M.E. (Structural Engineering)

2013 Regulations, Curriculum & Syllabi

BANNARI AMMAN INSTITUTE OF TECHNOLOGY

(An Autonomous Institution Affiliated to Anna University, Chennai

Approved by AICTE - Accredited by NBA New Delhi, NAAC with 'A' Grade and ISO 9001:2008 Certified)

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Contents

Rules and Regulations

M. E. / M. Tech. Programmes

(For the batch of students admitted in 2013-2014 and onwards)

NOTE: *The regulations hereunder are subject to amendments as may be decided by the Academic Council of the Institute from time to time. Any or all such amendments will be effective from such date and to such batches of students including those already in the middle of the programme) as may be decided by the Academic Council.*

1. Conditions for Admission

(i) Candidates for admission to the I Semester of M. E. / M. Tech. degree programme will be required to satisfy the conditions of admission thereto prescribed by the Anna University, Chennai and Government of Tamil Nadu.

(ii) Part–time candidates should satisfy conditions regarding experience, sponsorship, place of work, etc., that may be prescribed by Anna University, Chennai from time to time, in addition to satisfying requirements as in Clause 1(i).

2. Duration of the Programme

(i) **Minimum Duration:** The programme will lead to the Degree of Master of Engineering (M.E.) / Master of Technology (M. Tech.) of the Anna University, Chennai extend over a period of two years. The two academic years (Part-time three academic years) will be divided into four semesters (Part-time six Semesters) with two semesters per year.

(ii) **Maximum Duration**: The candidate shall complete all the passing requirements of the M. E. / M. Tech. degree programmes within a maximum period of 4 years / 8 semesters in case of full-time programme and 6 years / 12 semesters in case of part-time programme, these periods being reckoned from the commencement of the semester to which the candidate was first admitted.

3. Branches of Study

The following are the branches of study of M.E. / M.Tech. Programmes

M.E.

Branch I	Applied Electronics
Branch II	CAD/CAM
Branch III	Communication Systems
Branch IV	Computer Science and Engineering
Branch V	Embedded Systems
Branch VI	Engineering Design
Branch VII	Power Electronics and Drives
Branch VIII	Software Engineering
Branch IX	Structural Engineering
Branch X	VLSI Design

M. Tech.

Branch I	Biotechnology

4. Structure of Programmes

(i) **Curriculum:** The curriculum for each programme includes Courses of study and detailed syllabi. The Courses of study include theory Courses (including electives), seminar, practicals, Industrial training / Mini-project, Project Work (Phase I) and Project Work (Phase II) as prescribed by the respective Boards of Studies from time to time.

Full-time Programme: Every full-time candidate shall undergo the Courses of his/her programme given in clause 12 in various semesters as shown below:

Semester 1:	6 Theory Courses and two Practicals
Semester 2:	6 Theory Courses, one Practical and a Technical Seminar
Semester 3:	3 Theory Courses and Project Work (Phase I)
Semester 4:	Project work (Phase II).

Part-time Programme: Every part-time candidate shall undergo the Courses of his/her programme in various semesters as shown below:

Semester 1:	3 Theory Courses and one Practical
Semester 2:	3 Theory Courses and one Practical
Semester 3:	3 Theory Courses, Technical Seminar and one Practical
Semester 4:	3 Theory Courses
Semester 5:	3 Theory Courses and Project Work (Phase I)
Semester 6:	Project Work (Phase II)

(ii) **Theory Courses:** Every candidate shall undergo core theory, elective, and practical Courses including project work of his/her degree programme as given in clause 12 and six elective theory Courses. The candidate shall opt electives from the list of electives relating to his/her degree programme as given in clause 12 in consultation with the Head of the Department. However, a candidate may be permitted to take a maximum of two electives from the list of Courses of other M.E. / M.Tech. Degree programmes with specific permission from the respective Heads of the Departments.

(iii) **Project Work:** Every candidate individually shall undertake the Project Work (Phase I) during the third semester (fifth semester for part-time programme) and the Project Work (Phase II) during the fourth semester (Sixth semester for part-time programme). The Project Work (Phase II) shall be a continuation work of the Project Work (Phase I). The Project Work can be undertaken in an industrial / research organisation or in the Institute in consultation with the faculty guide and the Head of the Department. In case of Project Work at industrial / research organization, the same shall be jointly supervised by a faculty guide and an expert from the organization.

(iv) **Industrial Training / Mini Project:** Every full-time candidate shall opt to take-up either industrial training or Mini Project under the supervision of a faculty guide.

(v) **Value added / Certificate Courses:** Students can opt for any one of the Value added Courses in II and III semester. A separate certificate will be issued on successful completion of the Course.

(vi) **Special Self-Study Elective Courses:** Students can opt for any one of the special elective Courses as Self-Study in addition to the electives specified in the curriculum in II and III semesters, under the guidance of the faculty. The grades of only passed candidates will be indicated in the mark sheet, but will not be taken into account for assessing CGPA.

(vii) **Application oriented and Design Experiments**: The students are to carryout Application oriented and Design Experiments in each laboratory in consultation with the respective faculty and Head of the department.

(viii) **Mini project**: A Mini Project shall be undertaken individually or in a group of not more than 3 in consultation with the respective faculty and the Heads of the Department, in any one of the laboratories from I to III semesters.

(ix) **Credit Assignment:** Each course is normally assigned a certain number of credits with 1 credit per lecture hour per week, 1 credit for 1 or 2 hours of practical per week (2 credits for 3 hours of practical), 4 credits for theory with lab component with 3 hours of lecture and 2 hours of practical per week, 2 credits for 3 hours of seminar per week, 6 credits for the Project Phase I and 12 credits for the Project Phase II. The exact numbers of credits assigned to the different courses of various programmes are decided by the respective Boards of Studies.

(x) **Minimum Credits:** For the award of the degree, the candidate shall earn a minimum number of total credits as prescribed by the respective Board of Studies as given below:

M.E./M. Tech. Programmes	Total Credits
M.E. Applied Electronics	75
M.E. CAD / CAM	75
M.E. Communication Systems	75
M.E. Computer Science and Engineering	75
M.E. Embedded Systems	75
M.E. Engineering Design	77
M.E. Power Electronics and Drives	76
M.E. Software Engineering	76
M.E. Structural Engineering	77
M.E. VLSI Design	75
M.Tech. Biotechnology	76

5. Requirements for Completion of Study of a Semester

(i) a) Candidate will be deemed to have completed the study of any semester only if he /she has kept not less than 70% of attendance in each course and at least 80% of attendance on an average in all courses in that semester put together.

b) On medical grounds, 10% relaxation in the attendance can be allowed

(ii) his/her progress has been satisfactory, and

(iii) his/her conduct has been satisfactory

6. Assessment and Passing Requirements

(i) **Assessment:** The assessment will comprise continuous assessment and final examination, carrying marks as specified in the scheme (clause 10). Continuous assessment will be made as per the guidelines framed by the Institute from time to time. All assessments will be done on absolute marks basis. However, for the purpose of reporting the performance of a candidate, letter grades and grade points will be awarded as per clause 6(v).

(ii) **Final Examinations:** Final examinations will normally be conducted during November / December and during April / May of each year. Supplementary examinations may be conducted at such times as may be decided by the Institute.

A candidate will be permitted to appear for the final examination of a semester only if he/she has completed the study of that semester satisfying the requirements given in clause 5 and registers simultaneously for the examinations of the highest semester eligible and all the Courses which he/she is in arrears of. A candidate, who is not permitted to appear at the final examination of a semester, is not permitted to proceed to the next semester. A candidate who is not permitted to appear at the final examination of any semester has to register for and redo the Courses of that semester at the next available opportunity.

(iii) **Rejoining the Programme:** A candidate who has not completed the study of any semester as per clause 5 or who is allowed to rejoin the programme after a period of discontinuance or who on his/her own request is permitted to repeat the study of any semester, may join the semester which he/she is eligible or permitted to join, only at the time of its normal commencement for a regular batch of candidates and after obtaining the approval from the Director of Technical Education and Anna University, Chennai. No candidate will however be enrolled in more than one semester

at any point of time. In the case of repeaters, the earlier continuous assessment in the repeated Courses will be disregarded.

(iv) **Industrial Training, Mini-project and Project Work:**
Every candidate shall submit reports on Industrial training / Mini-project, Project Work (Phase I) and Project Work (Phase II) on dates announced by the Institute / department through the faculty guide to the Head of the Department. If a candidate fails to submit the reports of any of these Courses not later than the specified date, he/she is deemed to have failed in it. Every candidate shall present report/papers in the seminars in each of the relevant semesters about the Industrial training / Mini-project, Project Work (Phase I) and Project Work (Phase II). The reports/papers shall be presented in the seminar before a review committee constituted by the Head of the Department. The Industrial training / Mini-project, Project Work (Phase I) and Project Work (Phase II) will be evaluated based on the presentations in the seminar, reports and viva-voce examinations. In case of the industrial training for the full-time candidates, evaluation will be carried out in the third semester.

In case of Project Work (Phase II), the viva-voce examination will be carried out by a team consisting of an internal examiner, usually the supervisor, and an external examiner, appointed by the Principal.

1. Due weight will be given for the training report from the Organisation / Industry while evaluating the report and its presentation at the seminar about the nature of the training and what the student has learnt. The student shall be required to get a grade not less than "C". The grade will be indicated in the mark sheet. This will not be taken into account for assessing CGPA.
2. The evaluation of the Mini Project will be based on the report, presentation at the seminar and viva-voce. The student shall be required to get a Grade not less than "C". The grade will be indicated in the mark sheet. This will not be taken into account for assessing CGPA.
3. Every Candidate shall pursue Project work-Phase I in third semester and Project Work – Phase II in fourth semester which is in continuation of Phase I. Project work –Phase I and Phase II will be evaluated as given below in the scheme of evaluation

A candidate is permitted to register for the Project Work (Phase II), only after passing the Project Work (Phase I). A candidate who fails in Industrial training / Mini-project, Project Work (Phase I) or Project Work (Phase II) shall register for redoing the same at the beginning of a subsequent semester.

(v) **Letter grade and grade point:** The letter grade and the grade point are awarded based on percentage of total marks secured by a candidate in an individual Course as detailed below:

Range of Percentage of Total Marks	Letter grade	Grade Point (g)
90 to 100	S	10
80 to 89	A	9
70 to 79	B	8
60 to 69	C	7
55 to 59	D	6
50 to 54	E	5
0 to 49 or less than 50% in final examination	RA	0
Incomplete	I	
Withdrawal	W	

"RA" denotes reappearance in the course.
"I" denotes incomplete as per clause 5 (i) & (ii) and hence prevented from writing semester end examination.
"W" denotes withdrawal from the final examination

After completion of the programme earning the minimum number of credits, the Cumulative Grade Point Average (CGPA) from the semester in which the candidate has joined first to the final semester is calculated using the formula:

$$CGPA = \frac{\sum g_i * C_i}{\sum C_i}$$

Where g_i : Grade point secured corresponding to the Course

C_i : Credits allotted to the Course.

(vi) **Passing a Course:** A candidate who secures grade point 5 or more in any Course of study will be declared to have passed that Course, provided a minimum of 50% is secured in the final examination of that Course of study.
A candidate, who is absent for the final examination or withdraws from final examination or secures a letter grade RA (Grade point 0) in any Course carrying continuous assessment and final examination marks, will retain the already earned continuous assessment marks for two subsequent appearances in the examination of that Course and thereafter he/she will be solely assessed by the final examination carrying the entire marks of that Course.
A candidate, who scores a letter grade RA (Grade point 0) in any Course carrying only continuous assessment marks, will be solely examined by a final examination carrying the entire marks of that Course, the continuous assessment marks obtained earlier being disregarded.

7. Qualifying for the Award of the Degree

A candidate will be declared to have qualified for the award of the M.E. / M.Tech. Degree provided:

(i) he/she has successfully completed the Course requirements and has passed all the prescribed Courses of study of the respective programme listed in clause 12 within the duration specified in clause 2.
(ii) No disciplinary action is pending against the candidate

8. Classification of Degree

(i) **First Class with Distinction:** A candidate who qualifies for the award of degree (vide clause 7) having passed all the Courses of all the semesters at the first opportunity within four consecutive semesters (six consecutive semesters for part-time) after the commencement of his / her study and securing a CGPA of 8.5 and above shall be declared to have passed in First Class with Distinction. For this purpose the withdrawal from examination (vide clause 9) will not be construed as an opportunity for appearance in the examination.
(ii) **First Class:** A candidate who qualifies for the award of degree (vide clause 7) having passed all the Courses of all the semesters within a maximum period of six semesters for full-time and eight consecutive semesters for part-time after commencement of his /her study and securing a CGPA of 6.50 and above shall be declared to have passed in First Class.
(iii) **Second Class:** All other candidates who qualify for the award of degree (vide clause 7) shall be declared to have passed in Second Class.

9. Withdrawal from Examination

(i) A candidate may, for valid reasons, be granted permission to withdraw from appearing for the examination in any Course or Courses of only one semester examination during the entire duration of the degree programme. Also, only one application for withdrawal is permitted for that semester examination in which withdrawal is sought.
(ii) Withdrawal application shall be valid only if the candidate is otherwise eligible to write the examination and if it is made prior to the commencement of the semester examinations and also recommended by the Head of the Department and the Principal.
(iii) Withdrawal shall not be construed as an opportunity for appearance in the examination for the eligibility of a candidate for First Class with Distinction.

10. Scheme of Assessment

- Students who were absent for the previous periodicals and those who wish to improve their periodical test marks shall take up an optional test consisting of two units prior to the commencement of model examination.

Scheme of Evaluation

i) Theory

Final Examination	: 50 Marks
Internal Assessment	: 50 Marks

Distribution of marks for internal assessment:

Assignment/Tutorial	: 05	
Test 1	: 10	
Test 2	: 10	
Model Exam	: 15	(Entire syllabus)
Innovative Presentation[#]	: 10	
	: 50	

[#] Innovative Presentation includes Seminar / Quiz / Group Discussion / Case Study /Soft Skill Development / Mini Project / Review of State-of-the art

ii) Technical Seminar **:** 100 Marks

Three Seminars (3 × 25)	: 75 Marks
Report	: 25 Marks

iii) Practical

Final Examination	: 50 Marks
Internal Assessment	: 50 Marks

Distribution of marks for internal assessment:

Preparation	: 5
Conduct of Experiments	: 10
Observation & Analysis of results	: 10
Record	: 10
Model Exam & Viva-voce	: 15
	: 50

iv) Project Work Phase – I & Viva Voce **Marks**

Internal

Project Identification	: 10
Literature survey + analysis	: 15
Sub Total	: 25
Approach & Progress	: 25
Total	: 50

External – Final Evaluation

Report Preparation & Presentation	: 25
Viva Voce	: 25
	: 50

v) Project Work Phase – II **Marks**

Internal

Continuation of Approach & Progress	: 50
Findings, Discussion & Conclusion	: 50
Total	: 100

External – Final Evaluation

Report Preparation & Presentation	: 50
Viva Voce	: 50
	: 100

11 . Question paper pattern for Theory Examination

Max. Marks	: 100
Time	: 3 Hours

PART A
Short Answer Questions: 15
(15 × 2 Marks) : 30 Marks
(Three Questions from each unit)

PART B
Lengthy Answer Questions: 2
(2 × 14 Marks) *(Compulsory)* : 28
(Questions may be framed from any of the five units)
Lengthy Answer Questions: 3
(3 × 14 Marks) *(Either Or Type)* : 42
(Questions may be framed from the remaining three units)

Total Marks	: 100

12. Curriculum and Syllabi

M.E. STRUCTURAL ENGINEERING

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

PEO 1

The graduates of Structural Engineering will demonstrate an exceptional involvement and active participation in Research and Development activities related to structural engineering and publish/present technical research papers of high quality in accordance with codal provisions

PEO II

The graduates of Structural Engineering will practice the profession of Structural Engineering proficiently with a well-balanced preparation in engineering fundamentals and practical applications

PEO III

The graduates of Structural Engineering will demonstrate a high degree of analytical handiness to solve real world engineering problems

PEO IV

The graduates of Structural Engineering will engage themselves in lifelong learning

PROGRAMME OUTCOMES (POs)

(a) an ability to understand and perform research by identifying the nature of the information required; investigating sources of information, including professionals, texts, databases, and the Internet; organizing the information by employing a variety of techniques such as, spreadsheets, graphs, tables, and charts; and examining the information to select the most relevant, important, and useful for Structural engineering

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(b): an ability to identify and define problems, gathering data related to the problem, generating and prioritizing a set of alternative solutions, and selecting and implementing the best alternative with an exposure to relevant codes

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(c): an ability to analyze, design, detailing, estimation and costing of Structural components with high level of competency

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(d): an ability to lead, manage and be productive in a multidisciplinary team.

(e): an ability to use the techniques, skills, and advanced modern engineering tools, instrumentation and software packages necessary for engineering practice

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(f): an ability to recognize the need for and to engage in continual learning through sustained education to meet the challenging and demand - driven needs of the construction field

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(g): an ability to communicate effectively

MAPPING OF PEOs & POs

		Programme Educational Objectives	Program Outcomes
PEO :	I	The graduates of Structural Engineering will demonstrate an exceptional involvement and active participation in Research and Development activities related to Structural engineering and publish/present technical research papers of high quality with codal provisions	(a),(b),(f),(g)
PEO :	II	The graduates of Structural Engineering will practice the profession of Structural Engineering proficiently with a well-balanced preparation in engineering fundamentals and practical applications	(c) (d) and (e)
PEO :	III	The graduates of Structural Engineering will demonstrate a high degree of analytical handiness to solve real world engineering problems	(c) and (e)
PEO :	IV	The graduates of Structural Engineering will engage themselves in lifelong learning	(f)

M. E. Structural Engineering

First Semester

Code No.	Courses	Objectives & Outcomes		L	T	P	C
		PEOs	POs				
13ST11	Advanced Concrete Technology	I	(a),(b)	3	0	0	3
13ST12	Advanced Reinforced Concrete Design	I, II	(a),(c)	3	1	0	4
13ST13	Advanced Structural Analysis		(b),(e)	3	1	0	4
13ST14	Structural dynamics		(b),(e)	3	1	0	4
13ST15	Theory of Elasticity and Plasticity		(b),(e)	3	1	0	4
13ST16	Design of Foundation Structures	II	(c)	3	1	0	4
13ST17	Structural Engineering and Dynamics Laboratory	I,IV	(a),(f)	0	0	3	2
13ST18	Advanced Computer Aided Analysis and Design Laboratory	I,II	(b),(e)	0	0	3	2
			Total	18	5	6	27

Second Semester

Code No.	Courses	Objectives & Outcomes		L	T	P	C
		PEOs	POs				
13ST21	Earthquake Resistant Design of structures	II	(c),(e)	3	0	0	3
13ST22	Advanced Structural Steel Design		(c),(e)	3	1	0	4
13ST23	Finite Element Analysis		(c),(e)	3	1	0	4
	Elective			3	0	0	3
	Elective			3	0	0	3
	Elective			3	0	0	3
13ST24	Advanced Structural Design Practice	II	(c),(d),(e)	0	0	3	2
13ST25	Technical Seminar	I	(g)	0	0	2	1
			Total	18	2	5	23

Third Semester

Code No.	Courses	Objectives & Outcomes		L	T	P	C
		PEOs	POs				
	Elective			3	0	0	3
	Elective			3	0	0	3
	Elective			3	0	0	3
13ST31	Project Work Phase - I	I ,II	(b) ,(c),(e)	-	-	-	6
			Total	-	-	-	15

Fourth Semester

Code No.	Courses	Objectives & Outcomes		L	T	P	C
		PEOs	POs				
13ST41	Project Work Phase - II	I ,II	(b) ,(c),(e)	-			12

List of Electives							
Code No.	**Courses**	**Objectives & Outcomes**		**L**	**T**	**P**	**C**
		PEOs	**POs**				
13ST51	Theory of Plates and Shells	I	(a),(b),(f)	3	0	0	3
13ST52	Non -Traditional Optimization Techniques*		(b)	3	0	0	3
13ST53	Steel – Concrete Composite Structures	I,II	(b),(c)	3	0	0	3
13ST54	Behavior and Analysis of Tall Structures	II	(d)	3	0	0	3
13ST55	Repair and Rehabilitation of Structures		(e)	3	0	0	3
13ST56	Design of Prestressed Concrete Structures		(d)	3	0	0	3
13ST57	Design of Bridges			3	0	0	3
13ST58	Design of Industrial Structures			3	0	0	3
13ST59	Prefabricated Structures			3	0	0	3
13ST60	Stability of Structures			3	0	0	3
13ST61	Offshore Structures			3	0	0	3
13ST62	Space Structures			3	0	0	3
13ST63	Experimental Stress Analysis and Techniques	I	(b)	3	0	0	3
13ST64	Research Methodology			3	0	0	3
Self Study Electives							
13ST01	Concrete Technology	I	(b)	-	-	-	3
13ST02	Discrete Structural Optimization			-	-	-	3

* **Open Elective**

13ST11 ADVANCED CONCRETE TECHNOLOGY

3 0 0 3

Course Objectives (COs):

- To impart knowledge on concrete mix design as per ACI and IS methods
- To impart knowledge on the understanding the properties of fresh and hardened concrete and to make the students to identify the concrete properties through testing of materials.

Course Learning Outcome (CLO):

- The students will be able to demonstrate the properties, types of concrete, their design methods and testing methodologies

Programme Outcomes (POs):

(a) An ability to understand and perform research by identifying the nature of the information required; investigating sources of information, including people, texts, databases, and the Internet; organizing the information by employing a variety of techniques such as, spreadsheets, graphs, tables, and charts; and examining the information to select the most relevant, important, and useful for structural engineering

(b) An ability to identify and define problems, gathering data related to the problem, generating and prioritizing a set of alternative solutions, and selecting and implementing the best alternative.

Unit I

Fresh Concrete

Chemical composition, Hydration of cement, structure of hydrated cement, special cements, water, chemical admixtures, Workability –Need-Factors affecting workability-Segregation Bleeding-Mixing of concrete-Compaction of concrete - Revibration-Self compacting concrete-Ready-mixed concrete – effect of retarders in slump retention in transportation of transit mixer--Pumped concrete-Preplaced concrete-Shotcrete-Analysis of fresh concrete

9 Hours

Unit II

Hardened Concrete

Factors affecting strength of concrete-Curing-Maturity of concrete-High strength concrete-Ultra High strength concrete-Properties of Hardened concrete and their significance-Structure of concrete-Structure concrete relationships in hydrated cement paste-Dimensional stability-Durability-Transition zone in concrete - Micro structure of concrete-Autogeneous healing-Evaluation of heat of hydration and expansion-Creep-Shrinkage-Elasticity

9 Hours

Unit III

Testing of concrete

Workability-Compression-Tension-Flexure-Bond strength-Factors affecting the results-Accelerated strength results-Stress strain characteristics -Pull off test- Modulus of Elasticity-In site strength determination-Durability testing of concrete-structural health monitoring of concrete – types of sensors for various applications

9 Hours

Unit IV

Concrete Mix Design

Basic consideration-Factors in the choice of mix proportions-Mix design methods- A.C.I .Method - I.S. Method - British Method - Correction for moisture content-Bulking-Yield of concrete-Design of High strength concrete and Self compacting concrete- EFNARC Specifications and Design of SCC mixes- Design of concrete mix using mineral admixtures – Design mix for pumpability and effect of super plasticizers in water reduction.

9 Hours

Unit V

Special Concretes

Properties of constituents materials and applications - Light weight concrete-Aerated concrete-No fines concrete-Heavy weight concrete for radiation shield- Fiber reinforced concrete- Polymer concrete-Geopolymer concrete--High volume flyash concrete-High performance concrete-self curing concrete-Concrete admixtures – Nano materials used in the construction industry- protective coating to save energy – energy saving materials

9 Hours

Total: 45 Hours

References

1. A. M. Neville, J. J. Brooks, *Concrete Technology*, Pearson Education, 2010
2. A. R. Shantha Kumar, *Concrete Technology*, Oxford University Press, 2007
3. M. S. Shetty, *Concrete Technology*, S. Chand & Co., 2008
4. Raft Siddique, *Spacial Structural Concrete*, Galgotia Publication, 2000
5. N. Krishna Raju, *Design of Concrete Mixes*, C.B.S. Publication, 2002
6. M. L. Gambhir, *Concrete Technology*, Dhanpatrai & Sons, 2012
7. IS 10262-1982: *Recommended Guidelines For Concrete Mix Design*

13ST12 ADVANCED REINFORCED CONCRETE DESIGN

3 1 0 4

Course Objective (CO):

- To impart knowledge on the limit state design of RCC Structural components
- To enhance the confident level of students to design the special structural elements as per Indian standard code of practice.

Course Learning Outcome (CLO):

- The students will be able to design and detail the RCC structural components in accordance with relevant IS code and standards.

Programme Outcomes (POs):

(a) An ability to understand and perform research by identifying the nature of the information required; investigating sources of information, including people, texts, databases, and the Internet; organizing the information by employing a variety of techniques such as, spreadsheets, graphs, tables, and charts; and examining the information to select the most relevant, important, and useful for Structural Engineering

(c) An ability to analyze, design, draw and detailing of structural components with high level of competency

Unit I

Design of Beams and Columns

Properties and behavior of concrete and steel -Behaviour of R.C .beams in flexure, shear, torsion and combined loadings applied gradually-modes of failure interaction effects-analysis and -design for serviceability limit states-calculations of deflections and crack width as per I.S 456 - behavior of slender R.C.columns under gradually increasing load-failure modes and interaction curves-calculation of design moments for braced and un-braced long columns-design of slender columns.

9 Hours

Unit II

Design of Hyperstatic R.C Beams and Frames

Design and detailing of continuous beams and portal frames-design of multibay, multistoryed R.C. frames: preliminary design-use of substitute frames for calculating stress resultants caused by gravity loading-portal method for wind and earthquake forces-design of members and detailing of reinforcements.

9 Hours

Unit III

Design of Special R.C. Elements

Design and detailing of deep beams and corbels-braced and un-braced walls-approximate analysis - design of beams circular in plan and spandrel beams.

9 Hours

Unit IV

Design of Slabs

Yield line theory of slabs-virtual work and equilibrium methods-Hillerborg method of design - design of flat slabs- design of grid floors as per I.S.456.

9 Hours

Unit V

Inelastic behavior and ultimate load analysis

Conditions for ultimate load analysis –Concept of moment redistribution and moment rotation characteristics of a R.C. section plastic hinges - check for rotation capacity of sections.

9 Hours

Total: 45+15Hours

References

1. S. Unnikrishna Pillai and Devados Menon, *Reinforced Concrete Design* , Tata McGraw-Hill Education, 2011
2. P. C. Varghese, *Advanced Reinforced Concrete Design*, Prentice Hall, International Edition, 2006
3. N. Krishnaraju, *Advanced Reinforced Concrete Design*, CBS Publishers and Distributors, 2000
4. R. Park and T. Paulay, *Reinforced Concrete Structures*, John Wiley Sons, 2008
5. S. S. Bhavikatti , *Advanced RCC Design volume I and II*, New Age International, 2008.
6. S.N Sinha ,*Handbook of Reinforced Concrete Design*, Tata McGraw-Hill Education, 2004
7. IS 456:2000: *Plain and Reinforced Concrete Code of Practice*.

13ST13 ADVANCED STRUCTURAL ANALYSIS 3 1 0 4

Course Objectives (COs):

- To educate the students to analyze the structures by flexibility and stiffness method.
- At the end of the course the students will have the confidence in applying this method to pin jointed trusses, continuous beams, grids and frames

Course Learning Outcome (CLO):

- The students will be able to understand the fundamental concepts and modern methods of analysis.

Program Outcomes (POs):

(b) an ability to identify and define problems, gathering data related to the problem, generating and prioritizing a set of alternative solutions, and selecting and implementing the best alternative with an exposure to relevant codes

(e) an ability to use the techniques, skills and advanced modern engineering tools, instrumentation, software packages for engineering practice

Unit I

Review of Fundamental Concepts

Determination of static and Kinematic Indeterminacies of two Dimensional and three Dimensional portal frames, pin jointed trusses and hybrid frames Coordinates system – Degree of freedom - Force and Displacement measurements - Principles of superposition – Flexibility and Stiffness matrices – Force displacement relationships for axial force , couple , torsional moments - Stiffness and flexibility matrices in Single, Two and n coordinates.

9 Hours

Unit II

Energy Concepts in Structures and transformation of information

Strain energy - Strain energy in terms of stiffness and flexibility matrices – Betti's Law and it is application – Other energy theorems using matrix notations - Transformation of System force to element forces – Transformation of Element Flexibility to System Flexibility matrix – Transformation of System Displacement to Element Displacement – Transformation of Element Stiffness matrix to system stiffness matrix -Normal coordinates and orthogonal coordinates.

9 Hours

Unit III

Flexibility Method

Flexibility method applied to Statically Determinate and Statically Indeterminate Structures – Choice of redundants - ill and well conditioned matrices – Automatic choice of redundants –Internal forces due to thermal expansion and lack of fit – Analysis of Two Dimensional, Three Dimensional Pin jointed trusses - Analysis of Two Dimensional portal and gable Frames, continuous beams, grids.

9 Hours

Unit IV

Stiffness Method

Development of the stiffness method – Analogy between flexibility and stiffness methods – internal force due to thermal expansion - lack of fit – Application to pin jointed plane and space trusses, continuous beams, frames and grids.

9 Hours

Unit V

Special Topics - Matrix Displacement Methods : Static condensation Technique – Substructure Technique - Transfer Matrix method – Symmetry & Anti symmetry of structures – Reanalysis Technique.

Direct Stiffness Method: Discrete system – Direct stiffness approach – Application to two and three dimensional pin-jointed trusses - plane frames – Grids – Three dimensional space frames.

9 Hours

Total: 45+15 Hours

References

1. S. Rajasekaran, *Computational methods of Structural mechanics*, Prentice Hall, 2006.
2. M. L. Gambhir Fundamentals of Structural Mechanics and Analysis, PHI Learning, New delhi,2011
3. F. M. Rubinstein, *Matrix Computer Methods of Structural Analysis*, Prentice Hall, 1966.
4. Mc Guire and R. H. Gallagher, *Matrix Structural Analysis*, John Wiley, 1999
5. J. R. William Weaver and James M. Gere, *Matrix Analysis of Framed Structures*, CBS Publishers & Distributors, 2004
6. C. K. Wang, *Intermediate Structural Analysis*, McGraw Hill International Editions, 1984
7. V. K Manicka selvam, *Elementary Structural Analysis*, Dhanpat Rai & Sons , 1988

13ST14 STRUCTURAL DYNAMICS

3 1 0 4

Course Objectives (COs):

- To impart knowledge on analysis of structures subjected to dynamic loading
- The students will be able to estimate the amplitude, frequency and vibration of the structures by various techniques.

Course Learning Outcome (CLO):

- The students will be able to understand the fundamental methods involving dynamic properties and behavior of structures.

Programme Outcomes (POs):

(b) an ability to identify and define problems, gathering data related to the problem, generating and prioritizing a set of alternative solutions, and selecting and implementing the best alternative with an exposure to relevant codes
(e) an ability to use the techniques, skills and advanced modern engineering tools, instrumentation, software packages for engineering practice

Unit I
Principles of Structural Dynamics
Vibration studies and their importance - Simple harmonic motion - Constraints - Generalized mass D'Alembert's principle-Hamilton's principle - Degree of freedom - Equation of motion for SDOF system. - Damped and un-damped free vibrations and forced vibration - Critical damping - Logarithmic decrement -Force transmitted to foundation - Vibration isolation**.**

9 Hours

Unit II
Response to General Dynamic Loading
Response to periodic and impulse loading- Fourier series expression for loading-Response to general dynamic loading - (blast or Earthquake) - Duhamel's integral. Equation of motion for MDOF system -Generalized distributed flexibility: Expression for generalized system properties – Vibrational analysis with Rayleigh's variational method - Rayleigh - Ritz method

9 Hours

Unit III
Multi-degree Freedom System
Evaluation of structural property matrices- Natural vibrations - solution of the eigen value problem – vector interaction methods - Stodala and Subspace iteration techniques, Transformation methods - Jacobi and Given's method, Frequency search methods - Holzer and Transfer matrix methods - Dunkerlay's equation - Orthogonality of natural modes.

9 Hours

UNIT IV
Continuous systems
Introduction-Vibration of springs-Free longitudinal vibration of a bar-Free torsional vibration of a shaft-Fee flexural vibration of beams, simply supported beams, and beams with other end conditions. Orthogonality properties of normal modes-Effect of axial force on the free flexural vibration of beams-Forced axial vibration of bars-Forced vibration of flexural member-Forced vibration of flexural member subjected to ground motion excitation. **9 Hours**

Unit V

Other Methods for Dynamic Problems

Introduction - Direct integration methods - The central difference method - The Houbolt method - Wilson-θ-method and the Newmark method. Analysis of structures subjected to dynamic loads: Idealisation of multistoreyed frames for dynamic analysis - floor vibration - analysis for blast loading - Wind induced vibration of Structures.

9 Hours

Total: 45 + 15 Hours

References

1. Jagmohan L. Humar, *Dynamics of structures*,CRC Press publishers, Netherland,2012.
2. Anil K. Chopra, *Dynamics of Structures – Theory and Applications to Earthquake Engineering*, Prentice Hall of India Pvt. Ltd., New Delhi, 2007
3. Madhujit Mukhopadhyay, Structural dynamics-Vibrations and Systems, Ane Books India,2008
4. R. W. Clough and Penzien, *Dynamics of Structures*, McGraw Hill Book Co Ltd, 1993.
5. Mario Paz, *Structural Dynamics – Theory and Applications*, CBS Publishers and Distributors, New Delhi, 2004.

13ST15 THEORY OF ELASTICITY AND PLASTICITY

3 1 0 4

Course Objective (CO):

- To impart knowledge on elastic and plastic behavior of bodies subjected to stresses and strain

Course Learning Outcomes (CLOs):

- The students will be in a position to find out the stresses in bodies subjected to two-dimensional & three dimensional forces
- The students will be able to develop a mathematical model for two-dimensional problems

Programme Outcomes (POs):

(b) an ability to identify and define problems, gathering data related to the problem, generating and prioritizing a set of alternative solutions, and selecting and implementing the best alternative with an exposure to relevant codes

(e) an ability to use the techniques, skills and advanced modern engineering tools, instrumentation, software packages for engineering practice

Unit I

Analysis of Stress and Strain

Analysis of stress (three dimension)- Body force, surface force - Uniform state of stress – Principal stresses - stress transformation laws - Differential equations of equilibrium. Analysis of strain (two and three dimension) Strain displacement relations - state of strain at a point – strain transformation - principal strain - principle of superposition Compatibility equations. Stress - strain relations - generalized Hook's law - Lame's constants

9 Hours

Unit II

Two Dimensional Problems in Cartesian Coordinates

Methods of formulation of elasticity problems - Equilibrium equations in terms of displacements - compatibility equations - Boundary value problems. Plane stress and Plane strain problems - Airy's stress function - polynomials – Direct method of determining Airy's polynomial stress function - solution of Biharmonic equation - St. Venant principle.

9 Hours

Unit III

Two Dimensional Problems in Polar Coordinates

Equilibrium equations in polar coordinates - stress distribution symmetrical about an axis - pure bending of curved bars - strain components in polar coordinates - displacements for symmetrical stress distribution - Rotating Disc - Bending of a curved bar by force at the end - Effect of circular hole on stress distribution - concentrated force at a point of a straight boundary - Forces on wedges - A circular disc with diametric loading.

9 Hours

Unit IV

Torsion of Prismatic Bars

General solutions of the problem by displacement (St. Venant's warping function) and force (Prandtl's stress function) approaches - Membrane analogy-Torsion of shafts of circular and noncircular (elliptic, triangular and rectangular) cross sectional shapes. Torsion of thin rectangular section - Torsion of thin walled single and multicelled sections.

9 Hours

Unit V

Introduction to Plasticity

Introduction to stress-strain curve - Visco elastic material - Ideal plastic body - criterion of yielding - Beltramis theory - Von-mises criterion - Mohr's theory of yielding - yield surface - Flow rule (plastic stress- strain relation) Prandtl Reuss equations - Plastic work - Plastic potential - uniqueness of stress distribution - Elastoplastic problems of beams in bending – thick hollow spheres and cylinders subjected to internal pressure - General relations - plastic torsion –Nadai's sand heap analogy.

9 Hours

Total: 45 + 15 Hours

References

1. S. Timoshenko and J. N. Goodier, *Theory of Elasticity*, Mc Graw Hill Book Co., 2007
2. Sadhu Singh, *Theory of Elasticity*, Khanna Publishers, New Delhi, 2005.
3. Sadhu Singh, *Theory of Plasticity*, Khanna Publishers, New Delhi, 2008.
4. P. C. Chow and N. J. Pagano, *Elasticity, Tensor, Dyadic and Engg. Approaches*, D. Vannostrard Co., New York, 1992
5. T. Chakrabarthy, *Theory of Plasticity*, Mc Graw Hill Book Co., New Delhi, 2006
6. N.Krishna raju, *Advanced mechanics of solids*, Narosa Publishing House,1997
7. L. S. Srinath, *Advanced mechanics of solids*, Tata Mc Graw Hill Publishing Company Ltd, 2009

13ST16 DESIGN OF FOUNDATION STRUCTURES

3 1 0 4

Course Objectives (COs):

- To impart knowledge on the types and purposes of different foundation systems and structures
- To provide students with exposure to the systematic methods for designing foundations.
- To discuss and evaluate the feasibility of foundation solutions to different types of soil conditions considering the time effect on soil behavior.
- To build the necessary theoretical background for design and construction of foundation systems
- To impact the knowledge on Cost of foundation

Course Learning Outcome (CLO):

- The students will be able to understand the nature of soil condition and design the foundation structure accordingly

Programme Outcome (PO):

(c) An ability to analyze, design detailing, estimation and costing of Structural components with high level of competency

Unit I
Introduction
Soil investigation report for foundation structure – types and selection of suitable foundation - Basic requirement of foundation – Computation of loads - Bearing Capacity – Theoretical methods (Terzaghi's, Meyorhof's, Vesic's) – IS method – penetration test – SPT, SCPT & DCPT – Cyclic Plate load test – Problems - General principle of design of shallow and deep foundation – Introduction to Floating foundation, Demonstration of SPT and Cone penetration test

9 Hours

Unit II
Pile Foundation
Introduction – Load carrying capacity of different types of piles and pile groups according to IS 2911-2010 – Pile load test - Settlement of piles - Negative skin friction - Lateral load resistance of individual piles and pile groups - Design of Piles and Pile cap and detailing of reinforcements – Design of well foundation - Case studies on different types of pile foundations

9 Hours

Unit III
Sheet Pile Walls and Caissons
Sheet pile structures - cantilever sheet pile walls in granular soils and cohesive soils - Anchored Bulk head - Free earth support method - Fixed earth support method - lateral earth pressure on Braced sheet pile walls - Caissons – Types – Design - Case studies on sheet pile walls and caissons

9 Hours

Unit IV
Special Foundation
Expansive Soils- Introduction - Identification of expansive soils – Swell potential and swelling pressure - Methods of foundation in expansive soils - Under reamed pile foundation – Design. Reinforced Earth - Introduction – Basic Mechanism of reinforced earth - Choice of soil and reinforcement - Reinforced earth retaining walls – Design and check for stability. Foundations of transmission line towers – Design of Anchors.
Case studies on soil reinforced soil - Software application in foundation Engineering.

9 Hours

Unit V

Machine Foundations

Introduction – Fundamentals of soil dynamics - Types of machine foundations – General criteria for design of machine foundation - Vibration analysis of machine foundation - Design of foundation for Reciprocating machines and Impact machines – Vibration isolation – Construction aspects of machine foundations - Study experiment – Block vibration test

9 Hours

Total: 45 + 15 Hours

References

1. Swamy Saran, *Analysis and Design of Substructures*, Oxford and IBH Publishing Co. Pvt. Ltd., 2006
2. Narayan V. Nayak *Foundation design manual* , Dhanpat Rai & Sons, 2006
3. P. C. Varghese, *Foundation Engineering*, Prentice-Hall of India Private Ltd, New Delhi, 2006
4. P. C. Varghese, *Design Of Reinforced Concrete Foundations*, Prentice-Hall of India Private Ltd, New Delhi, 2009.
5. V. N. S. Murthy, *Advanced Foundation Engineering*, CBS publisher, 2007
6. IS 2911 : Part 1 : Sec 1 : 1979 Code of practice for design and construction of pile foundations: Part 1 Concrete piles, Section 1 Driven cast in-situ concrete piles
7. IS 6403 : 1981 Code of practice for determination of bearing capacity of shallow foundations

13ST17 STRUCTURAL ENGINEERING AND DYNAMICS LABORATORY

0 0 3 2

Course Objectives (COs):

- To determine the physical properties of building materials like cement, fine aggregate and course aggregates
- To determine the appropriate mix proportion of normal concrete at specified properties and to prepare the specimens
- To impart knowledge on non-destructive testing

Course Learning Outcomes (CLOs):

- Students will be able to prepare a concrete mix design
- Students will be able to identify the quality of concrete
- Students will be able to perform non destructive testing and predict the strength of concrete at site

Programme Outcomes (POs):

(a) an ability to understand and perform research by identifying the nature of the information required; investigating sources of information, including people, texts, databases, and the Internet; organizing the information by employing a variety of techniques such as, spreadsheets, graphs, tables, and charts; and examining the information to select the most relevant, important, and useful for structural engineering

(f) an ability to recognize the need for and to engage in continual learning through sustained education to meet the challenging and demand - driven needs of the construction field.

List of Experiments

1. Concrete mix design and study of mechanical properties of concrete
2. Fabrication, casting and testing of RC Beams.
3. Evaluate the strength of hardened concrete by
   - Ultrasonic Pulse Velocity.
   - NDT Pundit
4. Vibration test on beams
5. Vibration tests on frames with and without shear walls
6. Casting and testing of Post tension Prestressed concrete beam

Total: 45 Hours

13ST18 ADVANCED COMPUTER AIDED ANALYSIS AND DESIGN LABORATORY

0 0 3 2

Course Objective (CO):

- To impart basic knowledge on the Behaviour analysis and design of structural components.

Course Learning Outcome (CLO):

- The students will be capable of understanding the behavior of structural elements.

Program Outcomes (POs):

(b) an ability to identify and define problems, gathering data related to the problem, generating and prioritizing a set of alternative solutions, and selecting and implementing the best alternative with an exposure to relevant codes

(e) an ability to use the techniques, skills and advanced modern engineering tools, instrumentation, software packages for engineering practice

List of Experiments

1. Solution of Linear System of Equations using mathematical Software Packages
   - Gaussian Elimination method
   - Gauss Siedel Iteration
2. Numerical Integration
3. Computer aided analysis and Design of a
   - 2D steel truss.
   - 3D steel truss.
   - Single-storey framed building..
   - Multi-storey building.
   - Bridge subjected to moving load.
   - Multi-storey building subjected to wind forces.
   - Multi-storey building subjected to seismic forces.
4. Finite Element Analysis of a
   - deep beams
   - plate with holes

Total: 45 Hours

13ST21 EARTHQUAKE RESISTANT DESIGN OF STRUCTURES

3 0 0 3

Course Objectives (COs):

- At the end of this course the students will be able to understand the causes and effects of earthquake
- They will be able to design beams and frames subjected to earth quake forces as per the recommendations of IS code of practice

Course Learning Outcome (CLO):

- Students will be able to analyze and design the structures subjected to earthquake forces.

Programme Outcomes (POs):

(c) an ability to analyze, design, draw and detailing of structural components with high level of competency
(e) an ability to use the techniques, skills, and advanced modern engineering tools, instrumentation, software packages necessary for engineering practice

Unit I
Seismological Background
Seismology –Structure of the earth – Earthquake faults and waves –Plate tectonics – Elastic rebound theory of earthquakes – Measures of earthquake size, Earth quake Response of Linear Systems: Earth quake Excitation - Equation of motion – Response quantities - Response History – Response Spectrum Concept - Peak Structural Response from the response spectrum.

9 Hours

Unit II
Earthquake Analysis of Linear Systems
Response History Analysis - Modal Analysis – Multi-storey Buildings with Symmetric Plan – Multi-storey Buildings with Unsymmetric Plan; Response Spectrum Analysis - Peak Response from Earthquake Response Spectrum – Multi storey Buildings with Symmetric Plan – Multi-storey Buildings with Unsymmetric plan. Earthquake response of linearly elastic buildings: Influence of fundamental period on response – influence of beam-column stiffness ratio on response – modal contribution factors – influence on higher mode response – height wise variation of higher mode response.

9 Hours

Unit III
Earthquake Response of Inelastic System
Force- deformation Relations - Normalized Yield strength, Yield reduction Factor, and Ductility Factor- Equation of motion and controlling parameters - Effects of yielding - Response Spectrum for Yield deformation and Yield strength - Design strength and deformation from the Response spectrum – Design Yield Strength, Earthquake response of inelastic buildings: Allowable ductility and ductility demand – Buildings with weak and soft first storey – Estimation of force distribution as per Indian Code.

9 Hours

Unit IV
Earthquake Resistant design
Philosophy of seismic design -base shear – storey shears and equivalent static forces masonry, steel and RCC buildings- Ductility in reinforced concrete members - Designing for ductility - multi storey building – shear wall –Buildings with soft storey.

9 Hours

Unit V

Seismic Evaluation of Buildings

Soil - structure interaction - Isolation systems- Base isolation – effectiveness of base isolation – base isolated multistory buildings – application of base isolation – design of damper. Seismic retro fitting of RC , masonry buildings and Case studies.

9 Hours

Total: 45 Hours

References

1. Pankaj Agarwal and Manish Shrikhande, Earthquake Resistant Design of structures, PHI Learning Pvt. Ltd., New Delhi, 2009
2. Anil K. Chopra, *Dynamics of Structures – Theory and Applications to Earthquake Engineering*, Prentice Hall of India Pvt. Ltd., New Delhi, 2007
3. S.K.Duggal, Earthquake Resistant Design of structures, Oxford University Press India, 2007.
4. Ray W. Clough and Joseph Penzien, *Dynamics of Structures*, Mc Graw Hill Inc, New Delhi, 2007
5. IS 1893 – 1984, *Criteria for Earthquake Resistant Design of Structures*
6. IS 4326 – 1976, *Code of Practice for Earthquake Resistant Design and Construction of Buildings*
7. IS 13920 – 1993, *Ductility Detailing of Reinforced Concrete Structures subjected to Seismic Forces*
8. *http://www.nicee.org/*

13ST22 ADVANCED STRUCTURAL STEEL DESIGN

3 1 0 4

Course Objectives (COs):

- To impart knowledge on analysis and design of steel structures.
- To impart knowledge on design of bolted and welded connections in industrial structures, light gauge sections and all related connections incorporating the recommendations of IS 800-2007 code.

Course Learning Outcome (CLO):

- On completion of this course, students will be able to analyze and design different types of steel structures subjected to lateral forces.

Programme Outcomes (POs):

(c) an ability to analyze, design, draw and detailing of structural components with high level of competency

(e) an ability to use the techniques, skills, and advanced modern engineering tools, instrumentation, software packages necessary for engineering practice

Unit I

Structural Connections

Design of high strength function grip bolts - Design of bolted connections at the junctions of beams and columns in frames - Design of un-stiffened & stiffened seat connections - Welded connections - eccentric connections - Beam end connections - Direct web fillet welded connections - Direct web Butt welded connection - Double plate web connection - Double angle web connection - Un-stiffened and stiffened seat connection - Moment resistant connection -T stub connections.

9 Hours

Unit II

Industrial Building

Industrial building frames - wind load analysis-Calculation of wind load and its combination- Framing – Roof Bracing - Crane girders and columns - Analysis of Trussed bents - Design example - Design of rigid joints knee for gable frames. Structure of Multistoreyed Buildings - Bracing systems of Multistorey frames

9 Hours

Unit III

Analysis and Design of Special Structures

Design of steel bunkers and silos - Janssen's theory - Airy's theory - design parameters-design criteria. Design and detailing of self supporting and guyed steel chimneys. Transmission line towers. types of towers - tower configuration, Load analysis and design of members.

9 Hours

Unit IV

Light Gauge Sections

Concepts -Design of cold formed sections - effective width - stiffened sections - multiple stiffened sections - design of light gauge beams and columns – Torsional – Flexural buckling – composite decks.

9 Hours

Unit V

Plastic Analysis and Design

Concept of plastic analysis-Theory of plastic bending - Plastic hinge - redistribution of moments - failure mechanisms - plastic analysis and design of fixed beams, continuous beams and portal frames by mechanism method.

9 Hours
Total: 45 + 15 Hours

References

1. N. Subramanian, *Steel Structures Design and Practice, Oxford University Press 2011*
2. S. K. Duggal, *Limit State Design of Steel, Graw Hill, New Delhi, 2011.*
3. Ramchandra (Vol I and II), *Design Of Steel Structures-1* ,Scientific Publishers, 2007
4. IS 800-2007, *General Construction in Steel-Code of Practice (Third revision).*
5. IS 811 - 1987, *Specification for cold formed light gauge structural steel sections.*
6. IS 9178 (Part 1)-1989, *Design and construction of steel chimney code of practice.*
7. IS 9178 (Part 2)-1979, *Criteria for design of steel bins for storage of bulk materials.*

13ST23 FINITE ELEMENT ANALYSIS

3 1 0 4

Course Objective (CO):

- To impart fundamental knowledge on the finite element analysis of structures and their methods

Course Learning Outcome (CLO):

- The students will be able to demonstrate various aspects of finite element method for structural analysis

Programme Outcomes (POs):

(c) an ability to analyze, design, draw and detailing of structural components with high level of competency
(e) an ability to use the techniques, skills, and advanced modern engineering tools, instrumentation, software
packages necessary for engineering practice

Unit I
One Dimensional formulation
Concept of an element - various element shapes - one, two and three dimensional elements – Finite Element procedure, variational principles and method of weighted residual - Principle of virtual work - Rayleigh Ritz method Galerkin's method of weighted residual. Displacement, stress and hybrid models - principle of minimum potential energy - principle of minimum complementary energy - Reissner's principle. Convergence and compatibility requirements - Assumed displacement field – Pascal's Triangle - Melosh criteria - Two dimensional Truss problem. Review of Gaussian Elimination and Cholesky methods, Storage schemes - skyline, band forms - band solver, Frontal solver - Cholesky LU decomposition in skyline storage.

9 Hours

Unit II
Two Dimensional Elements
Triangular Elements - constant strain triangle - Element stiffness matrix - various methods of evaluating element stiffness Higher order triangular elements - comparison of different elements. Rectangular Elements - Serendipity family - Lagrangean family - Hermitian family. Sub-Iso-Super Parametric elements - Shape function - Mapping - Linear isoparametric quadrilateral.

9 Hours

Unit III
Three Dimensional Elements
Numerical Integration using Gaussian Quadrature - Weights and Gauss points. Selective and reduced integration. Axisymmetric stress analysis - Tetrahedran element family - parallelopiped element - Hexahedran Element family - ZIB 8 and ZIB 20 elements.

9 Hours

Unit IV
Plate/Shell Elements and Finite Strip Method
Triangular and Rectangular elements - BFS Element - Faceted element for shells - Semi - loof elements Degenerated shell elements - Axisymmetric shell elements. Finite strip method - Development of stiffness matrix and consistent load vector - Application to folded plates and bridge decks - Applications to Reinforced Concrete.

9 Hours

Unit V
Non-Linear Analysis
Types of non-linearities - Stability analysis - Load deformation response - Solution techniques – Newton Raphson method - Modified Newton Raphson method, Alpha constant method, Riks Wempner method - classical Eigen Value analysis - programming organisation of Finite Element Schemes - Input / output plotting -

Mesh generation aspects - software packages. Introduction to Analysis of 2D Truss by FEM - Stress Analysis of Deep Beams using FEM Package - Analysis of Folded Plates & Shells, using FEM Package - Analysis of Grids using FEM Package. (Not for Examination).

9 Hours
Total: 45 + 15 Hours

References

1. Klaus-Jürgen Bathe *Finite Element Procedures*, Prentice Hall, 2006.
2. J.N. Reddy ,*An Introduction to the Finite Element Method*, McGraw-Hill Companies,2005
3. F. M. Rubinstein, *Matrix Computer Methods of Structural Analysis*, Prentice Hall, 1966.
4. S. Rajasekaran, *Finite Element Methods in Engineering Design*, Wheeler, 1993.
5. C. S. Krishnamoorthy, *Finite Element Method -Theory and Programming*, Tata Mc Graw Hill Publishing Company, New Delhi 1994.
6. S. S. Rao, *The Finite Element Method in Engineering*, Butterworth –Heinemann, 2010.
7. V. K. Manickaselvam, *Elementary Structural Analysis*,Dhanpatrai and sons,1988

13ST24 ADVANCED STRUCTURAL DESIGN PRACTICE

0 0 3 2

Course Objectives (COs):

- To make students capable of solving a system of simultaneous equations using computers
- To impart basic knowledge on the use of finite element based software for analysis and design of structural components.

Course Learning Outcomes (CLOs):

- The students will be able to develop computer programs for the analysis and design of structural components.
- The students will be able to work with finite element based software for the analysis and design of structures

Program Outcomes (POs):

(c) an ability to analyze, design, draw and detailing of structural components with high level of competency
(d) an ability to lead, manage and be productive in a multidisciplinary team
(e) an ability to use the techniques, skills, and advanced modern engineering tools, instrumentation, software packages necessary for engineering practice

List of Experiments

1. A multi-bay multi-storyed building
2. Multiple Cylindrical Shell
3. Northlight Cylindrical Shell
4. Hyperbolic Paraboloid Shell
5. Folded Plate
6. R.C.C Gabled Frame
7. T-beam Slab bridge
8. Prestressed concrete bridge
9. A Twin-box Culvert bridge
10. Industrial building with Gantry girder

Total: 45 Hours

13ST51 THEORY OF PLATES AND SHELLS

3 0 0 3

Course Objectives (COs):

- To impart knowledge on analysis of different types of plates and shells under different boundary conditions
- To impart knowledge on two design philosophy of RCC folded plates and shell roof structures.

Course Learning Outcome (CLO):

- The students will be able to design RCC folded plates and shell roof structures.

Programme Outcomes (POs):

(a) an ability to understand and perform research by identifying the nature of the information required; investigating sources of information, including people, texts, databases, and the Internet; organizing the information by employing a variety of techniques such as, spreadsheets, graphs, tables, and charts; and examining the information to select the most relevant, important, and useful for structural engineering

(b) an ability to analyze, design, detailing, estimation and costing of Structural components with high level of competency

(f) an ability to use the techniques, skills, and advanced modern engineering tools, instrumentation and software and hardware necessary for engineering Practice

Unit I

Analysis of Rectangular Plates

Introduction – General behavior of plates – Assumptions – Small deflection theory of thin plates – Governing differential equation for deflection of plate – Boundary conditions. Bending of Isotropic Rectangular Plates: Navier solution for an all – round simply supported rectangular plate subjected to uniformly distributed load, sinusoidal load and point load – Levy's solution for a rectangular plate with different boundary conditions and subjected to uniformly distributed load.

9 Hours

Unit II

Analysis of Circular plates

Symmetrical bending of circular Plates – Simply supported solid circular plate subjected to an uniformly distributed load, an end moment and partially distributed load.

9 Hours

Unit III

Analysis and design of folded plates

Structural behaviour of folded plates – Assumptions – Analysis of folded plates – Design of prismatic folded plate roofs as per ASCE task committee recommendations – Reinforcements details.

9 Hours

Unit IV

Analysis of shell structures

Structural behaviour of thin Shells – Classification of shells – methods of generating the surface of different shells like conoid, hyperbolic and elliptic paraboloid - Membrane Theory of shells– Edge disturbances - Geometry of hyper Shell – Analysis of membrane forces - forces in the edge members

9 Hours

Unit V

Design of Shell structures

Design of cylindrical shells with edge beams using theory for long shells – Design of cylindrical shell with ASCE manual coefficients – Detailing of reinforcement in shells and edge beams. - Design of R. C. hypar

shell roof of the inverted and tilted inverted umbrella type – Design and detailing of RC spherical shell and conical shells – Design example.

9 Hours
Total: 45 Hours

References

1. N. Krishnaraju, *Advanced Reinforced Concrete Design*, CBS Publishers and Distributors, New Delhi, 2003.
2. G. S. Ramasamy, *Design and Construction of Concrete Shell Roofs*, CBS Publishers & Distributions, New Delhi, 1999.
3. B. K. Chatterjee, *Theory and Design of Concrete Shells*, Chapman and Hall Ltd., London, 1988.
4. *Design of Cylindrical Concrete Shell Roofs* ASCE – Manuals of Engineering Practice – No.31, ASCE, Newyork, 1952.
5. S. Timoshenko and S. W. Kreiger, *Theory of Plates and Shells*, Mc Graw – Hill Book Company, Newyork, 1990

13ST52 NON-TRADITIONAL OPTIMIZATION TECHNIQUES

3 0 0 3

Course Objectives (COs):

- To impart knowledge on cost effective designs
- To impart knowledge on conventional and non-conventional optimization techniques for engineering applications

Course Learning Outcome (CLO):

- The students will get sound knowledge on optimization procedures.

Programme Outcome (PO):

(b) an ability to identify and define problems, gathering data related to the problem, generating and prioritizing a set of alternative solutions, and selecting and implementing the best alternative with an exposure t relevant codes.

Unit I
Introduction
Optimization – Definition – Constrained Optimization – Unconstrained Optimization – Minimization and Maximization problems – Local Optimum – Global Optimum – Continuous Optimization – Combinatorial Optimization - Traditional Optimization Techniques – Traveling Salesman problem.

9 Hours

Unit II
Genetic Algorithm
Biological Inspiration – The Genetic Algorithm – Generic Operators (Crossover and Mutation) – Selection Method – Population Size – Premature Convergence – Epistasis – Applications to Structural Optimization (not for examination)

9 Hours

Unit III
Simulated Annealing
Natural Motivation – Simulated Annealing Algorithm – Initial Solution – Assess Solution – Randomly Tweak Solution – Acceptance Criteria – Temperature (Initial Temperature, Final Temperature, Temperature Function, iterations at Temperature)

9 Hours

Unit IV
Ant Colony Optimization
Natural Motivation – Ant Algorithm – Network – The Ant – Difference between Real and Virtual Ants – Initial population/colony size – Ant Movement – Ant Tour – Pheromone and Pheromone Evaporation – Restart – Influence of Number of Ants – Multiple Ant Colony Optimization – Application to Structural optimization.

9 Hours

Unit V
Engineering Application
Weight Minimization and Topology Optimization of Truss Structures

9 Hours
Total: 45 Hours

References

1. M. Tim Jones, *AI Application Programming*, Charles River Media Inc., U.S.A., 2005
2. S. Rajasekaran, Pai and G. A. Vijayalakshmi, *Neural Network, Fuzzy Logic and Genetic Algorithm,* PHI Publishers, India, 2006
3. M. Dorigo, *Ant Colony Optimization*, Prentice Hall India Limited, India, 2007
4. http://www.doc.ic.ac.uk/~nd/surprise_96/journal/vol4/tcw2/report.html
5. http://iridia.ulb.ac.be/~mdorigo/ACO/ACO.html
6. International Journal of *Engineering Optimization*, Taylor & Francis and Journal of Heuristics.

13ST53 STEEL - CONCRETE COMPOSITE STRUCTURES

3 0 0 3

Course Objectives (COs):

- To impart Knowledge on design of composite beams, columns, trusses and box girder bridges including the related connections.
- They will get exposure on case studies related to steel-concrete composite construction of buildings

Course Learning Outcome (CLO):

- The students will get sound knowledge on composite structures and its behavior.

Programme Outcomes (POs):

(b) an ability to identify and define problems, gathering data related to the problem, generating and prioritizing a set of alternative solutions, and selecting and implementing the best alternative with an exposure to relevant codes.
(c) an ability to analyze, design, detailing, estimation and costing of structural components with high level of competency.

Unit I
Introduction
Introduction to steel - concrete composite construction – Advantages - Theory of composite structures - Introduction to steel - Concrete - Steel sandwich construction. **9 Hours**

Unit II
Design of Composite Beams and Columns
Behaviour of composite beams - Design of composite beams including shear connector - Behaviour and design of composite columns. **9 Hours**

Unit III

Composite Trusses

Introduction – Stud shear connectors – Effective Concrete Slab - Design consideration: Preliminary design – Detailed analysis and design – Design of studs – Partial shear – Concrete cracking – Practical considerations – Cost implifications – Design problems.

9 Hours

Unit IV

Composite Bridges

Introduction – design of composite bridge deck – Composite box girder bridges - Behaviour of composite box girder bridges - Design concepts.

9 Hours

Unit V

General

Seismic behavior of composite structures - Case studies on steel - Concrete composite construction in Buildings.

9 Hours

Total: 45 Hours

References

1. N. Krishna Raju, Design of Bridges, Oxford & IBH Publishing Company Pvt. Ltd, New Delhi. Fourth edition 2009.
2. R. P. Johnson, *Composite Structures of Steel and Concrete*, Blackwell Scientific Publications, UK, 1994.
3. G. W. Owens and P. Knowels, *Steel Designers Manual*, Steel Concrete Institute (UK), Oxford Blackwell Scientific Publications, 1992.
4. INSDAG Hand book on Composite Construction – Institute for Steel Development and Growth Publishers, Calcutta.

13ST54 BEHAVIOUR AND ANALYSIS OF TALL STRUCTURES

3 0 0 3

Course Objectives (COs):

- To impart Knowledge on behavior of tall multistoried structures.
- They will be able to analyze and design such structures taking into account the effect of creep, Shrinkage and p-delta effect

Course Learning Outcome (CLO):

- The students will get in depth knowledge on analysis and design of tall structures.

Programme Outcome (PO):

(d) an ability to lead, manage and be productive in a multidisciplinary team

Unit I

Introduction and Design Criteria

Factors affecting growth, height and structural form. Tall building structure- design process-philosophy, scope and content-Raisons D'Etre.Design Philosophy-Loading-Sequential loading. Strength and stability-stiffness ad drift limitations-human comfort criteria-creep, shrinkage and temperature effects-fire-foundations, settlement and soil-structure interaction.

9 Hours

Unit II

Loading

Gravity loading-methods of live load reduction-impact gravity loading-construction loads. Wind loading-simple static approach-dynamic methods. Earthquake loading- equivalent lateral force procedure- modal analysis procedure. Combination of loading-working stress design-limit state design-plastic design.

9 Hours

Unit III

Structural form and Modelling for analysis

Structural form-braced frame structures-rigid frame structures-in filled frame structures-flat plate and flat slab structures-shear wall structures-wall frame structures-framed tube structures- outrigger braced structures-suspended structures-core structures- space structures-hybrid structures. Floor systems-reinforced concrete one way slabs on beams and slabs on beams or walls-one way pan joists and beams-one way slabs on beams and girders-two way flat plate-two way flat slab- waffle flat slabs-two way slab and beam. Floor systems-Steel framing-One way beam system-two way beam system- three way beam system- composite steel –concrete floor systems

9 Hours

Unit IV

Braced Frames and Rigid frame structures

Types and behaviour of bracing-behaviour of braced bents-methods of analysis-member force analysis - drift analysis, approximate analysis-use of large scale bracing. Rigid frame behaviour-approximate determination of member forces caused by gravity loading-horizontal loading-approximate drift analysis-flat plate structure-computer analysis of rigid frame- reduction of rigid frames-lumped girder frame-single-bay substitute frame.

9 Hours

Unit V

Shear wall and Tubular structures

Behaviour of shear wall structures-analysis of proportionate wall systems-non proportionate structures and its behaviour-effects of discontinuities at the base-stress analysis of shear walls. Structural behaviour of tubular structures-general three-dimensional structural analysis simplified analytical models for symmetrical tubular structures.

9 Hours

Stability of high-rise buildings

Overall buckling analysis of frames: approximate methods-overall buckling analysis of wall frames-second order effects of gravity loading- simultaneous first order and P-delta analysis-translational –torsional instability calculations-effects of foundation rotation.

9 Hours
Total: 45 Hours

References

1. Bryan Stafford Smith and Alexcoull, *Tall Building Structures, Analysis and Design*, John Wiley and Sons, Inc., 2005.
2. Y. P. Gupta, *Proceedings National Seminar on High Rise Structures - Design and Construction Practices for Middle Level Cities*, New Age International Limited, Publishers, Nov. 1995.
3. S. D. Ramaswamy and C. T. Yam, *Proceedings of the International Conference on buildings*, Singapore, 1984.
4. S. B. Mehta, *High Rise Buildings*, M/S Skyline, 1978.
5. Lynn S. Beedle, *Advances in Tall Buildings*, CBS Publishers and Distributors, Delhi, 1986.

13ST55 REPAIR AND REHABILITATION OF STRUCTURES 3 0 0 3

Course Objectives (COs):

- To emphasize the importance of maintenance and inspection of structures
- To impart fundamental knowledge on various repairing strategies

Course Learning Outcomes (CLOs):

1. Demonstrate the various types of distress in concrete structures.
2. Identify the effects due to climate, temperature, chemicals, wear and erosion on structures.
3. Analyze the failures in structure due to design and construction errors.
4. Recommend the best Materials and Techniques for Repair.

Programme Outcome (PO):

(e) an ability to identify, formulate, and solve construction problems

Unit I

Introduction

General Consideration - Distresses monitoring- Causes of distresses - Quality assurance - Defects due to climate, chemicals, wear and erosion – Inspection - Structural appraisal – Economical appraisal.

9 Hours

Unit II

Building cracks

Causes - diagnosis - remedial measures - Thermal and Shrinkage cracks - unequal loading - Vegetation and trees - Chemical action - Foundation movements - Techniques for repair - Epoxy injection.

9 Hours

Unit III

Moisture Penetration

Sources of dampness - Moisture movement from ground - Reasons for ineffective DPC - Roof leakage - Pitched roofs - Madras Terrace roofs - Leakage of Concrete slabs -Dampness in solid walls - condensation - hygroscopic salts- remedial treatments - Ferrocement overlay - Chemical coatings - Flexible and rigid coatings.

9 Hours

Unit IV

Concrete Structures

Introduction - Causes of deterioration - Diagnosis of causes - Flow charts for diagnosis - methods of repair -repairing, spalling and disintegration - Repairing of concrete floors and pavements. Steel Structures: Types and causes for deterioration - preventive measures - Repair procedure- Brittle fracture - Lamellar tearing - Defects in welded joints - Mechanism of corrosion - Design to protect against corrosion - Design and fabrication errors - Distress during erection. Masonry Structures: Discoloration and weakening of stones - Biocidal treatments - Preservation -Chemical preservatives - Brick masonry structures – Distresses and remedial measures.

9 Hours

Unit V

Strengthening of Structures

General principle - relieving loads - Strengthening super structures - plating-Conversion to composite construction - post stressing - Jacketing - bonded overlays- Reinforcement addition - strengthening the substructures – under pinning-Increasing the load capacity of footing- Repair of structures distressed due to earthquake- Design for rehabilitation.

9 Hours

Total: 45 Hours

References

1. Dension, C. Alien and H. Roper, *Concrete Structures, Materials, Maintenance and Repair*, Longman Scientific and Technical, UK, 1991.
2. B. A. Richardson, *Remedial Treatment of Buildings*, Construction Press, London, 1980.
3. R. T. Alien and S. C. Edwards, *Repair of Concrete Structures*, Blakie and Sons, UK, 1987.
4. S. M. Johnson, *Deterioration, Maintenance and Repair of Structures*, McGraw-Hill Book Company, Newyork, 1965.
5. R. K. Guha, *Maintenance and Repairs of Buildings*, New Central Book Agency (P) Ltd, Calcutta, 1985.
6. R. N. Raikar, *Learning from failures - Deficiencies in Design, Construction and Service*, - R & D Centre (SDCPL), Raikar Bhavan, Bombay, 1987.
7. SP25-84 – Hand Book on *Causes and Prevention of Cracks on Buildings*, Indian Standards Institution, New Delhi, 1984.

13ST56 DESIGN OF PRESTRESSED CONCRETE STRUCTURES

3 0 0 3

Course Objectives (COs):

- To impart knowledge on the basic principles of Prestress concrete structures
- To impart the design philosophy of prestressed beams, tanks, pipes, poles etc.

Course Learning Outcome (CLO):

- The students will get in depth knowledge on Techniques and design of Prestressed concrete structures.

Programme Outcome (PO):

(d) an ability to lead, manage and be productive in a multidisciplinary team

Unit I
Introduction
Basic principles of prestressing – Classification and types – Advantages over ordinary reinforced concrete – Materials – high strength concrete and high tensile steel – Methods of prestressing – Freyssinet, Magnel Blaton, Lee M_c Call and Killick anchorage systems – Analysis of sections for stresses by stress concept, strength concept and load balancing concept

9 Hours

Unit II
Design for Flexure and Shear
Basic assumptions for calculating flexural stresses – Permissible stresses in steel and concrete as per I.S.1343 Code – Design of sections of Type I and Type II post – tensioned and pre - tensioned beams – Check for strength limit state based on I.S. 1343 Code – Layout of cables in post - tensioned beams – Location of wires in pre-tensioned beams – Design for shear based on I.S.1343 Code

9 Hours

Unit III
Deflection and Design of Anchorage zone
Factors influencing deflections – Short term deflections of uncracked members – Prediction of long term deflections due to creep and shrinkage – Check for serviceability limit state of deflection. Determination of anchorage zone stresses in post - tensioned beams by Magnel's method, Guyon's method and I.S. 1343 code – Design of anchorage zone reinforcement

9 Hours

Unit IV

Composite Beams

Types of R.C.C. – P.S.C. composite beams – Analysis and design of composite beams and Continuous Beams - Methods of achieving Continuity in continuous beams - Analysis for secondary moments – Concordant cable and linear transformation - Calculation of stresses – Principles of design.

Deflection and shear strength of composite beams

9 Hours

Unit V

Miscellaneous Structures

Design of tanks, pipes, sleepers, tension and compression members – Use of non-prestressed reinforcement – Definition, methods of achieving, merits and demerits of partial prestressing.

Design of Poles

9 Hours

Total: 45 Hours

References

1. Krishna Raju, N.,"Prestressed Concrete", Tata M_c Graw Hill Publishing company, New Delhi, 1995.
2. Lin, T.Y. and Ned.H.Burns,"Design of Prestressed Concrete Structures", John Wiley & Sons, New York, 1982.
3. Rajagopalan, N.,"Prestressed Concrete", Narosa Publishing House, New Delhi, 2002.
4. Mallik, S.K. and Gupta, A.P.,"Prestressed Concrete", Oxford & IBH Publishing Co., Pvt.Ltd., India, 1986.
5. Arthur H.Nilson, "Design of Prestressed Concrete", John Wiley & Sons, New York, 1978
6. Dayaratnam,P.,"Prestressed Concrete Structures",Oxford and IBH, New Delhi, 1982.
7. Sinha, N.C.and Roy, S.K.,"Fundamentals of Prestressed Concrete", S.Chand &Co., Ltd., 1994.

13ST57 DESIGN OF BRIDGES

3 0 0 3

Course Objectives (COs):

- To impart knowledge on design different types of reinforced concrete bridges
- To impart knowledge on the design of steel bridges and pre stressed concrete bridges along with the sub structures and foundation.

Course Learning Outcome (CLO):

- The students will get in depth knowledge on types of Bridges and its design methodologies.

Programme Outcome (PO):

(d) an ability to lead, manage and be productive in a multidisciplinary team

Unit I

Introduction

Introduction - Definition and basic forms – Components of a bridge - Classification of bridges – IRC Loading Standards and specifications - Design of Reinforced Concrete Slab Bridge decks – Design of Tee Beam and Slab Bridge Deck – Bearings – Types of bearings – Design of bearings – Dynamic response of bridge deck and codal provisions.

9 Hours

Unit II

Other Reinforced Concrete Bridges

Design of Balanced Cantilever Bridges, Continuous girder Bridges-Rigid Frame Bridges – Box culverts.

9 Hours

Unit III

Steel Bridges

General- Railway loadings- Dynamic effect-Railway culvert with steel beams-Design of Plate Girder Bridges, Steel Trussed bridges.

9 Hours

Unit IV

Substructures and Foundations

Design of Piers and abutments - Foundations: Types of Foundations - Design of Pile Foundation and Well foundation - Caisson Foundation.

9 Hours

Unit V

Prestressed Concrete Bridges

Introduction – Design of Post – tensioned prestressed Concrete Slab Bridge deck – Design of Post – tensioned prestressed Concrete Tee beam and Slab Bridge deck.

9 Hours

Total: 45 Hours

References

1. N. Krishna Raju, Design of Bridges, Oxford & IBH Publishing Company Pvt. Ltd, New Delhi. Fourth edition 2009.
2. S.Ponnuswamy, *Bridge Engineering*, Tata McGraw-Hill Publishing Company Limited, New Delhi,2003.
3. D. Johnson Victor, *Essentials of Bridge Engineering*, Oxford and IBH Publishing Co., New Delhi, 2001.
4. Raina V.K. "Concrete Bridge Practice" , Tata McGraw Hill Publishing Company, New Delhi, 1991.
5. IRC: 6, 18, 21, 22, 24, 78 & 83.
6. SP: 16 (S & T) - 1980, *Design Aids to I.S.456-1978.*
7. I.S. 1343 – 1980, *Indian Standard Code of Practice for prestressed concrete*

13ST58 DESIGN OF INDUSTRIAL STRUCTURES

3 0 0 3

Course Objectives (COs):

- The students shall be able to plan engineering, chemical and textile industries
- They will be able to design folded plate and shell structures and other structures such as silos, bunkers and chimneys.

Course Learning Outcome (CLO):

- The students will get in depth knowledge on types of industrial structures and its design methodologies.

Programme Outcome (PO):

d) an ability to lead, manage and be productive in a multidisciplinary team

Unit I
General
Classification of Industries and Industrial Structures – Specific requirements for Industries like Engineering,Textiles, Chemicals, etc. – Site layout and external facilities required.

9 Hours

Unit II
Functional Requirements
Natural and artificial lighting – protection from the sun light – Services – Electrical wiring fixtures – cable and pipe bridge – Electrical installations – substations – Effluent disposal – Heating and Ventilation – Air conditioning – Fire expanse and chutes – fire alarm, extinguishers and hydrants – Guidelines from factories act**.**

9 Hours

Unit III
Industrial Structures
Design and detailing of R.C. gable frames, corbels and nibs, bunkers, silos and Gantry girders – North light shell roofs and folded plates –Application of prefabrication techniques.

9 Hours

Unit IV
Power Transmission Structures
Cables – Transmission line towers – Substation Structures – Tower Foundation – Testing of towers.

9 Hours

Unit V
Power Plant Structures
Types of power plants – Design of Turbo generator foundation – containment structures - Machine foundations – R.C.C and Steel chimneys.

9 Hours
Total: 45 Hours

References

1. P. Dayaratnam, *Deign of Steel Structures*, A.H. Wheeler & Co., Ltd., Allahabad, 2008.
2. S. N. Manokar, *Tall Chimneys – Design and Construction*, Tata McGraw Hill, 1986
3. A.R. Santhakumar and S. S. Murthy, *Transmission Line Structures*, Tata Mc Graw Hill, 1992.
4. IS: 9178 Criteria for design of Steel bins for Storage of Bulk materials Part I – General Requirements and Assessment of Loads and Part II – Design Criteria
5. IS: 3483 Code of Practice for Noise Reduction in Industrial Buildings
6. IS: 6060 Code of Practice for Day lighting of Factory buildings

13ST59 PREFABRICATED STRUCTURES

3 0 0 3

Course Objectives (COs):

- To impart Knowledge on pre fabricated elements and the technologies used in fabrication and erection
- They came to know the applications of Pre-Engineered Buildings in construction

Course Learning Outcome (CLO):

- The students will get in depth knowledge on types of prefabricated elements and its design methodologies.

Programme Outcome (PO):

(d) an ability to lead, manage and be productive in a multidisciplinary team

Unit I

General Principles of Fabrication

Comparison with monolithic construction – Types of prefabrication – site and plant prefabrication - Economy of prefabrication – Modular coordination – Standardization – Planning for Components of prefabricated structures – Disuniting of structures – Design of simple rectangular beams and I beams – Handling and erection stresses – Elimination of erection stresses – Beams, columns – Symmetrical frames.

9 Hours

Unit II

Prefabricated Elements

Roof and floor panels, ribbed floor panels – wall panels – footings – Joints for different structural Connections – Effective sealing of joints for water proofing – Provisions for non-structural fastenings – Expansion joints in pre-cast construction. Designing and detailing of precast unit for factory structures – Purlins, Principal rafters, roof trusses, lattice girders, gable frames – Single span single storeyed frames – Single storeyed buildings – slabs, beams and columns.

9 Hours

Unit III

Production and Hoisting Technology

Choice of production setup – Manufacturing methods – Stationary and mobile production – Planning of production setup – Storage of precast elements – Dimensional tolerances – Acceleration of concrete hardening. Equipments for hoisting and erection – Techniques for erection of different types of members like Beams, Slabs, Wall panels and Columns – Vacuum lifting pads.

9 Hours

Unit IV

Applications

Designing and detailing of precast unit for factory structures – Purlins, Principal rafters, roof trusses, lattice girders, gable frames – Single span single storeyed frames – Single storeyed buildings: slabs, beams and columns, Application of prestressed concrete in prefabrication.

9 Hours

Unit V

Pre-Engineered Buildings

Introduction – Advantages - Pre Engineered Buildings Vs Conventional Steel Buildings - Design of Pre Engineered Buildings (PEB) – Applications

9 Hours

Total: 45 Hours

References

1. L. Mokk, *Prefabricated Concrete for Industrial and Public Structures*, Publishing House of the Hungarian Academy of Sciences, Budapest, 2007.
2. T. Koncz, *Manual of Precast Concrete Construction*, Vol. I, II, III & IV, Berlin, 1971.
3. B. Lewicki, *Building with Large Prefabricates*, Elsevier Publishing Company, Amsterdam, London, New York, 1998.
4. *Structural Design Manual, Precast Concrete Connection Details*, Society for the Studies in the use of Precast Concrete, Netherland Betor Verlag, 2009.
5. Hass, A.M.*Precast concrete design and Applications,* Applied Science Publishers, 1983.
6. Promyslow.V, *Design and Erection of Reinforced Concrete Structures,* MIR Publishers, Moscow 1980.

13ST60 STABILITY OF STRUCTURES

3 0 0 3

Course Objectives (COs):

- To impart Knowledge on phenomenon of buckling and its effects on structural components
- They will be in a position to design these components taking into account the effect of bucking

Course Learning Outcome (CLO):

- The students will get in-depth knowledge on structural stability and behavior of individual components

Programme Outcome (PO):

(d) an ability to lead, manage and be productive in a multidisciplinary team

Unit I

Fundamental Concepts of Stability

Criterion for design of structures: strength, stability and stiffness - concepts of stability, instability and bifurcation - stability criteria – Concepts of Equilibrium, Energy and Dynamic approaches- South well Plot – Stability of Link models.

9 Hours

Unit II

Buckling of columns

Governing differential equations- Higher order differential equations - Analysis for various boundary conditions - Behaviour of imperfect column - initially bent column - eccentrically loaded column-Energy method- Rayleigh Ritz, Galerkin methods - Effect of shear on buckling – Large deflection analysis of columns.

9 Hours

Unit III

Buckling of beam - column & Frames

Buckling of beam column- Derivation of stability function for standard cases of beam columns: Beam-columns with concentrated lateral loads - distributed loads - effect of axial loads on bending stiffness. Buckling of frames: Mode of buckling- Single storey frames with sway and no sway; Buckling analysis of frames with various methods: Slope deflection and Stiffness method.

9 Hours

Unit IV

Lateral Stability of Beams

Differential equations for lateral buckling - lateral buckling of beams in pure bending - lateral buckling of cantilever and simply supported I beams. Buckling of Thin Walled Open Sections: Introduction – torsional buckling - torsional flexural buckling - Equilibrium and energy approaches. **9 Hours**

Unit V

Stability of Plates & Inelastic buckling

Governing Differential equation-Equilibrium, energy concepts - Buckling of rectangular plates for various end conditions -Finite difference method - post-buckling strength. Introduction to inelastic buckling - Double modulus theory (reduced modulus) - tangent modulus theory - Shanley's theory - determination of double modulus for I section and rectangular section. Application: Review of relevant codal provisions for design of steel, concrete and masonry structures.

9 Hours

Total: 45 Hours

References

1. A. Chajes, *Principles of Structural Stability Theory*, Prentice Hall, 2008.
2. N. G. R. Iyengar, *Structural Stability of Columns and Plates*, Affiliated East West press Pvt. Ltd, New Delhi – 1988.
3. D. O. Brush, and B. O. Almorth, *Buckling of Bars, Plates and Shells*, Mc Graw Hill, 2006.
4. S. O. Timoshenko and J. M. Gere, *Theory of Elastic Stability*, McGraw-Hill, 2009
5. M. S. El Naschie, *Stress, Stability and Chaos in Structural Engineering: An Energy Approach*, McGraw Hill International al Editions, 1999.
6. Ashwini Kukar, *Stability of Structures*, Allied Publishers LTD, New Delhi, 2003.

13ST61 OFFSHORE STRUCTURES

3 0 0 3

Course Objectives (COs):

- To impart Knowledge on forces due to ocean waves and to design off shore structures.

Course Learning Outcome (CLO):

- The students will get an exposure to analyze and design the offshore structures

Programme Outcome (PO):

(d) An ability to lead, manage and be productive in a multidisciplinary team

Unit I

Wave Theories

Wave generation process, small and finite amplitude wave theories.

9 Hours

Unit II

Forces of Offshore Structures

Wind forces, wave forces on vertical, inclined cylinders, structures – Current forces and use of Morison equation**.**

9 Hours

Unit III

Offshore and Soil Structure Modeling

Different types of offshore structures, foundation modeling, structural modeling.

9 Hours

Unit IV

Analysis of Offshore Structures

Static method of analysis, foundation analysis and dynamics of offshore modeling

9 Hours

Unit V

Design of Offshore Structures

Design of Platforms, helipads, Jacket tower and mooring cables and pipe lines.

9 Hours

Total: 45 Hours

References

1. D. V. Reddy and M. Arockiasamy, *Offshore Structures*, Vol.1 and Vol.2, Krieger Publishing Company, Malabar, Florida, 1991.
2. S. K. Chakrabarti, *Hydrodynamics of Offshore Structures,* Computational Mechanics Publication, 1987
3. APl Recommended Practice for *Planning, Designing and Constructing Fixed Offshore Platforms*, American Petroleum Institute Publication, RP2A, Dalls, Tex, 2000
4. R. L. Wiegel, *Oceanographical Engineering*, Prentice Hall Inc, Englewood Cliffs, N.J. 2008
5. B. C. A. Walker., *Dynamic Analysis of Offshore Structures*, New-nes Butterworths, U.K.1979.
6. Thomas H. Dawson**,** *Offshore Structural Engineering,* Prentice Hall Inc Englewood Cliffs, N.J.1983.

13ST62 SPACE STRUCTURES

3 0 0 3

Course Objectives (COs):

- At the end of this course students will be able to analyze many types of space structures such as Geodesic dome, cable suspension structures and Tensile Membrane and Tensegritic Structures
- They will be able to apply non -traditional optimization methods for such structures.

Course Learning Outcome (CLO):

- The students will get an exposure to analyze and design the space structures

Programme Outcome (PO):

(d) an ability to lead, manage and be productive in a multidisciplinary team

Unit I

Principles

Definition – Historical development – Types – Materials – Practical difficulties – Construction – Support conditions – Cladding – Aesthetics Failure of space structures – Formex data generation of space structure – Single and Multi – layer grids and domes – Advantages – Water drainage – Progressive collapse and composite space trusses – Network domes – Geodesic domes – Double dome – Ice dome – erection – Folded plate roofs.

9 Hours

Unit II

Connectors

Classification – Ball joint systems – Socket joint – Plate joint – Slot joint – Shell joint – Modular systems – Composite system – Prefabricated systems – Patented systems – MERO joints – simple connectors.

9 Hours

Unit III

Stressed Skin-Cable Suspension Structures

Stressed skin steel buildings – Stressed skin grids – Cable suspended roofs – Design of cable roofs – Erection of cable roofs – Economy – New trends.

9 Hours

Unit IV

Tensile Membrane and Tensegritic Structures

Pneumatic structures – Materials and coatings – Fans and pressure control – Lighting anchor design – Trends in pneumatic construction – Failures – Tensegritic structures – Maxwell's rules – Stability of tensegritic structures – Cable tenstar dome – Flying mast fabric roof system.

9 Hours

Unit V

Analysis

Finite element analysis of skeletal structures – Approximate methods – Optimal design of space structures using non – traditional optimization methods such as (Genetic Algorithm) GA, (Evolution Strategies) ES or (Ant colony Optimization) ACO – Space structures with changing geometries.

9 Hours

Total: 45 Hours

References

1. G. S. Ramaswamy, M. Eekhout and G. R. Suresh, *Analysis, design and Constructions of space Structures*, Thomas Telford, 2002
2. N. Subramaniam, *Space Structures: Principles and Practice*, Multi Science Publishing Company, 1983.
3. B. B. Wang, *Free Standing Tension Structures*, Taylor & Francis, 2007

13ST63 EXPERIMENTAL STRESS ANALYSIS AND TECHNIQUES

3 0 0 3

Course Objectives (COs):

- At the end of this course the students will know about measurement of strain, vibrations and wind Blow.
- They will be able to analyze the structure by non-destructive testing method and model analysis

Course Learning Outcome (CLO):

- The students will be able to demonstrate the methods of modal analysis and testing of materials.

Programme Outcome (PO):

(b) an ability to identify and define problems, gathering data related to the problem, generating and prioritizing a set of alternative solutions, and selecting and implementing the best alternative with an exposure to relevant codes..

Unit I

Strain Measurement

Methods of Measurement -Calibration-Load calibration of testing machines-I.S. Code provisions - Measurement system- Mechanical, Optical and Acoustical extensometers -Strain measurement-Electrical resistance strain gauges- Principle, Types, Performance, Uses- Strain Rosettes- Wheatstone Bridge-Electronic load cells-Proving rings.

9 Hours

Unit II

Measurement of Vibration & Wind Flow

Measurement of vibration- Vibration galvanometers- Vibrometer-Characteristics of Structural vibration-Pressure gauges-Velocity transducers- Seismic transducers – Linear Variable Differential Transformer-Cathode ray oscilloscope – X Y Plotter- Wind Tunnels-Flow meters- Venturimeter- Digital Data Acquisition systems.

9 Hours

Unit III

Distress Measurement & Control

Diagnosis of distress in structures-Cracks in structures-Formation of cracks- Types of cracks-Causes of cracks- Crack measurement- Monitoring and measurement of crack movement- Corrosion of reinforcement in RCC- Half cell-Construction and use-Damage assessment-Controlled blasting for demolition-Photoelasticity-Two dimensional photo elasticity, Concept of light – photoelastic effects - stress optic law-Interpretation of fringe pattern- Compensation and separation techniques- Photo elastic materials. Introduction to three dimensional photo elasticity.

9 Hours

Unit IV

Non-Destructive Testing Methods

Load testing on structures-In situ load testing-Ultimate load testing-Rebound hammer-Principle and Applications-Limitations-Ultrasonic testing- Principles and Applications- Brittle coating- Principle and Applications-Stress coat- All Temp- Comparison of brittle coatings- Evaluation of the coating - Introduction to Moiré techniques- Holography- ultrasonic C- Scan- Thermograph- Fiber – optic Sensors.

9 Hours

Unit V

Model Analysis

Model laws- Laws of similitude-Model materials- Model testing- Necessity for Model analysis-Advantages-Applications- Types of similitude- Scale effect in Models- Indirect model study- Direct model study-Limitations of model investigations- Structural problems that may demand model studies- Usage of influence lines in model studies. **9 Hours**

Total: 45 Hours

References

1. Sadhu Singh, *Experimental Stress Analysis*, Khanna Publishers, New Delhi, 2006.
2. J. W. Dally and W. F. Riley, *Experimental Stress Analysis*, McGraw-Hill, Inc. New York, 1965
3. L. S. Srinath, *Experimental Stress Analysis*, Tata Mc Graw-Hill Publishing Co. Ltd., New Delhi, 1984
4. C. S. Rangan, *Instrumentation – Devices and Systems*, Tata McGraw-Hill Publishing Co. Ltd., New Delhi, 1983.

13ST64 RESEARCH METHODOLOGY

3 0 0 3

Course Objectives (COs):

- To impart knowledge on sampling methods, data collection methods and on statistical analysis of data
- They will be able to do interpretation and prepare the report.

Course Learning Outcome (CLO):

- The students will get an exposure to various methods and techniques related to research process.

Programme Outcome (PO):

(b) an ability to identify and define problems, gathering data related to the problem, generating and prioritizing a set of alternative solutions, and selecting and implementing the best alternative with an exposure to relevant codes.

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Unit I

Introduction

Research methodology – definition – Mathematical tools for analysis, Types of research exploratory research, conclusive research, modeling research, algorithmic research, Research process –steps. Data collection methods – Primary data – Observation method – Personal interview – Telephonic interview – Mail survey – questionnaire design – Secondary data – Internal sources of data – external sources of data

9 Hours

Unit II

Sampling Methods

Scales – measurement, Types of scale – Thurstone's case V Scale model, Osgood's Semantic Differential scale, Likert scale, Q-sort scale – Sampling methods – Probability sampling methods – simple random sampling with replacement, simple random sampling without replacement, stratified sampling, cluster sampling, Non probability sampling method –convenience sampling, judgment sampling, quota sampling.

9 Hours

Unit III

Theories

Hypotheses testing – Testing of hypotheses concerning means (one mean and difference between two means – one tailed and two tailed tests), concerning variance – one tailed Chi-square test.

9 Hours

Unit IV

Data Collection Methods and Statistical Analysis

Non-parametric tests – one sample tests –one sample sign test – Kolmogorov-Sminov test, run test for randomness Two sample tests – two sample sign test – Mann Whitney U test, K-sample test – Kruskal Wallis test (H- test)

9 Hours

Unit V

Interpretation and Report Writing

Introduction to Disciminant analysis, Factor analysis, Cluster Analysis, Multi-dimensional scaling, conjoint analysis, report writing, types of report, guidelines to review report, typing instructions, oral presentation.

9 Hours

Total: 45 Hours

References

1. C. R. Kothari, *Research Methodology – Methods and Techniques*, New Age International, 2008
2. R. Pannerselvam, *Research Methodology*, Prentice- Hall India, New Delhi, 2008

13ST01 CONCRETE TECHNOLOGY

- - - 3

Course Objectives (COs):

- To impart knowledge on the latest developments in the field of concrete technology
- To learn the tests on Bendable Concrete, Self Curing Concrete, Self Compacting Concrete, Ultra High Strength Concrete and Light & Heavy Weight Concrete.

Course Learning Outcome (CLO):

- The students will get an exposure to various advanced methods and techniques related to concrete technology

Programme Outcome (PO):

(b) an ability to identify and define problems, gathering data related to the problem, generating and prioritizing a set of alternative solutions, and selecting and implementing the best alternative with an exposure to relevant codes.

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Unit I
Bendable Concrete
Method of Achieving – Various Tests on Fresh Concrete – Hardened Concrete – Application of Bendable Concrete

Unit II
Self Curing Concrete
Method of Achieving – Various Tests on Fresh Concrete – Hardened Concrete – Application of Self Curing Concrete

Unit III
Self Compacting Concrete
Method of Achieving – Various Tests on Fresh Concrete – Hardened Concrete – Application of Self Compacting Concrete
Unit IV
Ultra High Strength Concrete
Method of Achieving – Various Tests on Fresh Concrete – Hardened Concrete – Application of Ultra High Strength Concrete

Unit V
Light & Heavy Weight Concrete
Method of Achieving – Various Tests on Fresh Concrete – Hardened Concrete – Application of Light and Heavy Weight Concrete

References

1. www.cement.org
2. Canadian Journal of Civil Engineering
3. Journal of Structural Engineering (ASCE)
4. Journal of Structural Engineering (JoSE, CSIR)
5. ACI Material Journal
6. Concrete International

13ST02 DISCRETE STRUCTURAL OPTIMIZATION

- - - 3

Course Objectives (COs):

- To impart knowledge on the recent advances in the area of met heuristics
- To create awareness among students to generate cost effective designs

Course Learning Outcome (CLO):

- The students will get an exposure to various advanced methods and techniques related to concrete technology.

Programme Outcome (PO):

(b) an ability to identify and define problems, gathering data related to the problem, generating and prioritizing a set of alternative solutions, and selecting and implementing the best alternative with an exposure to relevant codes.

Unit I
Tabu Search
Topology Optimization of Truss Structures

Unit II
Genetic Algorithm
Sizing Optimization of Truss Structures

Unit III
Ant Colony Optimization
Topology and Sizing Optimization of Truss Structures – Framed Structures – Plates and Shells

Unit IV
Harmony Search
Weight Minimization of Space Structures

Unit V
Particle Swarm Optimization
Post Buckling Behavior of Columns – Weight Minimization of Truss Structures – Frames

References

1. Engineering Optimization
2. International Journal on Computers and Structures
3. International Journal on Computer-Aided Civil and Infrastructure Engineering
4. Canadian Journal of Civil Engineering
5. Journal of Structural Engineering (ASCE)
6. Journal of Structural Engineering (JoSE, CSIR)