precast Prestressed Concrete Institute, Sixth Edition, Chicago, USA.
12. AASHTO LRFD Bridge Design Specifications (2007) American Association of State Highway and Transportation Officials - Load and Resistance Factor Design, Fourth Edition, Washington DC, USA.

19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	LARSA 4D, midas Civil, RM Bridge
19.2	Hardware	NIL
19.3	Teaching aides (videos, etc.)	Microsoft (MS) Powerpoint and Videos
19.4	Laboratory	Concrete Structures Laboratory and Computational Laboratory
19.5	Equipment	Prestressing Devices, Hydraulic Jack (to apply vertical load), Computer Systems/ Workstations
19.6	Classroom infrastructure	LCD Projector and PA System
19.7	Site visits	NO

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	40%
20.2	Open-ended problems	10%
20.3	Project-type activity	30%
20.4	Open-ended laboratory work	10%
20.5	Others (please specify)	10% (Class Assignments and Quizzes)

Date: 13th February 2015

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	STRENGTHENING AND RETROFITTING OF STRUCT.
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	CEL * * *
6.	Status (<i>category for program</i>)	PE for CES, CET, and CEC Programmes

7.	Pre-requisites (<i>course no./title</i>)	None
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	15% with Durability and Repair of Concrete Structures
8.2	Overlap with any UG/PG course of other Dept./Centre	No
8.3	Supercedes any existing course	No

9.	Not allowed for (<i>indicate program names</i>)	None
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course Dr. Shashank Bishnoi, Dr. Dipti Ranjan Sahoo, Dr. Vasant Matsagar
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12.	Will the course require any visiting faculty?	No
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13.	Course objective (<i>about 50 words</i>): This course will cover aspects of: - analysing existing structures, - repairing damage to structures, and - strengthening and retrofitting existing structures.
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Structural assessment, damage under accidental and cyclic loads, cracking in structures, evaluation of damage, analysis of existing structures, compression, flexural and shear strengthening, strengthening using laminates, strengthening using prestressing, bracing and stiffening of structures, maintenance of retrofitting, design codes for retrofitting of structures, retrofitting of steel structures, retrofitting of masonry structures.
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Assessment of existing structures	4
2	Damage in structures under accidental, monotonic and cyclic loads	5
3	Cracking and evaluation and repair of cracks in structures	4
4	Strengthening of compression, flexural and shear elements	4
5	Strengthening using metal and composite laminates	5
6	Strengthening using prestressing	3
7	Overall stiffening of structures	4
8	Maintenance of retrofitting in structures	4
9	Design codes for retrofitting	4
10	Strengthening of steel structures	5
11		
12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

No tutorials planned

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	No laboratories planned.	
2		
3		
4		
5		
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7		
8		
9		
10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

Text Books:

FIB technical report, Retrofitting of concrete structures by externally bonded FRPs

Alexander M.G., Beushausen H.-D., Dehn F. and Moyo P, Concrete Repair, Rehabilitation and Retrofitting, CRC press 2013

Delatte N. (Ed.), Failure distress and repair of concrete structures, CRC press, 2009

Fardis M.N., Seismic design, assessment and retrofitting of concrete buildings, Springer 2009

Perkins P, Repair, Protection and Waterproofing of Concrete Structures, Third Edition, E&FN Spon, 1997

Reference Material:

Comite Euro-international du Beton, Durable concrete structures: design guide, Second Edition, Thomas Telford Services Ltd., 1989

Reid I.L.K., Steel Bridge Strengthening, Thomas Telford Publishing, 2001
Relevant ACI and FIB codes

19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	Yes
19.2	Hardware	Yes
19.3	Teaching aides (videos, etc.)	Yes
19.4	Laboratory	Yes
19.5	Equipment	Yes
19.6	Classroom infrastructure	LCD Projector
19.7	Site visits	Yes

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	Design of retrofitting schemes to be given as assignments (20%)
20.2	Open-ended problems	Nil
20.3	Project-type activity	Nil
20.4	Open-ended laboratory work	Nil
20.5	Others (please specify)	Nil

Date: 13th February 2015

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	CIVIL ENGINEERING
2.	Course Title (<i>< 45 characters</i>)	STRUCTURAL HEALTH MONITORING
3.	L-T-P structure	2 – 0 – 2
4.	Credits	3
5.	Course number	CEP836
6.	Status (<i>category for program</i>)	ELECTIVE

7.	Pre-requisites (course no./title)	CEL719/ AML734/ MEL 733/ MEL 831/ MEL 841 EEL 731
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	NO
8.2	Overlap with any UG/PG course of other Dept./Centre	NO
8.3	Supercedes any existing course	NO

9.	Not allowed for (indicate program names)	
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course Dr. Suresh Bhalla, Prof. Ashok Gupta	
12.	Will the course require any visiting faculty?	NO

13.	Course objective (<i>about 50 words</i>): In today's scenario, structural health monitoring has taken an important role for critical structures. This course aims to make the student familiar with the state-of-the art in structural health monitoring both in theory and practice.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Concept of structural health monitoring, sensor systems and hardware requirements, global and local techniques, computational aspects of global dynamic techniques, experimental mode shapes, damage localization and quantification, piezo–electric materials and other smart materials, electro–mechanical impedance (EMI) technique, adaptations of EMI technique. Laboratory: Sensor installation and diagnostics, mode shape extraction, location and quantification of damage using global dynamic techniques, damage detection using electro – mechanical impedance technique, remote monitoring.	
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction to concept of structural health monitoring	02
2	Sensor systems and requirements	03
3	Global and local techniques	02
4	Computational and experimental aspects of global dynamic techniques: experimental mode shapes, damage localization and quantification,	07
5	Piezo–electric materials and other smart materials,	05
6	Electro–mechanical impedance (EMI) technique,	05
7	Low cost adaptations of EMI technique.	02
8	Term project	02
9		
10		
11		
12		
COURSE TOTAL (14 times 'L')		28

16. Brief description of tutorial activities

Not Applicable

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	Installation of sensors on structures, sensor diagnostics	02
2	Mode shape extraction	04
3	Location and quantification of damage using global dynamic techniques	04
4	Damage detection using EMI technique on concrete structures	04
5	Damage detection using EMI technique on metal structures	04
6	Remote monitoring	02
7	Programming exercise involving data acquisition, analysis and interpretation	08
8		
9		
10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. Ewins, D. J. (2000), Modal Testing: Theory, Practice and Applications, 2nd edition, Research Studies Press Ltd., Baldock.
2. Bhalla, S., Choi, S. B et. al (2007), Smart Material and Structures: New Research, editor P. L. Reece, Nova Science Publishers Inc., New York.
3. Inman, D. J., Farrar, C.R., Steffan, V. and Lopes, V. (2005), Damage Prognosis -For Aerospace, Civil and Mechanical Systems, John Wiley & Sons, Ltd., Chichester, UK
4. Soh, C. K, yang Y. W. and Bhalla S. (2010), Smart Materials in Structural Health Monitoring, Control and Bio – mechanics, Springer, in press.

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19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	MATLAB, VEE PRO
19.2	Hardware	SEE UNDER EQUIPMENT
19.3	Teaching aides (videos, etc.)	POWERPOINT
19.4	Laboratory	SMART STRUCTURES AND DYNAMICS LAB (V 211), STRUCTURAL SIMULATION LAB (V 216), CONCRETE STRUCTURES LAB (IV 112)
19.5	Equipment	DIGITAL MULTIMETERS, OSCILLOSCOPES, LCR METER, COMPUTERS,
19.6	Classroom infrastructure	LCD PROJECTOR
19.7	Site visits	NO

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	40%
20.2	Open-ended problems	
20.3	Project-type activity	20%
20.4	Open-ended laboratory work	40%
20.5	Others (please specify)	

Date: 16 February 2015

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	STRUCTURAL SAFETY AND RELIABILITY
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	CEL * * *
6.	Status (<i>category for program</i>)	PE

7.	Pre-requisites (<i>course no./title</i>)	None
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	NIL
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	NONE

9.	Not allowed for (<i>indicate program names</i>)	Not Applicable
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course Prof. A. K. Jain, Dr. Vasant Matsagar	
12.	Will the course require any visiting faculty?	NO

13.	Course objective (<i>about 50 words</i>): To review set theory and fundamentals of probability theory. To introduce stochastic processes and example in civil engineering applications. To teach concept of safety factor and probability of failure; fundamentals of reliability and risk analysis; first order reliability method (FORM); random numbers generation and simulation based reliability analysis. To teach structural reliability engineering problems; second order and advanced reliability methods.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Fundamentals of Set Theory and Probability; Probability Distribution, Regression Analysis, Hypothesis Testing. Stochastic Process and Its Moments; Probability Distributions; Concepts of Safety Factors, Safety, Reliability and Risk Analysis; First Order and Second Order Reliability Methods; Simulation Based Methods; Confidence Limits and Baysean Revision of Reliability; Reliability Based Design; System Reliability; Examples	
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	of Reliability Analysis of Structures.
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Set Theory; Random Events and Random Variables; Expectation, Probability Distributions	4
2	Statistical Properties of Basic Structural Materials: Steel, Concrete, Brick, Mortar; Reliability Based Computation of Allowable Stress	4
3	Probabilistic Analysis of Loads: Gravity Loads, Wind Loads	3
4	Introduction to Structural Reliability; Reliability Index; Computation of Structural Reliability	3
5	Simulation Based Reliability Analysis; Inverse Transformation Technique	3
6	Monte Carlo Simulation; Applications in Structural Engineering	3
7	Introduction to Level 2 Reliability Analysis; Concept of Design Variables and Failure Surface	2
8	First Order Second Moment (FOSM) method; Hasofer and Lind's Method; Numerical Examples Related to Structural Engineering	6
9	Computation of Reliability Index for Normal and Lognormal Distributions; Consideration of Correlated Variables; Confidence Limits and Baysean Revision of Reliability	5
10	Introduction to Reliability Based Design; Determination of Partial Safety Factor and Safety Checking; Development of Reliability Based Design Criteria	4
11	Modelling of Structural System and System Reliability; Generation of Mechanism	3
12	Introduction to Second Order Reliability Method; Sampling Methods; Response Surface Method	2
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

NIL

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
3		
4		
5		
6		
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8		
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10		
COURSE TOTAL (14 times 'P')		0

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

Text Books:

1. R. Ranganathan (2000), "Structural Reliability Analysis and Design", Jaico Publishing

House; Mumbai, India.

2. A. H-S. Ang and W. H. Tang (2006), "Probability Concepts in Engineering: Emphasis on Applications to Civil and Environmental Engineering", 2nd Edition, John Wiley & Sons, USA.
 3. A. Halder and S. Mahadevan (2000), "Probability, Reliability, and Statistical Methods in Engineering Design", John Wiley & Sons, USA.
 4. S. M. Ross (2009), "Introduction to Probability and Statistics for Engineers and Scientists", 4th Edition, Academic Press, Netherland.
- Reference:
5. A. Chakraborty, "NPTEL : National Program on Technology Enhanced Learning: Structural Reliability ", <http://nptel.ac.in/courses/105103140>.

19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	MATLAB
19.2	Hardware	NIL
19.3	Teaching aides (videos, etc.)	Microsoft (MS) Powerpoint and Videos
19.4	Laboratory	NIL
19.5	Equipment	NIL
19.6	Classroom infrastructure	LCD Projector and PA System
19.7	Site visits	NIL

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	25%
20.2	Open-ended problems	25%
20.3	Project-type activity	20%
20.4	Open-ended laboratory work	NIL
20.5	Others (please specify)	30% (Class Assignments and Quizes)

Date: 13th February 2015

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	STRUCTURAL VIBRATION CONTROL
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	CEL * * *
6.	Status (<i>category for program</i>)	PE

7.	Pre-requisites (<i>course no./title</i>)	Structural Dynamics (PG)
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supercedes any existing course	Nil

9.	Not allowed for (<i>indicate program names</i>)	Nil
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☒ 2 nd sem ☐ Either sem
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11.	Faculty who will teach the course Dr. Dipti Ranjan Sahoo, Dr. Abhijit Ganguli, Dr. Vasant Matsagar, Prof. Alok Madan	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): The objective is to teach the basic concepts and computational procedures of structural control emphasizing on serviceability and to broaden the knowledge in the recent trends of development and applications of vibration control techniques for structures.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Introduction; Types and classifications; Control theories; Optimal stiffness distributions for building type structures; Role of damping in controlling motion; Active and semi-active systems; Tuned mass dampers - single/ multiple; Quasi-static active control; Passive control: viscous, visco-elastic, friction, hysteretic dampers, base isolation; Nonlinear modeling; Dynamic feedback control; Neural network based control systems; Design for buildings, bridges, power plants, and other structures; Current trends and performance-based design.	
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15. Lecture Outline (*with topics and number of lectures*)

Module no.	Topic	No. of hours
1	Introduction, Types and classifications, Control theories,	2
2	Optimal stiffness distributions for building type structures,	3
3	Role of damping in controlling motion,	3
4	Active and semi-active systems; Tuned mass dampers,	4
5	Quasi-static active control,	4
6	Passive control: Viscous, Friction, Hysteretic, Base isolation,	8
7	Nonlinear modeling,	2
8	Dynamic feedback control, Neural network based control systems,	8
9	Design for buildings, bridges, power plants, and other structures,	4
10	Current trends and performance-based design.	4
11		
12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

NIL

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Sonntag, R. E., Borgnakke, C., and Van Wylen, G. J., *Fundamentals of Thermodynamics*, 5th Ed., John Wiley, 2000.

Text Books:

- Soong, T.T., Active structural control: theory and practice, Longman Scientific & Technical, 1990, 194 pp.
- Lagaros, N.D., Plevris, V., Mitropoulou, C.C., Design Optimization of Active and Passive Structural Control Systems, IGI Global; 1 edition (August 31, 2012).
- Gawronski, W.K., Advanced Structural Dynamics and Active Control of Structures, Springer, 2004, 397 pp.
- Connor, J.J., Introduction to Structural Motion Control, Prentice Hall Pearson Education, Incorporated, 2003, 680 pp.
- Chu, S.Y., Soong, T.T., Reinhorn, A. M., Active, Hybrid, and Semi-active Structural Control: A Design and Implementation Handbook, Wiley, 2005, 294 pages

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19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	Yes
19.2	Hardware	Yes
19.3	Teaching aides (videos, etc.)	Yes
19.4	Laboratory	Yes
19.5	Equipment	Yes
19.6	Classroom infrastructure	Yes
19.7	Site visits	Yes

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	20
20.2	Open-ended problems	30
20.3	Project-type activity	30
20.4	Open-ended laboratory work	20
20.5	Others (please specify)	Nil

Date: 13th February 2015

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	THEORY OF PLATES AND SHELLS
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	CEL * * *
6.	Status (<i>category for program</i>)	PE

7.	Pre-requisites (<i>course no./title</i>)	None
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	NIL
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	NIL

9.	Not allowed for (<i>indicate program names</i>)	Not Applicable
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course Dr. Gurmail S. Benipal, Dr. Vasant Matsagar, Dr. Dipti Ranjan Sahoo
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12.	Will the course require any visiting faculty?	NO
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13.	Course objective (<i>about 50 words</i>): To teach fundamentals of plates and shells. To introduce various theories of analysis and design of plates and shells. To introduce theoretical and practical aspects of the recent technological advancements made in design of plate and shells for structural engineering applications.
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Thin and thick plate theories. Bending of long rectangular plate to a cylindrical surface. Prismatic folded plate systems. Pure and symmetric bending of plates. Small and large deflections of plates. Special and approximate methods in theory of plates. General theory of cylindrical shells. Shell equations. Approximate solutions of plates and shells equations. Analysis and design of cylindrical shells. Approximate design methods for doubly curved shells. Stress analysis methods in spherical shells. Spherical shell of constant thickness. Symmetrical bending of shallow spherical shells. Conical shells.
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction: Thin and thick plates, small and large deflections. Small deflection theory of thin plates: Assumptions, Moment Curvature relations. Stress resultants. Governing differential equation in Cartesian co-ordinates, various boundary conditions. Pure Bending of Plates	3
2	Prismatic folded plate systems Analysis of Plates: Navier solution for plates.	3
3	Levy's Method: Distributed load and line load. Plates under distributed edge moments. Raleigh- Ritz approach for simple cases	3
4	Introduction to shear deformation theories. Reissener - Mindlin Theory, Moment curvature relationship for First order shear deformation theory	3
5	Circular Plates: Analysis of circular plates under axi-symmetric loading. Moment Curvature relations. Governing differential equation in polar co-ordinates. Simply supported and fixed edges. Distributed load, ring load, a plate with a central hole.	4
6	Introduction: Classification of shells on geometry, thin shell theory, equations to shell surfaces, stress resultants, stress- displacement relations, compatibility and equilibrium equations.	4
7	Shells of Revolution: Membrane theory, equilibrium equations, strain displacement relations, boundary conditions, cylindrical, conical and spherical shells.	4
8	Circular Cylindrical Shells: Membrane theory: Equilibrium equations, strain displacement relations, boundary conditions.	4
9	Theory of Bending: Equilibrium equation, strain displacement relations, governing differential equation, solution for a simply supported cylindrical shell, various boundary conditions. Application to pipes and pressure vessels.	4
10	Cylindrical Shell and its Beam Theory: Principles of Lundgren's beam theory, beam analysis, arch analysis, application to cylindrical roof shells.	6
11	Shell equations and their approximate solution methods.	2
12	Approximate design methods for doubly curved shells. Analysis and design of cylindrical shells. Hand calculations and developing numerical programmes for solving the design problems of plates and shells.	2
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

NOT APPLICABLE

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
3		
4		
5		

6		
7		
8		
9		
10		
COURSE TOTAL (14 times 'P')		28

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

Text Books:

1. Timoshenko S. and Krieger W., Theory of Plates and Shells, Edition 2, Tata McGraw-Hill, 2010.
2. Ramaswamy G.S., Design and Construction of Concrete Shell Roofs, Edition 1, Krieger Publishing Company, 1984.
3. Varghese P. C., Design of Reinforced Concrete Shells and Folded Plates, PHI Learning Pvt. Ltd., 2010.
4. Szilard R., Theories and Applications of Plate Analysis, John Wiley & Sons, 2004.

References:

5. Rao J. S., Dynamics of Plates, Alpha Science International Ltd., 1999.
6. Chandrashekhara K., Analysis of Thin Concrete Shells, New Age International, 2011.
7. N. K. Bairagi, A Textbook of Plate Analysis, Khanna publishers, 1986.
8. N. K. Bairagi, Shell Analysis, Khanna publishers, 1990.
9. G.S. Ramaswamy, Design and Construction of Shell Structures, CBS Publishers, New Delhi, 1996.
10. Billington D. P., Thin Shell Concrete Structures, McGraw-Hill, 1995.

19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	MATLAB, FORTRAN, C, C++,
19.2	Hardware	NIL
19.3	Teaching aides (videos, etc.)	Microsoft (MS) Powerpoint and Videos
19.4	Laboratory	Computational Laboratory
19.5	Equipment	Computer Systems/ Workstations
19.6	Classroom infrastructure	LCD Projector and PA System
19.7	Site visits	No

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	40%
20.2	Open-ended problems	10%
20.3	Project-type activity	30%
20.4	Open-ended laboratory work	10%
20.5	Others (please specify)	10% (Class Assignments and Quizes)

Date: 13th February 2015

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	THEORY OF STRUCTURAL STABILITY
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	CEL * * *
6.	Status (<i>category for program</i>)	PE

7.	Pre-requisites (course no./title)	Nil
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	15% AML834
8.3	Supercedes any existing course	CEL822

9.	Not allowed for (indicate program names)	Nil
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course Dr. Gurmail S. Benipal, Dr. Abhijit Ganguli, Dr. Dipti Ranjan Sahoo, Dr. Vasant Matsagar	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): There is a trend towards stronger and slender structural members more vulnerable to loss of stability. In this course, the theories of static and dynamic stability applicable to steel and concrete structures will be presented. Explanations for current codal recommendations as well as the recent trends will be discussed.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Introduction: Buckling of steel and concrete structures; Conservative and non-conservative loads. Elastic buckling of columns and beam-columns: Static, dynamical and energy-based approaches. Viscoelastic and elastoplastic buckling. Torsional buckling. Flexural-torsional and lateral buckling. Plate and frame buckling. Imperfection sensitivity; Post-buckling theory. Snap-through. Dynamic stability: Divergence, flutter and parametric resonance. Nonlinear dynamical systems theory; Bifurcations. Recent trends.	
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction: Buckling of steel and concrete structures; Conservative and non-conservative loads	3
2	Elastic buckling of columns and beam-columns: Static, dynamical and energy-based approaches	6
3	Viscoelastic and elastoplastic buckling	6
4	Flexural-torsional and lateral buckling	3
5	Plate and frame buckling	6
6	Imperfection sensitivity; Post-buckling theory; Snap-through	3
7	Dynamic stability: Divergence, flutter and parametric resonance	6
8	Nonlinear dynamical systems theory; Bifurcations	3
9	Codal recommendations	3
10	Recent trends	3
11		
12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

NIL

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Sonntag, R. E., Borgnakke, C., and Van Wylen, G. J., *Fundamentals of Thermodynamics*, 5th Ed., John Wiley, 2000.

Text Books:

A. Chajes, *Principles of Elastic Stability*, Prentice Hall, NJ, 1974.

Bazant Z. P. and Cedolin, L., *Stability of Structures: Elastic, Inelastic, Fracture and Damage Theories*, Word Scientific Pub. Co., Singapore, (2010).

Bolotin, V.V., *Nonconservative Problems in the Theory of Elastic Stability*, Pergamon Press, New York, (1964).

Reference Texts:

Chen, W. F. and Atsuta, T., *Theory of Beam-Columns, Vol. I: In-plane Behaviour and Design*, McGraw-Hill, New York, (1976).

El Naschie, M. S., Stress, Stability and Chaos in Structural Engineering: An Energy Approach, McGraw Hill, London, (1990).

Hoyer, T.G. and Hansen, L.Z., Stability of Concrete Columns, PhD Theses, Technical Univ. of Denmark, Lyngby (2002).

Leipholz, H.H.E., Stability of Elastic Structures, Springer Verlag, Wien, (1978).

Perelmuter V. A. and Slivker V., Stability of Equilibrium of Structures and Related Problems, World Scientific Publishing Co. Pte. Ltd., Singapore, (2013).

Thompson, J.M.T. and Stewart, H.B., Nonlinear Dynamics and Chaos, John Wiley and Sons, New York (1986).

Thomsen, J.J., Vibrations and Stability: Advanced Theory, Analysis and Tools, 2nd Edition, Springer (India) Private Limited, New Delhi (2003).

Timoshenko, S.P. and Gere, J. M., Theory of Elastic Stability, McGRAW-HILL Book Company, INC., New York, (1961).

19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	Yes
19.2	Hardware	Nil
19.3	Teaching aides (videos, etc.)	Yes
19.4	Laboratory	No
19.5	Equipment	No
19.6	Classroom infrastructure	Yes
19.7	Site visits	No

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	
20.2	Open-ended problems	<20%
20.3	Project-type activity	<20%
20.4	Open-ended laboratory work	
20.5	Others (please specify)	

Date: 13th February 2015

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	WIND RESISTANT DESIGN OF STRUCTURES
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	CEL * * *
6.	Status (<i>category for program</i>)	PE

7.	Pre-requisites (<i>course no./title</i>)	Strctural Dynamics (CEL719)
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supercedes any existing course	Nil

9.	Not allowed for (<i>indicate program names</i>)	Not Applicable
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☒ 2 nd sem ☐ Either sem
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11.	Faculty who will teach the course Prof. A.K. Jain, Dr. Vasant Matsagar	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): To teach the basic principles of wind engineering; fundamentals of design of structures for wind loading; estimation of the design wind speed. To teach concepts of bluff body aerodynamics wind-induced vibrations of structures with special reference to tall building aerodynamics; concepts of along wind and across wind response considering vortex shedding of line-like (slender) structures in frequency domain using different spectra; concepts of gust buffeting and fluttering effect on structures. Teaching gust factor approach to evaluate the along-wind response of structures to wind excitation; control of the wind induced response of structures.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Causes and types of wind. Atmospheric boundary layer and turbulence. Wind velocity measurements and distribution. Bluffbody aerodynamics, random vibrations, and spectral analysis. Along wind and across wind response considering vortex shedding of tall buildings, towers, and slender structures.	
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	Vortex induced vibrations of slender structures. Wind-Induced lock-in excitation of tall structures. Buffeting response prediction subjected to random load. Aeroelastic phenomena. Turbulence modeling. Gust buffeting and fluttering effect on structures. Vibration of cable supported bridges and power lines due to wind effects. Wind pressure on cooling towers. Design of cladding and wind damping devices. Wind tunnel simulations and tornado effects.
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Basics of wind engineering	2
2	Basic bluffbody aerodynamics	4
3	Structural dynamics I: Along wind response of structures	5
4	Structural dynamics I: Across wind response of structures, vortex shedding	5
5	Structural dynamics II: Spectral analysis of line-like structures using different wind spectra (random vibrations)	6
6	Wind loading in special structures like suspended span bridges, power lines and hyperbolic cooling towers	4
7	Vortex induced vibrations of slender structures. Wind-Induced lock-in excitation of tall structures	2
8	Buffeting response prediction subjected to random load	2
9	Aeroelastic phenomenon, wind fluttering effect, and turbulence modeling for gust buffeting of structures	3
10	Wind tunnel simulation of wind structure interactions	3
11	Applications in design: building/ structural response, design of cladding, and wind damping devices	4
12	Code and standard provisions for wind loading and structures	2
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

Nil

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

Text Books:

- 1) Holmes, J. D., "Wind Loading of Structures", Spon Press, London, UK, 2001.
- 2) Scanlan, R. H., Simiu, E., "Wind Effects on Structures - Fundamentals and Applications to Design", John Wiley & Sons Publication, New York (NY), USA, 1978.
- 3) Kareem, A., "Advanced Structural Wind Engineering", Springer, New York (NY), USA, 2013.
- 4) Stathopoulos, Ted; Baniotopoulos, Charalambos C., "Wind Effects on Buildings and Design of Wind-Sensitive Structures", Springer Science & Business Media, 2007.

- 5) Melaragno, Michele G. "Severe Storm Engineering for Structural Design", Taylor & Francis, UK, 1996.

19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	MATLAB, SAP-2000
19.2	Hardware	Nil
19.3	Teaching aides (videos, etc.)	Microsoft (MS) Powerpoint and Videos
19.4	Laboratory	Nil
19.5	Equipment	Computer Systems/ Workstations
19.6	Classroom infrastructure	LCD Projector
19.7	Site visits	No

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	60%
20.2	Open-ended problems	0
20.3	Project-type activity	30%
20.4	Open-ended laboratory work	0
20.5	Others (please specify)	10% (Simulations)

Date: 13th February 2015

(Signature of the Head of the Department)