RAMAIAH UNIVERSITY OF APPLIED SCIENCES

M S Ramaiah University of Applied Sciences

Program Structure and Course Details of M Tech (Construction Engineering and Management) Degree Programme

Programme Code: 040

Batch 2022-24

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Bangalore - 560 054

Department of Civil Engineering
Faculty of Engineering and Technology
M S Ramaiah University of Applied Sciences

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Faculty	Engineering and Technology
Department	Civil Engineering
Name of the Programme	M Tech in Construction Engineering and Management
Programme Code	040
Mode of Study	Full Time
Date of Commencement of the Programme	August 2022
Date of Programme Approval by the Academic Council of MSRUAS	June 2019

1. Programme Objective

The aim of the programme is to produce postgraduates with advanced knowledge and understanding of Construction Engineering and Management; higher order critical, analytical, problem solving and transferable skills; ability to think rigorously and independently to meet higher level expectations of civil construction industry, academics, research or take up entrepreneurial route.

2. Programme Outcomes (POs) / Graduate Attributes

PO 1. Modern construction materials, methods and equipment
PO 2. Planning and formulation of design alternatives and solutions for construction projects
PO 3. Developing and administering project budgets and fiscal controls, contract and quality control provisions
PO 4. Selection of materials, construction method and designing of construction process
PO 5. Reviewing the contract strategies for construction projects and to suggest the appropriate contract forms and payment methods
PO 6. Planning and controlling project cost including cost estimating, risk analysis, determination of contingencies, progress reporting and value engineering
PO 7. Application of IT tools in project planning, design and management
PO 8. Corporate and construction industry practice, process, standards and their impact on project activities giving general perspective and opportunities for a career in the construction industry
PO 9. Teamwork, lifelong learning and continuous improvement.

3. Programme Specific Outcomes (PSOs)

The programme specific outcomes are listed under four headings:

1. Knowledge and Understanding
2. Cognitive skills
3. Practical skills and
4. Capability/Transferable skills

Knowledge and Understanding: After undergoing this programme, a student will be able to:

KU1: Explain structural systems, form work, construction techniques, resources, economic principles, properties of modern construction materials and equipment applied to engineering construction for sub structure, super structure, special structures, rehabilitation and strengthening techniques and demolition techniques, Intelligent Systems, significance of green and alternate building materials

KU2: Describe the factors critical in planning and designing construction processes to achieve needed safety, quality, durability, sustainability, and economic objectives, concepts of cost effective building design

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KU3: Explain formulation, planning, scheduling, cost and quality control, safety, construction system integration, environmental factors, services, maintenance and safety systems in construction engineering

KU4: Discuss advantages, disadvantages and limitations of various construction materials, types of special concretes and their application, construction process, equipment, strategies, optimization techniques, inventory models, scheduling techniques, structural systems and services in construction engineering

Cognitive Skills: After undergoing this programme, a student will be able to:

CS1: Design and analyze various structural systems, form work, construction techniques and processes of sub systems/components of a project to meet the overall specifications of the project

CS2: Analyze and propose construction technique and management technique changes essential for solving a broad set of engineering problems in construction considering societal and economic impacts to achieve needed safety, quality, durability, sustainability, and economic objectives

CS3: Evaluate the performance of the various construction materials, special concretes, personnel, construction processes, equipment, strategies, optimization techniques, inventory models, scheduling techniques, structural systems and services in construction engineering

CS4: Propose and implement various safety norms in a construction project

Practical Skills: After undergoing this programme, a student will be able to:

PS1: Produce tender and contract documents along with the ability to carry out estimation of costs and expenditures during all project stages

PS2: Use appropriate software packages relevant to construction industry

PS3: Conduct physical tests to evaluate performance of civil construction materials

PS4: Perform laboratory tests on models structures to understand their behavior

Capability Skills / Transferrable Skills: After undergoing the programme, a student will be able to:

TS1: Manage information, develop technical reports and make presentations

TS2: Build, Manage and Lead a team to successfully complete a project and communicate across teams and organizations to achieve professional objectives

TS3: Work under various constraints to meet project targets

TS4: Adopt to the chosen profession by continuously upgrading his/her knowledge and understanding through Life-long Learning philosophy

4. Eligibility for Admission:

4.1. Eligibility for students seeking admission under Government of Karnataka quota (for 40% seats):

i. A candidate seeking admission to postgraduate programme must have passed graduate level in Engineering and Technology in a related discipline with at least 50% marks in aggregate or equivalent CGPA.

ii. A candidate belonging to SC/ST category will be entitled to a relaxation in the qualifying marks in accordance with the related government notification in this regard.

4.2. Eligibility for Indian students seeking admission under the university quota:

Students seeking admission under University quota must have passed graduate level degree in Engineering in a related discipline with at least 50% marks in aggregate or equivalent CGPA.

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4.3. Eligibility for foreign students seeking admission under University quota:

i.Foreign students should have Association of Indian Universities recognized first degree qualification in the Engineering related discipline of equivalent

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ii. Should have proof of proficiency in English.

4.4: Selection of Students

Selection of students for admission under Government of Karnataka will be based on Karnataka

Government notified admission tests.

Selection of students for admission to University quota of seats is based on admission policy of the University notified from time to time.

Selection of foreign students for admission to University quota of seats is based on the admission policy of the University notified from time to time.

4.4.1: Admission to Programme

Selected candidates shall complete the admission procedure within the prescribed date by paying the prescribed fees and completing all other admission formalities notified by the University. Failure to do so may lead to cancellation of the selection.

4.4.2: Annual Programme Fee

Details of the fees payable for each Programme will be notified well in advance to the commencement of the programme.

The fees, once paid, will not be refunded under any circumstances.
The continuation of a student's registration in subsequent academic years is subject to payment of the prescribed programme and registration fees for each of those years.

4.4.3: Free-ship and scholarships

The Board of Management, in consultation with the Board of Governors, may consider offering free ships / scholarships to deserving students who maintain a minimum level of academic performance on a yearly basis.

5. Programme Duration

5.1. Normal Duration: The normal duration of the M.Tech. postgraduate programme is:

a. Two years in the Full-Time Route
b. Three years in the Part-Time Route

5.2. Maximum Duration: The maximum period a student is allowed to complete the M.Tech Programme shall be double the normal duration of the programme, i.e., Four Years for Full-Time students and Six years for Part-Time students.

5.3. Duration for Lateral Entry Scheme: N/A

6. Medium of Instruction

English is the medium of instruction for the programme.

7. Programme Structure

The programme structure is presented in **Appendix A**.

8. Programme Curriculum

The programme curriculum is presented in **Appendix B**.

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9. Attendance Requirement

A student is required to have a minimum attendance of 80% to be eligible to appear for the examination and for assignment submission. Students who fail to achieve the minimum attendance will be declared as "FAIL". A failed student is required to re-register, attend the course and take up all the components of assessment at the next offering.

10. Assessment

10.1. Achievement Testing: During each semester, students' performance is assessed through two components, Continuous Evaluation (CE) and a Semester-End Examination (SEE). Both CE and SEE carry equal weight.

10.1.1. Continuous Evaluation (CE): This includes term tests, assignments, viva-voce, quiz, seminars, mini projects and other such evaluation methods designed for specific courses and conducted as per the norms of the University for Assessment.

10.1.2. Semester End Examination (SEE): This includes a written/laboratory examination conducted as per the norms of the University for Assessment.

The attainment of student in all COs are evaluated. A typical evaluation template in a theory course is presented in Table 1. A student is required to score a minimum of 40% marks in each course, scoring a minimum of 40% in each of CE and SEE.

Table 1: Typical evaluation template for a theory course

Course Outcome	CE (Weightage: 50 %)				SEE (Weightage: 50 %) Semester End Exam
	Component	Component	Component	Component	
	XX Marks	XX Marks	XX Marks	XX Marks	50 Marks
CO-1					
CO-2					
CO-3					
CO-4					
CO-5					
CO-6					

In the case of a laboratory course, there are two components: Component-1 and Component-2. Component-1 (CE) carries a weight of 50% and Component -2 (SEE) carries a weight of 50%.

The template for weightage of CE and SEE in percentages for each course is indicated in Table 2.

Table 2: Typical evaluation template for a laboratory course

Course Outcome		CE (Weightage: 50 %) 25 Marks				SEE (Weightage: 50 %): 25 Marks
	Assessment Type	Conduction of Lab Exercises	Viva-Voce	Lab Record Submission	Lab Test	SEE

	Component Weightage	10 Marks	05 Marks	05 Marks	05 Marks	25 Marks
CO-1						
CO-2						
CO-3						
CO-4						
CO-5						
CO-6						

10.1.2: Second Assessment and External Review

Each student's work is first assessed by the Course teaching team. All the answer scripts of a given course are to be assessed by a second examiner. 10% of the evaluated scripts will be further reviewed by an examiner who is external to the University. An External examiner will have tenure of 2 years which can be renewed for a further period of 2 years. The first assessor or assessing team is required to fill in the evaluation data and write the Post Module Assessment Report (PMAR).

10.1.2.2: Feedback on Assessed work

The awarded marks and distribution pattern will be reviewed by the Dean of the Faculty before scheduling a face-to-face feedback session with the student. After completing assessment of the course, the course teaching team along with the concerned Head of the Department should provide face-to-face feedback to the student regarding his/her performance after handing over the assessed documents on a prescheduled day. After the feedback, the assessed documents are collected and deposited with the Examination and Assessment Unit of the Faculty.

10.3. Credits not earned in a Course and Opportunities for Make-up:

A minimum of 40 % marks in the assignment and a minimum of 40% marks in the written examination are required for successful completion of a course. A student failing in any one of the components will be declared 'FAILED' in the course. A failed student who has fulfilled the attendance criterion is eligible to re-sit under the fast track scheme.

There is no provision for a re-examination or re-submission of any of the assessment components for a failed course.

A maximum of 3 attempts, including the first attempt, are permitted for successful completion of a course.

11. Academic Awards

Award of Grades: Students will be awarded grades based on the marks scored. The basis for awarding grades is shown in Table 3.

Table 3: Grade Definition and Grade Points

Sl. No.	Marks Scored	Grading	GPA Grade Points
1.	91-100	O (Outstanding)	10
2.	75-90	A+ (Excellent)	9
3.	61-74	A (Very Good)	8
4.	55-60	B+ (Good)	7
5.	50-54	B (Above Average)	6
6.	45-49	C (Average)	5
7.	40-44	P (Pass)	4

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Table 4: SGPA and CGPA calculations for two semesters					
SGPA and CGPA: Sem-1 (All courses excluding 'Consideration Courses')					
Course	**Grade**	**Grade Point (GP)**	**Credit**	**GP * Credit**	
C1	A	8	4	32	**SGPA** = 129/18 = 7.166 = 7.17
C2	B+	7	4	28	
C3	C	5	3	15	
C4	B	6	4	24	
C5	O	10	3	30	
		Total	**18**	**129**	
Cumulative Credits and Grade Point * Credits			**18**	**129**	**CGPA** = 129/18 = 7.17
SGPA and CGPA: Sem-2 (All courses excluding 'Consideration Courses')					
Course	**Grade**	**Grade Point (GP)**	**Credit**	**GP * Credit**	
C10	O	10	3	30	**SGPA = 97/14 = 6.93**
C11	A+	9	3	27	
C12	C	5	4	20	
C13	C	5	4	20	
		Total	**14**	**97**	
Cumulative Credits and Grade Point * Credits			**18 + 14 = 32**	**129 + 97 = 226**	**CGPA** = 226/32 = 7.0625 = 7.10

8.	Below 40	F (Fail/Absent) RS – Re-sit RR – Re-registration	0
'RS' and 'RR' to be considered as 'F' for SGPA and CGPA calculations.			

The SGPA is indicated in the transcript only if all credits prescribed for the semester are earned by the student.

Computation of CGPA:

$$\text{CGPA} = \frac{\sum_1^N \text{Grade points scored in a given course} \times \text{Number of credits for that course}}{\text{Total number of registered credits}}$$

Here, N is the total number of courses registered for in a semester.

Example: Typical SGPA and CGPA calculations for two semesters are shown in Table 4.

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Appendix A

Programme Structure

The Programme consists of four semesters as shown below. A student is required to successfully complete the following courses and earn credits for the award of the degree.

Complete details of each of the courses such as ILO's, content, resources, teaching-learning processes and other related information are outlined in Course Specification of the respective programme.

SEMESTER 1

Sl.No.	Code	Course Title	Theory (h/W/S)	Tutorials (h/W/S)	Practical (h/W/S)	Total Credits	Max. Marks
1	19CMC501A	Advanced Concrete technology and Modern Construction Techniques	3	--	2	4	100
2	19CMC502A	Design of Form Work and Pre-Cast structures	3	1	2	5	100
3	19CMC503A	Construction Planning and Contract Management	3	1	2	5	100
4	19CME51XA	*Refer Elective course table*	4	--	0	4	100
5	19CME52XA	*Refer Elective course table*	4	--	0	4	100
6	19FET508	Research Methodology & IPR	2	--	--	2	50
7	19FET509A	Professional communication	1	--	--	--	--
		Total	**20**	**02**	**06**	**24**	**550**
	Total number of contact hours per week		**28** hours				
	Number of credits can be registered		Minimum	**18**		Maximum	**24**

SEMESTER 2

Sl.No.	Code	Course Title	Theory (h/W/S)	Tutorials (h/W/S)	Practical (h/W/S)	Total Credits	Max. Marks
1	19CMC511A	Construction Economics and Financial Management	4	--	0	4	100
2	19CMC512A	Resource Management in Civil Construction	3	--	2	4	100
3	19CMC513A	Construction Quality and Safety Management	4	--	0	4	100
4	19CME53XA	*Refer Elective course table/Online course/ MOOC*	4	--	0	4	100
5	19CME54XA	*Refer Elective course table/Online course/ MOOC*	4	--	0	4	100

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6	19FET510A	Value Education	1	--	--	0	--
		Total	**20**	**0**	**02**	**20**	**500**
	Total number of contact hours per week		**22** hours				
	Number of credits can be registered		Minimum	**16**		Maximum	**20**

SEMESTER 3

Sl.No.	Code	Course Title	Theory (h/W/S)	Tutorials (h/W/S)	Practical (h/W/S)	Total Credits	Max. Marks
1	19CMP521A	*Internship/ Other activities as specified*	--	--	10	4	100
2	19CMP522A	Group Project	--	--	12	8	200
		Total	**0**	**0**	**22**	**12**	300
Total number of contact hours per week			**22** hours				
Number of credits can be registered			Minimum	**12**		Maximum	**12**

SEMESTER 4

Sl.No.	Code	Course Title	Theory (h/W/S)	Tutorials (h/W/S)	Practical (h/W/S)	Total Credits	Max. Marks
1	19CMP523A	Dissertation and Publication	--	--	24	24	400
Total			**0**	**0**	**24**	**24**	**400**
Total number of contact hours per week			**24** hours				
Number of credits can be registered			Minimum	**24**		Maximum	**24**

Elective Modules List			
Stream / Specialization	**S. No.**	**Module Code**	**Module Title**
Group-1	E11	**19CME511A**	Design of building and allied services
	E12	19CME512A	Management Information System in Construction Engineering and Management
	E13	19CME513A	Risk and Reliability in Civil Infrastructure system

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	E14	19CME514A	Probability and Statistics for Civil Engineers
Group -2	E21	19CME521A	Direct Stiffness method and Finite Element Analysis
	E22	19CME522A	Green construction and Alternative building materials
	E23	19CME523A	Tunnel Engineering
	E24	19CME524A	Advanced Structural Materials
	E25	19CME525A	Construction Firm and Value Engineering
	E26	19CME526A	Big Data analytics
Group -3	E31	19CME531A	Bridge Engineering and Road Projects
	E32	19CME532A	Fire and Safety Engineering Design
	E33	19CME533A	Smart Cities and Sustainable Infrastructure
	E34	19CME534A	Environmental Impact assessment of Construction Projects
Group -4	E41	19CME541A	Condition assessment, repair, rehabilation and Artificial Intelligence
	E42	19CME542A	Circular Economy in Construction Industry
	E43	19CME543A	BIM and fabrication of steel structures
	E44	19CME544A	Advanced quantity surveying in civil engineering

Note:
The Vacations and other activities shall be as per the Timetable for the corresponding batch.

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Appendix B

Course Title	Advanced Concrete Technology and Modern Construction Techniques
Course Code	19CMC501A
Programme	Construction Engineering and Management
Department	Civil Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course deals with concrete, its components, properties and applications. Students will be taught concepts and procedures of concrete mix design. Concreting technologies, special concretes and their applications. Students will be trained to conduct tests on fresh and hardened concrete and evaluate their properties.

This course deals with various construction equipment and technologies adopted in the construction of different components of Civil Engineering structures. Identification, selection, planning and application of construction equipment and scaffolding technology will be discussed. The various techniques and technologies and their applications in the construction of substructures, superstructures and special structures as well as in the rehabilitation, strengthening, demolition and dismantling of Civil Engineering structures will be discussed.

Course Outcomes

After undergoing this module students will be able to:

- **CO 1.** Discuss the properties of fresh and hardened concrete along with the relevant test details
- **CO 2.** Compare and contrast the different technologies involved in manufacture, mix design and placement methods of concrete
- **CO 3.** Apply different codal provisions and prepare mix design of concrete and recommend suitable type of concrete for a given set of conditions
- **CO 4.** Discuss and compare different equipment and construction techniques adopted in the construction of substructures, superstructures and special structures
- **CO 5.** Discuss the retrofitting, dismantling and demolition procedures adopted for existing structures

Course Contents

Unit 1 (Mix Proportioning of Concrete): Principles and methods. Mix Design: Principles of concrete mix design, factors affecting mix design; Methods of concrete mix design- IS method, ACI method, DOE method, Statistical quality control, sampling and acceptance criteria.

Concreting Methods: Process of manufacturing of concrete, methods of transportation, placing, curing; Extreme weather concreting; Special concreting methods; Vacuum dewatering; Underwater concreting

Properties of Concrete: Durability of concrete- introduction, permeability of concrete, chemical attack, acid attack, efflorescence, corrosion in concrete, thermal conductivity, thermal diffusivity, specific heat, alkali-aggregate reaction, IS 456-2000 requirement of durability; Elastic properties.

Creep and shrinkage; Tests on fresh concrete; Tests on hardened concrete- effect of end condition of specimen, capping, H/D ratio, rate of loading, moisture condition, compression, tension and flexure tests, tests on composition of hardened concrete, cement content, original water, cement ratio, NDT tests concepts, rebound hammer and pulse velocity methods.

Special Concretes: Light weight concrete- Introduction, classification, properties, strength and durability, mix proportioning and problems;

High density concrete- radiation shielding ability of concrete materials for high density concrete, mix proportioning, properties in fresh and hardened state, placement methods.

Unit 2 (Ferro cement): Ferro cement materials, mechanical properties, cracking of Ferro cement, strength and behavior in tension, compression and flexure, design of Ferro cement in tension, Ferro cement constructions, durability and applications;
Fiber reinforced concrete- fiber materials, mix proportioning, distribution and orientation, interfacial bond, properties in fresh state, strength and behavior in compression and tension including pre-cracking and post cracking stages, behavior in flexure and shear; Fiber reinforced concrete- mechanical properties, crack arrest and toughening mechanism, applications; High performance concrete- constituents, mix proportioning, properties in fresh and hardened states, applications and limitations; RMC concrete- manufacture, transporting, placing, precautions; Methods of concreting pumping, underwater concrete, shotcrete; High volume fly ash concrete- concept, properties, typical mix;
Self compacting concrete- concept, materials, tests, properties, applications and typical mix; Reactive powder concrete; Bacterial concrete; Fly ash concrete; Sulphur impregnated concrete; Polymer concrete; Geopolymer concrete; Waste material based concrete.

Unit 3 (Construction Equipment and Management): Identification, selection and planning of equipment, equipment management and maintenance, equipment operating cost and cost control of equipment

Unit 4 (Earthwork Equipment): fundamentals of earthwork operations, earthmoving operations; Types of earthwork equipment- tractors- motor graders- scrapers- front end waders- dozers- excavators- rippers- loaders- trucks and hauling equipment, compacting equipment, finishing equipment; Equipment for excavating, dredging and trenching, dragline and clamshells; Tunneling- drilling, blasting equipments; Foundation and pile driving equipment; Erection equipments- cranes; Types of pumps used in construction, equipment for dewatering and grouting
Materials handling equipment-forklifts and related equipment, portable material bins, material handling conveyors, material handling cranes, industrial trucks; Concrete plants- aggregate production, different crushers, feeders, screening equipment, handling equipment, batching and mixing equipment, pumping equipment, ready-mix concrete equipment- concrete pouring equipment; Asphalt plant, asphalt pavers, asphalt compacting equipment; Precast flat panel system, 3D volumetric construction; precast foundations; fabrication of pre-cast and prestressed components; reinforcing steel- bending, placing, splicing and spacing, tendons.

Unit 5 (Substructure Construction): Box jacking, pipe jacking; Under water construction of basement; Tunneling techniques; piling techniques; Driving well and caisson; Sinking cofferdam; Cable anchoring and grouting; Driving diaphragm walls, sheet piles; Laying operations for built-up offshore system, shoring for deep cutting; Large reservoir construction with membranes and earth system, well points; Dewatering and stand by plant equipment for underground open excavation.

Unit 6 (Superstructure Construction): Vacuums dewatering of concrete flooring; Concrete paving technology; Techniques of construction of continuous concreting operation in tall buildings of various shapes and varying sections; Launching techniques; Suspended formwork; Erection technique of tall structures; Large span structures; In-situ prestressing in high rise structures; Post-tensioning of slab; Aerial transporting, handling, erecting light weight components on tall structures.

Unit 7 (Construction of Special Structures): Erection of lattice towers and rigging of transmission line structures; Construction sequence in cooling towers, silos, chimney, sky scrapers; Construction of bow string bridges, cable stayed bridges; Launching and pushing of box decks; Construction of jetties and breakwater structures; Construction sequence and methods in domes; Support structures for heavy equipment and machinery in heavy industries; Erection of articulated structures and space decks.

Unit 8 (Rehabilitation and Strengthening Techniques; Demolition and Dismantling): Seismic retrofitting; Strengthening of columns, Strengthening of slab, strengthening of masonry wall; Protection methods of structures; Mud jacking and grouting for foundation, micro piling and

underpinning for strengthening floor and shallow profile; Sub grade waterproofing; Soil stabilization techniques.

Demolition techniques- demolition by machines, demolition by explosives, advanced techniques using robotic machines, demolition sequence; Dismantling techniques; Safety precautions in demolition and dismantling.

Course Resources

a. Essential Reading

1. Class Notes
2. Shetty M. S.,(2009) Concrete Technology, S. Chand and Co. Ltd
3. Ashby M.F. and JonesD.R.H.H.,(2005) Engineering Materials 1: An introduction to Properties, applications and designs, Elsevier Publications
4. Deodhar S.V.,(2010) Construction Equipment and Job Planning, Khanna Publishers, New Delhi
5. Peter H.E.,(2008) Concrete repair and maintenance illustrated, Galgotia Publications Pvt. Ltd

b. Recommended Reading

1. Aitkens(1999) High Performance Concrete, McGraw Hill
2. Mamlouk M.S. and Zaniewski J.P.,(1999) Materials for Civil and Construction Engineers, Prentice Hall Inc.
3. Peurifoy R.L., Ledbetter W.B. and Schexnayder C.,(2006) Construction Planning, Equipment and Methods, McGraw Hill, Singapore
4. Ataev S. S., (1985) Construction Technology, Mir Publishers, Moscow
5. Allen R. T. and Edwards S. C.,(1993) Repair of Concrete Structures, Blakie and Sons, UK
6. Santhakumar A.R.,(1992) Training Programme notes on Damage Assessment and rLeopwair Co inst Housing, RHDC-NBO Anna University

c. Magazines and Journals

1. ACI Materials Journal, American Concrete Institute
2. Engineering Construction and Architectural Management, Wiley

d. Other Electronic Resources

1. http://nptel.ac.in/

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Course Title	Design of Formwork and Precast Structures
Course Code	19CMC502A
Programme	Construction Engineering and Management
Department	Civil Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course deals with various construction technologies adopted in the construction of different components of Civil Engineering structures. Identification, selection, planning and application of construction formwork and scaffolding technology will be discussed. The various methods, design techniques involved in formwork structures are discussed. Students will also be taught the concepts, classification, planning and design of precast structures.

Course Outcomes

After undergoing this module students will be able to:

- **CO 1.** Compute different types of loads acting on formwork and check for their stability
- **CO 2.** Design formworks for various civil engineering structures
- **CO 3.** Propose suitable construction and scaffolding technology for the construction of special structures
- **CO 4.** Suggest a cost effective solution for usage of equipment, formwork and technology
- **CO 5.** Compare and contrast the different technologies involved in manufacture, mix design and placement methods of concrete
- **CO 6.** Classify and design precast elements

Course Contents

Unit 1 (Planning, Site Equipment and Plant for formwork): Forms for foundations, columns, beams, walls, etc., general objectives of formwork building, overall planning, detailed planning, standard units, corner units, pass units; Calculation of labour constants, labour requirements, formwork hours; Overall programme, detailed programme, costing and planning at tender stage, development of a basic system, planning for maximum reuse;

Planning examples, site layout plan, crane arrangements, recheck plan details, planning for safety, transporting plant, formwork beams, scaffold frames, framed panel formwork, wales and ties, vertical transportable frame work, formwork accessories.

Unit 2 (Materials, Accessories and Proprietary Products): Lumber- types, finish, sheathing ratio, working stresses, repetitive member stress, plywood- types and grades, jointing, boarding, textured surfaces and strength, reconstituted wood; Steel- aluminium- form lining materials, hardware and fasteners, nails in plywood, allowable withdrawal load and lateral load, pressures on formwork, examples; Vertical loads for design of slab forms, uplift on shores, lateral loads on slabs and walls.

Unit 3 (Design Considerations): Live loads and wind pressure, concrete pressure on formwork, concrete density, height of discharge, temperature, rate of placing, consistency of concrete, vibration, hydrostatic pressure and pressure distribution, examples; Adjustment for non standard conditions, basic simplification, beam forms, slab forms, column forms, wall forms, allowable stresses; Check for deflection, bending and lateral stability shear and bearing, examples in each, simple wood stresses, slenderness ratio, allowable load v/s length behavior of wooden shores
Form lining, design tables for wall framework, slab formwork, column formwork, slab props, stacking towers, free standing and restrained; Rosette shoring, shoring tower, heavy duty props.

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Unit 4 (Formwork Design): Shell forms- design considerations, loads, building forms, strength requirements, tunnel forming components, curb and gutter forms, invert forms, arch forms, concrete placement methods; Slip forms- principles, types, advantages, functions of various components, planning, safety in slip forms, special structures built with slipform technique, codal provisions; Types of scaffolds- putlog and independent scaffold- single pole scaffolds, fixing ties, spacing of ties, bracing, knots safety net, general safety requirements, shuttering for precast members and continuous casting forms.

Unit 5 (Building and Erecting the Formwork): Location of job mill, storage, equipment, form for wall footings, column footings, slab on grade and paving work, highway and airport paving, external vibration, prefabricated panel systems, giant forms, curved wall forms, erection practices, column heads, beam or girder forms, suspended forms, concrete joint construction, flying system forms; Causes of failures- case studies, finishes of exposed concrete, design deficiencies, safety factors, stripping sequence, reshore installation, advantages of reshoring

Unit 6 (Concept of Prefabricated Construction): Necessity, advantages, disadvantages, mass produced steel, reinforced concrete and masonry systems, industrial buildings; Concept of modular coordination, basic module, planning and design modules, modular grid systems, National Building Code specifications; Standardization, dimensioning of products, preferred dimensions and sizes, tolerances and deviations, layout and process.

Unit 7 (Prefabricates Classification): Foundations, columns, beams, roof and floor panels, wall panels, clay units, box prefabricates in erection and assembly.
Construction techniques: Large panel system, tunnel system, skeletal system, lift slab system, box system, Equipment for horizontal and vertical transportation.
Precast materials and manufacturing: Dry cast concrete, wet cast concrete, self-compacting concrete, sandwich panel construction, precast light concrete, precast ultra concrete, types of surface finishes, supports and fixing.

Unit 8 (Design of Precast Elements): Basic design considerations, general design procedure for architectural precast concrete cladding units. Joints and connections: Definition, Basic mechanisms, compression joints, shear joints, tension joints, pinned jointed connections, moment resisting connections
Component design: Design of beams, columns, wall panels, slab footings and their lift point systems.

Course Resources

a. Essential Reading

1. Class Notes
2. Peurifoy R. L. and Oberlender, G. D. (1996), Formwork For Concrete Structures, McGraw Hill
3. Sheppard D. A. and Phillips W. R., (1989), Plant - Cast Precast and Prestressed Concrete : A Design Guide
4. Bachmann H., Steinle A., (2011), Precast Concrete Structures, Ernst and Sohn.

b. Recommended Reading

1. Elliot S.K., (2002), Precast Concrete Structures, Butterworth Heinemann
2. PCI Design Handbook Precast and Prestressed Concrete, 6th Edition, PCI Industry Handbook Committee

c. Magazines and Journals

1. Precast Inc Magazine., NPCA
2. Precast Solutions Magazine, NPCA
3. CMA Precast Magazines

d. Other Electronic Resources

2. http://nptel.ac.in/

Course Title	Construction Planning and Contract Management
Course Code	19CMC503A
Programme	Construction Engineering and Management
Department	Civil Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course deals with various aspects of construction project management and their significance. Planning, scheduling and contractual procedures involved in a Civil Engineering project are also dealt. Students will be trained in the usage of computer software dealing with appropriate scheduling and tracking of various activities of a construction project. They will be made familiar with the contract procedures and laws to be followed in the various stages of a construction project.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Discuss the concepts of construction projects, project management functions, Legal and regulatory requirements, and administration of contract
- **CO 2.** Solve scheduling and tracking problems of a construction programme using suitable software
- **CO 3.** Analyze the procedures involved in undertaking technical, financial, economic and ecological feasibility studies for the preparation of construction project reports
- **CO 4.** Evaluate a construction project to develop the scope of work, plan various activities involved in a construction project, and optimize the construction projects using Big-M method
- **CO 5.** Optimize the construction projects using Simplex and transportation techniques
- **CO 6.** Prepare the tendering and contracting documents for infrastructure development projects covering technical, commercial and legal aspects

Course Contents

Unit 1 (Project Management): Construction projects- concepts, project categories, characteristics of projects, project life cycle phases; Project management function-selection of professional services, construction contractors, role of a project manager; Legal and regulatory requirements; Changing environment of construction industry.
Objectives, types of project plans, resource planning process; Project feasibility reports- introduction, significance of feasibility report- technical analysis, financial analysis, economic analysis, ecological analysis, flow diagram for feasibility study of a project; Detailed project report; Different project clearances required; Analysis of risk, different methods, selection of a project and risk analysis in practice.

Unit 2 (Construction Planning): Project formulation, capital investments, generation and screening of project ideas; Project identification, preliminary analysis, market, technical, financial, economic and ecological, prefeasibility report and its clearance; Basic concepts in the development of construction plans, choice of technology and construction method, organizational structure, project management tools, defining work tasks, defining precedence relationships among activities, estimating activity durations, estimating resource requirements for work activities, coding systems; Project control and review.

Unit 3 (Optimization Techniques): Linear, dynamic and integer programming- branch and bound techniques- application to production scheduling, equipment replacement, material transportation and work assignment problems, software applications.

Inventory Models :Deterministic and probabilistic inventory models- software applications

Unit 4 (Scheduling Procedures and Techniques): Construction schedules- Critical Path Method, PERT, scheduling calculations, float, presenting project schedules, scheduling for Activity-on-Node and with leads-lags and windows; Line of Balance and Linear Scheduling Method, resource oriented scheduling, scheduling with resource constraints and precedence, use of advanced scheduling techniques, scheduling with uncertain durations; Calculations for Monte Carlo schedule simulation; Crashing and time cost tradeoffs; Improving the scheduling process.

Unit 6 (Scheduling Applications, Design and Construction Processes): Introduction to software like primavera, P6/ MS Project, for schedule development and tracking; Prolog, data management, RFI's (Request for Information), submittals, product data punch list.
Design and construction as an integrated system, innovation and technological feasibility, innovation and economic feasibility, design methodology, functional design, construction site environment

Unit 7 (Construction Contracts and Tenders): Definitions, essentials for a legally valid contract, salient features of a contract, discharging of a contract; Documents for an engineering contract, International Contract Document, Standard Contract Document; Classification based on tendering process, economic consideration, tasks involved; Main and subcontracts, features, merits, demerits, applicability of various types of contract; Indian Contracts Act, design of contract, laws of torts.
Definitions, list of documents, Earnest Money Deposit, Security Deposit, preparation of enquiry documents; Invitation of tenders and sale of document, preparation of tender documents and its submission, receipt of tender documents and its opening, evaluation of tender from technical, contractual and commercial points of view, contract formation and interpretation
Issues in tendering process: pre-registration, pre-qualification, nominated tendering, rejection of tenders, repeat orders, revocation of tenders, unbalanced bidding, cartel and collusion in tendering; Potential contractual problems, World Bank procedures and guidelines

Unit 8 (Administration/ Performance of Contract): Responsibilities (duties and liabilities) of principal and contractor, monitoring and quality control/ assurance; Settlement of claims, advances, bills, extension of time, extras and variations, cost escalations, retention money, performance bond, liquidated damages, penalties; Statutory requirements, social obligations/ responsibilities, labour welfare, reports, records, files.

Breach of Contract, Dispute Resolution :Definition and classification, common breaches by – principal, contractor, damage assessment, claims for damages, Quantum Meruit, Force Majeure or frustration.
General methods of dispute resolution- negotiation, mediation, conciliation, dispute resolution boards, arbitration, litigation/adjudication by courts; Conciliation- appointment of conciliator, role of conciliator, special features of conciliation; Dispute Resolution Boards(DRB)- constitution of DRB, functioning of DRB, procedure for hearings, status of award; Arbitration- comparison of actions and laws, agreements, module matter, violations, appointment of arbitrators, conditions of arbitrations, powers and duties of arbitrator, rules of evidence, enforcement of award, costs
Formulation of quadratic elements, rectangular elements and higher order elements, isoparametric formulation, stiffness matrices quadrilateral elements.

Legal requirements, International Contracts/ Contracts with International Funding : International competitive bidding, domestic preference, FIDIC document, conditions; Currency of bid and payment, escalation in foreign currency, financing of projects, applicable law and settlement of disputes, international arbitration; Private sector participation:- private sector participation in infrastructure development projects- Build, Operate and Transfer, Build, Operate, Lease and

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Transfer, Build, Own, Operate and Transfer; Technology transfer and foreign collaboration- scope of technology transfer.

Course Resources

a. Essential Reading

1. Class Notes
2. Punmia B.C. and Khandelwal K.K., (2002) Project Planning and Control with PERT and CPM. Firewall Media.
3. Hinze J.,(2001) Construction Contracts, McGraw Hill.

b. Recommended Reading

1. Willis E. M., (1986) Scheduling Construction Projects, John Wiley & Sons.
2. Feigenbaum L., (2002) Construction Scheduling with Primavera Project Planner Prentice Hall Inc.
3. Patil B.S., (2006) Civil Engineering Contracts and Estimates, Universities Press (India) Private Limited.
4. Prakash V. A., (1997) Contracts Management in Civil Engineering Projects, NICMAR.
5. John G. B., (1993) Engineering Contracts, McGraw Hills.
6. Vasavada B. J., (1997) Engineering Contracts and Arbitration, Self Publication by Jyoti Vasavada

c. Magazines and Journals

1. Engineering Construction and Architectural Management, Wiley
2. Project Management Journal, Project Management Institute

d. Other Electronic Resources

1. http://nptel.ac.in/

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Course Title	Design of Building and Allied Services
Course Code	19CME511A
Programme	Construction Engineering and Management
Department	Civil Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course aims to give an overview of the various building services and the architectural requirements for their accommodation in buildings. The students will be introduced to basic calculations for sizing the systems' components for incorporation in building design, standards and codes relating thereto. Students will be familiarized with sustainable principles of building services with a focus on efficiency of design, installation and operation. The course culminates in a module wherein Integrated Building Management, operation of service systems and building performance modelling through Intelligent Systems shall be the focus.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Explain the concepts of Planning, analysis and design of buildings
- **CO 2.** Discuss the sewage, storm water drainage and wastewater treatment systems
- **CO 3.** Discuss Electrification, Lighting & Acoustics for buildings
- **CO 4.** Design mobility, air-conditioning and sewerage systems for buildings
- **CO 5.** Analyse and Design all the structural components of building

Course Contents

Unit 1 (Structures): Design of a building involving a high level of services and advanced structural systems e.g. A hospital, hotel, housing, sports facilities, long span structure etc. Besides Architectural Design, the choice may be Interior Design, etc. Planning, analysis and design of different structures. Load calculations, wind analysis, seismic analysis.

Unit 2 (Water, Waste & Sanitation):

Water Supply: Introduction to water resources; collection, processing, distribution and storage of water; calculation of water demand and consumption; sizing of storage tanks and water quality standards for code compliance, importance of water conservation

Water Distribution: Service connections and systems of hot and cold water supply; plumbing networks; sanitary fixtures, fittings, valves and pipes, dual-plumbing systems.

Wastewater systems: Systems and components for sewage and storm water drainage; wastewater treatment systems and septic tanks; building and site planning for water drainage and sewage disposal; water harvesting and water recycling; solid waste collection, segregation and disposal.

Unit 3 (Electrification, Lighting & Acoustics):

Electricity: Electrical distribution and safety systems in buildings; fixtures, equipment, and appliances; electrical circuitry and internal wiring; electrical loads, peak demand, operational costs; **Communication:** Intercoms, Wi-Fi, broadband data cabling, and CCTV systems

Lighting: Lighting principles, luminance and glare; lighting systems and types of luminaires; lighting design and layouts; architectural lighting and special effects; integration with day-lighting and energy conserving strategies

Acoustics: Basic concepts of sound and acoustics; sound insulation and transmission; absorption, reverberation, noise control and attenuation; acoustical requirements for different space types and design planning; site planning for noise control

Inventory Models :Deterministic and probabilistic inventory models- software applications

Unit 4 (HVAC, Mechanised Mobility & Fire Safety):

Air-conditioning: Principles and components of mechanical ventilation and air-conditioning systems; calculation based on design conditions and system sizing, design considerations for chiller rooms, cooling plants, AHUs; integration with natural ventilation, and other energy conserving technologies.

Fire Safety: Fire sources, spreading, and growth decay curve; material fire response and fire retardant materials; fire hydrants, fire escapes, refuge areas, fire tender access; smoke detector, alarm, and sprinkler systems; representation of fire considerations in drawings.

Mobility Systems: Lifts, escalators, conveyors, and travolators; sizing of space for lifts and other mobility systems; construction and installation; design and operation of automated parking systems.

Course Resources

a. Essential Reading

1. Class Notes
2. G.M.Fair & J. C. Geyer, Water Supply and Waste disposal, John Wiley and sons, New York.
3. E.B Phelps &C.J. Velj, Public Health engineering, John Wiley and sons, New York.
4. F.C.Mcquiston, J.DParker and Jeffrey.D.Spitler,(2001) Heating, ventilating and air conditioning- Analysis and design-John Wiley and sons
5. R.W.Hines and D.C.Hittle, (2006) Control system for heating, ventilating and air conditioning- (6th Edition)springer

b. Recommended Reading

1. Air-conditioning Principles and systems, PHI Learning Private Limited
2. Carrier Hand Book Trane manual on design HVAC systems ASHRAE standards (1997) Engineering Contracts and Arbitration, Self Publication by Jyoti Vasavada

c. Magazines and Journals

3. Journal of Structural Engineering, CSIR-Structural Engineering Research Centre,
1. ACI Structural Journal, ACI Structural Journal American Concrete Institute, 38800 Country ClubDr.FarmingtonHills,MI48331-34349 USA

d. Other Electronic Resources

1. http://nptel.ac.in/

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Course Title	Management Information System in Construction Engineering
Course Code	19CME512A
Programme	Construction Engineering and Management
Department	Civil Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

The aim of this course is to provide understanding of the fundamentals of information management and the impact of information technology (IT) on construction projects. In particular, the student will learn what information is and what modern managers need to understand about their organization, their employees and technology to best manage information for operational, tactical and strategic benefits.

This course also provides knowledge on use of contemporary tools and approaches for information handling in construction industry. Understand the information requirements of any type of organization in construction industry. Basic terms, tools and processes in developing an information system will be discussed. A roadmap to implement project management information system in construction industry will be elaborated using case studies.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Discuss the importance of management information system in improving performance of construction project
- **CO 2.** Discuss the functions of and the differences among various types of information systems and technologies in construction industry.
- **CO 3.** Analyse data in construction, data base systems: how they function, how they are used, when they are used, and why they are used.
- **CO 4.** Develop an implementation framework of Management information systems for construction industry.
- **CO 5.** Apply ethical and social factors in development of information systems.

Course Contents

Unit 1 (Information systems, organization and management): Importance of Management Information Systems (MIS), Information management for the construction industry, Levels of management, Manger's View of Information systems, Functions of Management, managerial role. Challenges with information flow in the construction industry, Poor information management, characteristics or aspects of information system, process of information management.

Organization structure, spread and relevance of information within the organization, Influence of information on various levels within the hierarchy, nature of Information system at various levels, specifications of Information, integration of IS and Management, impact of information on organization at various levels.

Unit 2 (Enhanced Decision making): Decision making process in construction industry in Construction Industry, Role of IS in decision making, Various types of information systems - TPS (Transaction Processing System), MIS (Management Information System), DSS (Decision Support System) and ESS (Executive Support System), Comparison Concepts and Knowledge representation. DSS and business intelligence, expert systems, emerging trends in DSS (data warehouse/data mining, RFID, cloud computing, social networks), Application of IS in construction management.

Information technology

Information Technology, Information technology act 2000, Role of Information Technology in Construction Industry, Impact of Information Technology on the Individuals, Impact on the

Construction Organization and Process of Reengineering Work, contract: the essence of digital contracts, law of contract, construction of e-contracts.

Unit 3 (Data management): Data, information and knowledge, Role of data in construction project management, type of data, data sources, database concepts, Data Base management systems, managing data resources, Transactional processing system, traditional file system, database system, data structures, entity and relationships, database design, Information modelling, Entity–Relationship-based information modelling.

Unit 4 (PMIS): Information management in construction industry, ISO 19650 - concepts, processes for Project Delivery Design of Project Management Information System, Functional Areas, construction project cost database, MIS implementation in construction project management, Introduction to management project control system (MPCS) – tendering system, scheduling, monitoring, MIS, web based information system, BIM based IS, Enterprise resource planning (ERP), integrated and control information system for construction enterprise, Integrated Construction Management information system, role of AI in information management, Application of AI techniques, Case studies.

Unit 5 (Ethical and social issues in IS): Understanding ethical and social issues related to systems, ethics in an information society, the moral dimensions of information systems.

Course Resources

a. Essential Reading

1. Class Notes
2. Avison, D., Torkzadeh, G.(2008). Information Systems Project Management, Sage Publication.
3. Alkhaldi, A, N. (2019). Project Management Information Systems: A Hand Book for Managing Projects' Information, Environment and Software Management Information Systems. United Scholars Publications, USA.

b. Recommended Reading

1. Kenneth, C,L.,Jane, P.L. (2018). Management Information System. ; 15th edition, Pearson Education.
2. O'Brien, J,A., Marakas,G,M.,Behl, R.(2017). Management Information Systems, 10th edition, McGraw Hill Education.

c. Other Electronic Resources

1. Electronic resources on the module area are available at MSRUAS library

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Course Title	Risk and Reliability in Civil Infrastructure system
Course Code	19CME513A
Programme	M.Tech in Construction Engineering and Management
Department	Civil Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course is to provide basic and advanced skills and tools of risk and reliability in engineering. This course emphasizes on the application and the reasoning behind application of these skills and tools for the purpose of enhancing engineering decision making. Many current trends present challenges and opportunities to the field of risk and reliability analysis. At the narrowest level, structural engineering practice is beginning to adopt explicit probabilistic bases for the design of conventional facilities like new performance-based design seismic criteria that consider a range of damage levels and their likelihoods and to demand improvements to them.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Discuss the concepts and principals of risk and reliability engineering and their potential applications to different engineering problems.
- **CO 2.** Discuss and assess appropriate approaches to the collection and interpretation of data in the application of risk and reliability engineering methods
- **CO 3.** Apply appropriate techniques and tools for qualitative and quantitative risk analysis and reliability assessment,
- **CO 4.** Analyse and evaluate failure distributions, failure likelihood and potential consequences, and develop solutions for control/mitigation of risk
- **CO 5.** Recommend techniques of overcoming risk in various domains of construction using reliability engineering Recognize the scope for finite element analysis in civil structural design

Course Contents

Unit 1 Introduction and Fundamentals of risk and reliability engineering:
Basic concepts, background review, theory of elasticity, energy concepts, equilibrium and energy methods for analyzing structures.

Unit 2 Review of Basic probability theory and statistics:
Introduction; Definition of probability; Conditional probability and bayes' rule; Introduction to descriptive statistics; Numerical summaries; Graphical representations; Introduction to Engineering Uncertainity modelling; Uncertainities in Engineering Problems; Random variable, random processes and extremes; Engineering model building, probability distribution selection, estimation of distribution parameters.

Unit 3 Bayesian Decision Analysis:
Introduction, The decision/Event tree; decision based on Expected values; Decision making subject to uncertainty; Decision analysis with given/additional/unknown information –Prior/Posterior/Pre-posterior Analysis; Risk treatment Decision problem.

Unit 4 Risk Assessment in Civil Engineering:
The JCSS framework for Risk Assessment in Engineering; System Modeling; Assessment of risk; System Identification; tools for Risk analysis

Unit 5 Elements of classical reliability theory:
Introduction; failure rate data for various systems; reliability analysis for static components

Methods of structural reliability analysis:
Failure events and basic random variables; linear limit state functions and normal distributed variables; Error accumulation law; Non-linear state functions; Correlation and dependant random

variables; Non-normal and dependant random variables; software for reliability analysis; Assessment of partial safety factors by FORM Analysis; Simulation methods

Unit 6 Probablistic modeling:

Probabilistic modeling in construction engineering; Time variant reliability analysis; system reliability analysis - classic example; Bayesian probabilistic nets in Risk Assessment; Risk based assessment and inspection – classic examples; Risk acceptance and life safety in decision making

Course Resources

a. Essential Reading

1. Class Notes
2. Faber M. H., (2007), Risk and Safety in Civil Engineering, Swiss Federal Institute of Tehnology
3. Vijay S., Sharad J., Aditya T., (2007), Risk and Reliability Analysis: A Handbook for Civil and Environmental Engineers, American Society of Civil Engineers

b. Recommended Reading

1. Naiwei Lu., (2019) Risk and Reliability in Structural Engineering , Momentum Pr
2. Mohammad M , Mark P. K., Vasiliy K, (2017), CRC Press, Taylor and Francis group

c. Other Electronic Resources

1. http://nptel.ac.in/
2. Electronic resources on the module area are available at MSRUAS library

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Course Title	Probability and Statistics for Civil Engineers
Course Code	19CME514A
Programme	M.Tech in Construction Engineering and Management
Department	Civil Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course deals with understanding the use of statistical tools to express the traffic data for better interpretation. Apply probability concept to understand the vehicular flow behavior helping the planners to predicttraffic flow. Use appropriate statistical testing tools to check the degree of accuracy in the traffic data analysis.Test the hypothesis and assess the error involved in the data analysis.Use software tools like MATLAB, MINITAB etc., for analysis of traffic data and also use curve fitting techniques for predicting the performance trends.

Course Outcomes

After undergoing this course students will be able to:

CO 1. Use statistical tools to express the traffic data for better interpretation.
CO 2. Apply probability concept to understand the vehicular flow behavior helping the planners to predict traffic flow.
CO 3. Use appropriate statistical testing tools to check the degree of accuracy in the traffic data analysis.
CO 4. Test the hypothesis and assess the error involved in the data analysis.
CO 5. Use software tools like MATLAB, MINITAB etc., for analysis of traffic data and also use curve fitting techniques for predicting the performance trends.

Course Contents

Unit 1

Introduction to statistical methods, scope aim and limitations, sample, attribute and types of data, sources and collection of data. Accuracy of data. Representation and summarizing data. Frequency distribution, histogram and frequency curves. Ogive curve, Measure of central tendency – arithmetic mean,median and mode dispersion- range, standard deviation, variance and co-efficient of variation, skewness and kurtosis.

Unit 2

Introduction to probability & statistics for Traffic Engineering Design –Introduction, Random variables and statistical measures: arithmetic mean, measures of dispersion, basic laws of probability, probability laws for discrete random variables: binomial and Poisson distribution, probability laws for continuous random variables: normal distribution, Poisson distribution.

Unit 3

Sampling Techniques – objective, basics of sampling, advantages of sampling, sampling techniques, sampling distributions – sampling distribution of the sample mean, central limit theorem, chi square, t and F – distributions. Sampling error, sample size and design.

Unit 4

Statistical decisions – point estimation, properties of parameters, Testing of Hypothesis – Type I and II errors. Tests of significance – tests for mean and variance. Tests for proportions.

Unit 5

Chi-square test of goodness of fit, student's t test, Confidence interval. Curve fitting by the method of least squares, Linear correlation & regression, multiple linear regression. Analysis of variance Use of soft-wares in statistical analysis – MATLAB, MINITAB

Course Resources

a. Essential Reading

1. Martin Wohl, Brian V Martin, "Traffic System Analysis"- Mc Graw Hill Series
2. Johnson R and G Bhattacharya, "Statistics – Principles and methods"- John Wiley & sons, New york, 1985
3. Medhi, "Introduction to statistics"- New Age Pub, New Delhi
4. Benjamin Jack R and Cornell C Allin, "Probability Statistics & Decisions for Civil Engineers"- McGraw Hill Co.

b. Recommended Reading

1. Agarwal, B.L, "Basic Statistics"- 3rd edition, New Age Pub. New Delhi.
2. L.R Kadiyali, "Traffic Engineering"- Khanna Publishers New Delhi

c. Magazines and Journals

1. International Journal of Traffic Engineering

d. Other Electronic Resources

1. http://onlinepubs.trb.org/onlinepubs/archive/mepdg/home.htm

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Course Title	Direct Stiffness Method and Finite Element Analysis
Course Code	19CME521A
Programme	M.Tech in Construction Engineering and Management
Department	Civil Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course is intended to prepare students to solve structural problems using finite element methods. Basic procedure, meshing, Interpolation models, shape function and theory of isoparametric elements will be discussed. Application and formulation of finite element methodology to solve one dimensional, two dimensional, three dimensional elements and Jacobian matrix will be taught. Students will be trained to use FEM packages to solve complex problems and to develop computer algorithms, flow charts, simple computer program for the analysis of 2D structures. This module also deals with the finite element formulation of axisymmetric element and its applications.

Course Outcomes

After undergoing this course students will be able to:

CO 1.	Describe basic concepts, background review, theory of elasticity, energy concepts, equilibrium, energy methods for analyzing structures concepts of discretization and element formulation for finite element analysis
CO 2.	Recognize the scope for finite element analysis in civil structural design
CO 3.	Develop Interpolation models and shape functions in generalized and natural coordinates for 1D, 2D, 3D elements and axisymmetric elements
CO 4.	Model and analyse manually 1D and 2D structures
CO 5.	Compare and contrast analyses structures by using different elements

Course Contents

Unit 1 Introduction FEA:
Basic concepts, background review, theory of elasticity, energy concepts, equilibrium and energy methods for analyzing structures.

Unit 2 Matrix displacement formulation, introduction to direct stiffness method, local and global co-ordinate system, transformation of variables, transformation of the member displacement matrix, transformation of the member force matrix, transformation of the member stiffness matrix, transformation of the stiffness matrix of the member of a truss, transformation of the stiffness matrix of the member of the rigid frame, overall stiffness matrix, boundary conditions, computation of internal forces. Analysis of trusses and continuous beams by direct stiffness method.

Unit 3 Approximate method of structural analysis, Raleigh - Ritz Method, Galerkin's method application in structural analysis, finite difference method and finite element method. Principles of finite element method, finite element procedure, engineering applications of finite element method, advantages and disadvantages.
Euler's Lagrange's equations of bar, beams, principal of a minimum potential energy, principle of virtual work, principle of Varian's, variation method and minimization of energy approach of element formulation.

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Unit 4 Basic Procedure:
Discretization process, types of elements 1D, 2D and 3D elements, simplex, complex and multiplex elements, size of the elements, location of nodes, node numbering scheme, half bandwidth, properties of stiffness matrix, preprocessing, post processing.

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Finite elements used for one, two & three dimensional problems, element aspect ratio, mesh refinement vs. higher order elements, numbering of nodes to minimize band width.
Meshing:
Higher order elements, p and h methods of mesh refinement, ill conditioned elements, discretization errors, auto and adaptive mesh generation techniques, error evaluation.
Interpolation models:
Selection of the order of the interpolation polynomial, convergence requirements, 2d Pascal triangle, nodal displacement parameters, convergence criterion, compatibility requirements, geometric invariance.
Shape function:
Polynomial form of interpolation functions- linear, quadratic and cubic, linear interpolation polynomials in terms of global coordinates of bar, triangular (2D simplex) elements.
Linear interpolation polynomials in terms of local coordinates of bar, triangular (2D simplex) elements, CST element. Lagrange's shape functions in generalized and natural coordinates, serendipity family of elements, and Hermitian polynomials.

Unit 5 Theory of isoparametric elements:
Isoparametric, sub-parametric and super- parametric elements, characteristics of isoparametric elements, validity of isoparametric elements, numerical integration, Jacobian transformation matrix.

Unit 6 1- D element formulation and its applications:
Mathematical modeling of 1-D element for characteristics evaluation, extraction of shape functions in natural and global co-ordinates for higher order bar elements.
Derivation of element stiffness matrices and load vectors, under axial loading, concentrated and distributed loads for bar element.
Solution of bars, stepped bars, plane trusses for displacements, reactions and stresses by using elimination approach, penalty approach. Derivation of element stiffness matrices and load vectors for concentrated and distributed loads for beam element.
Application of FEM to analysis of continuous beams and frames, stiffness of truss members, analysis of truss, and stiffness of beam members, grid members, and finite element analysis of continuous beam, plane frame, grid and space frame.

Unit 7 2-D element formulation and applications:
Plane -stress and plane-strain problems, formulation of triangular element and its higher orders, constant strain triangle, linear strain triangle, isoparametric formulation for triangular elements, stiffness matrices.
Formulation of quadratic elements, rectangular elements and higher order elements, isoparametric formulation, stiffness matrices quadrilateral elements.
Computation of Jacobian matrix, consistent load vector, stresses and strains for 2D elements. Need for mesh quality checks and their effect on analysis, computer algorithms, flow charts, simple computer program for the analysis of 2D structures.

Unit 8 3-D element formulation and applications:
Finite element formulation, hexahedral elements and higher order elements, element stiffness, force terms, stress calculations, problems on modeling.
Axisymmetric cases:
Finite element formulation of axisymmetric element, derivation of the stiffness matrix, stress calculations, finite element formulation for 3 dimensional elements, applications of axisymmetric elements.

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Course Resources

a. Essential Reading

1. Class Notes
2. C.S. Krishnamoorthy,(2011) Finite Element Analysis, Tata McGraw-Hill
3. David V. Hutton,(2003) Fundamentals of Finite Element Analysis, McGraw-Hill
4. Daryl L. Logan,(2014) A First Programme In the Finite Element Method, University of Wisconsin–Platteville
5. S S Bhavikatti,(2010) Finite Element Analysis, New age international Pvt. Ltd.

b. Recommended Reading

1. D. Maity,(2007) Computer Analysis of Framed Structures, I. K. International Pvt. Ltd.
2. New Delhi
3. Erik G. TDhompson, (2004) Introduction to the Finite Element Method: Theory, Programming and Applications, John Wiley
4. H. C. Martin and G. F. Carey,(1979) Introduction to Finite Element Analysis - Theory and Application, NewYork, McGraw-Hill
5. Irving H. Shames, Clive L. Dym,(1995) Energy and Finite Element Methods in Structural Mechanics; New Age International
6. K. J. Bathe,(2007) Finite Element Procedures, Prentice-Hall of India, New Delhi, India

c. Magazines and Journals

1. Journal of Structural Engineering, CSIR-Structural Engineering Research Centre, CSIR Campus, Chennai
2. ACI Structural Journal, ACI Structural Journal American Concrete Institute, 38800 Country Club Dr. Farmington Hills, MI48331-34349 USA

d. Other Electronic Resources

1. http://www.sciencedirect.com
2. Electronic resources on the module area are available at MSRUAS library

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Course Title	Green construction and Alternative building materials
Course Code	19CME522A
Programme	Construction Engineering and Management
Department	Civil Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This module emphasizes on green building delivery and life cycle which includes need analysis, building planning, design review and post-occupancy evaluation. The students are taught building design which involve ecology, architecture, community health and building environment aspects. Sustainability in building resources like alternate and green building materials and processes are also dealt.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Discuss the green concepts, components of sustainable design and construction, modern, green and alternate building materials.
- **CO 2.** Discuss building economics and cost effective design for green construction
- **CO 3.** Apply sustainable techniques in planning and execution of construction projects
- **CO 4.** Compare and contrast different equipments and construction techniques adopted in the construction of substructures, superstructures and special structures
- **CO 5.** Compare and choose different alternate building materials and technologies suitable for a particular construction project
- **CO 6.** Design green building and construction process

Course Contents

Unit1 Introduction: Energy in building materials, Impact of Energy and Atmosphere, Environmental issues concerned to building materials, Global warming and construction industry, Environmental friendly and cost effective building technologies, Requirements for building of different climatic regions, Traditional building methods and vernacular architecture.

Unit 2Introduction to Green Construction: Green Concepts and Vocabulary, Components of Sustainable Design and Construction, Green Design and the Construction Process, Building Information Modeling, Indoor Environment Quality, Water Efficiency and Sanitary Waste, Indian Green Building Council (IGBC) certification.

Unit3Green Design, analysis and documentation: Green Design and Building Economics, Green Project Cost Monitoring and Closeout, Green Project Commissioning, Project Cost Analysis, Green Specifications and Documentation, Types of Building Contract Agreements, Green Business Development, Building Green Litigation and Liability Issues

Unit 4 Modern Construction Materials: Types of steel and their properties, advantages of new alloy steels- properties and advantages of aluminum and its products, types of coatings and coatings to reinforcement, application of coatings; Types of plastics, non-weathering materials and their uses; Types of flooring and façade materials and their applications; Construction chemicals - Types and properties of water proofing compounds, sealants, engineering grouts, mortars, admixtures and adhesives; Smart materials- types and differences between smart and intelligent materials, special features, case studies showing the applications of smart and intelligent materials.

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Unit 5 Green and Alternative Building Materials: Green Building Materials and Products, Characteristics of building blocks for walls, Stones and Laterite blocks, Bricks and hollow clay blocks, Concrete blocks, Stabilized blocks: Mud Blocks, Steam Cured Blocks, Fal-G Blocks and Stone Masonry Block. Lime-Pozzolana Cements: Raw materials, Properties and uses, manufacturing process
Fibre reinforced plastics, Matrix materials, Fibers : organic and synthetic with its properties and applications, Building materials from agro and industrial wastes, Types of agro wastes, Types of industrial and mine wastes with its properties and applications, Field quality control test methods.

Unit6. Equipment for Production of Alternative Materials: Equipment for production of stabilized blocks, Moulds required, and methods of production of precast elements.

Unit 7. Alternative Building Technologies: Alternative for wall construction – types, construction methods, Masonry mortars – types, preparation and properties, Alternative roofing systems – concepts, filler slab, Composite beam panel roofs, Masonry walls and domes.

Unit 8. Cost Effective Building Design: Cost concepts in buildings, Cost saving techniques in planning, design and construction, Cost Analysis: Case studies using alternative materials and processes.

Course Resources

a. Essential Reading

1. Class Notes
2. Kubba S., (2012) Handbook of Green Building Design, and Construction, Butterworth-Heinemann
3. Sabnis G. M., (2012) Green Building with Concrete: Sustainable Design and Construction, CRC Press Deodhar S.V.,(2010) Construction Equipment and Job Planning, Khanna Publishers, New Delhi

b. Recommended Reading

1. Cheshire D., (2016) Building Revolutions: Applying the Circular Economy to the Built Environment, RIBA Publishing
2. Hall K., (2008) The Green Building Bible Volume 1 & 2, Green Building Press
3. Johnston D., Gibson S., (2008) Green from the ground up: a builder's guide : sustainable, healthy, and energy-efficient home construction, Taunton Press

c. Magazines and Journals

1. ACI Materials Journal, American Concrete Institute
2. Engineering Construction and Architectural Management, Wiley

d. Other Electronic Resources

1. http://nptel.ac.in/

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Course Title	**Tunnel Engineering**
Course Code	**19CME511A**
Programme	**M.Tech in Construction Engineering and Management**
Department	**Civil Engineering**
Faculty	**Faculty of Engineering and Technology**

Course Summary

Obstacles along an alignment of a transportation mode has always been a challenge for a transportation engineer. This course emphasizes on the the general aspects of transportation tunnels, Planning, Design, Construction and Maintanace of transportation tunnels.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Disssus the general aspects of tunnel components
- **CO 2.** Discuss the methods and stages in tunneling
- **CO 3.** Design and construct the tunnel components
- **CO 4.** Discuss about the safety norms and maintenance measures in transportation tunneling

Course Contents

Unit 1 General Aspects of Tunnel Engineering:

General, Categories of obstacles, definitions, Advantages and Disadvantages of tunnels and open cuts, History of constructed tunnels, Developments in tunneling methods, Economics of tunneling, Classification of tunnels, Tunnel approaches, Metro tunnels.

Unit 2 Stages in tunnel construction:

Investigations, Setting out of tunnel, Excavation, Blasting, Temporary and Permanent supports, Ventilation during construction, Mock removal, Supplementary operations, Design of shape and size.

Unit 3 Soil Classification and Tunnelling Methods:

Soil classification, Choice of method, Methods of tunneling in soft soils-Forepoling, Needle beam, Army, American, English, Belgian, German, Austrian, Timbering in soft soil tunneling, Other popular methods of tunneling in soft soil.

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Unit 4 Tunnelling in Water Bearing Soils:

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General, Well points system, Plenum process or compressed air method, Pipes and conduits, Tunneling equipments, Methods.

Unit 5 Tunnelling in Rocks:

General, Sequence and faces of operations, Methods, Mucking, Hauling, General aspects, Drill bits, Nipper cars, Explosives, Safety precautions.

Unit 6 Shafts:

General, Advantages, Sizes and location, Construction in soft and hard startas, Supports, Protection, Classification.

Unit 7 Tunnel Lining, Drainage and Maintanance:

Tunnel Lining:

Necissity, Objectives, Materials, Thickness design, Sequence of lining.

Tunnel Drainage:

General, Pre-drainage, Dewatering, Permanent drainage

Inspection and maintenance of tunnels

Unit 8 Tunnel Ventilation, Lighting and Health Protection:

General, Temporary and Permanent ventilation, Dust prevention, Lighting, Safety measures, Health protection

Course Resources

a. Essential Reading

1. Class Notes
2. Harbour Dock and Tunnel Engineering, R. Srinivasan, Charotar Publications
3. Transportation Tunnels, S. Ponnuswamy and D Johnson Victor, Oxford and IBH Publications

a. Recommended Reading

1. "The Art of Tunnelling" by K Szechy
2. "TUNNEL ENGINEERING HANDBOOK" by John O Bickel
3. "Handbook Of Tunnel Engineering Ii: Basics And Additional Services For Design And Construction" by Ulrich Maidl

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4. "Roads Railways Bridges Tunnels Engineering" by T D Ahuja
5. "Handbook Of Tunnel Fire Safety" by Alan Beard

b. Other Electronic Resources

2. Electronic resources on the subject area are available at MSRUAS library
3. Journal Of Tunnel Engineering, JSCE

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Course Title	Advanced Structural Materials
Course Code	19CME524A
Programme	Construction Engineering and Management
Department	Civil Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course explores the materials science of structural materials, and attempts to bring about the understanding of material behaviour from a fundamental perspective. The behaviour of various types of advanced materials used in the construction engineering is discussed. The course also focusses on fibre reinforced plastics, smart materials and durability and deterioration of concrete structures.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Discuss the different types of advanced structural materials used in building construction
- **CO 2.** Discuss the application of fibre reinforced plastics and smart materials in engineering structures
- **CO 3.** Develop and design high strength, high density and high performance concrete mix
- **CO 4.** Discuss the microstructure of cementatious materials and durability and deterioration of concrete structures
- **CO 5.** Compare and choose different structural materials and technologies suitable for a particular construction project
- **CO 6.** Recommend technologies for production of advanced structural materials for engineering construction

Course Contents

Unit 1:
Introduction: types of concrete and cementatious materials, Types of steel and their properties, advantages of new alloy steels, Types of plastics, non-weathering materials

Unit 2 :
Special Concretes: Definition & Introduction, General properties, Advantages, Disadvantages, Applications, High density concrete, Shrinkage compensating concrete, Mass concrete, Roller compacted concrete. Light weight concrete, High strength concrete, Ultra-high strength concrete (reactive powder concrete). High performance concrete.

Unit 3:
Fibre Reinforced Plastics in construction (FRP): Introduction, types, uses, properties, manufacturing, advantages and disadvantages. Types of fibres and components of composite materials

Unit 4 :
Smart Construction Materials: Introduction, types of smart materials- shape memory alloys, magnetostrictive materials, piezoelectric materials, electrorheological fluids, Electrochromic materials, smart concrete and application of smart materials

Unit 5:
Microstructure of cement based materials – Identification and detection of hydrated compounds using specialized techniques including FTIR, TGA, XRD, XRF, NMR, SEM, Optical microscopy, Calorimetry and several others. Relationship between microstructural parameters such as porosity, permeability, pore structure of concrete with associated properties

Unit 6 :

Durability and deterioration of concrete structures: Definitions, Deterioration processes – Physical, Chemical, Environmental & Biological; Measures for ensuring durability, Corrosion of reinforcing steel, protective measures.

Course Resources

a. Essential Reading

1. Class Notes
2. Sabnis S.P. Arora & S.P. Bindra, A Text Book of Building Construction, Dhanpat Rai & Sons, New Delhi., 2010
3. Sheety, M.S, Concrete Technology, Theory and Practice, S. Chand and Company Ltd, New Delhi, 2008

b. Recommended Reading

1. Gambhir, M.L, Concrete Technology, Tata McGraw – Hill Publishing Company Ltd, New Delhi, 2013
2. Pijush Samui, Dookie Kim, New Materials in Civil Engineering, Butterworth-Heinemann, Elseveir, 2020
3. Lawarence C. Bank,Composite for Construction: Structural Design with FRP Materials, John Wiley & Sons, INC., New Jersey.
4. Concrete: Microstructure, properties and materials, P.K. Mehta and P.J.M. Monteiro, McGraw Hill, 2556.

c. Other Electronic Resources

1. Electronic resources on the module area are available at MSRUAS library

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Course Title	Construction firm and Value engineering
Course Code	19CME525A
Programme	Construction Engineering and Management
Department	Civil Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course allows students to develop the knowledge, understanding and skills required to undertake the Value Engineering process with a focus on the managing construction projects. The Value Engineering (VE) process is a systematic and creative method used to increase the value of a product or service. It is a technique used to reduce the cost of a product or service while retaining quality, reliability and safety. This course incorporates a mix of theory and practical sessions to ensure students have the opportunity to apply the tools and techniques being presented.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Discuss various type of organizations and roles of engineers in typical construction project.
- **CO 2.** Discuss various techniques in value engineering to increase value of the project.
- **CO 3.** Analyze and evaluate solution alternatives based on value engineering principles
- **CO 4.** Apply value engineering techniques to reduce cost of the project.
- **CO 5.** Create value engineering programs for effective management of construction projects.

Course Contents

Unit 1 (Construction organization): Various types of organization, organization structure, role, responsibilities, functions, qualifications, contribution of each staff (client, consultant, other external bodies, and contractor).

Unit 2 (Value engineering introduction): Introduction to Value Engineering and Value Analysis, objectives of VE, conventional vs VE approach, VE organization chart reasons for unnecessary costs, when to apply VE, Methodology of V.E., Quantitative definition of value, Use value and prestige value

Unit 3 (Principles of VE): Classification of functions, concept of cost, value and worth. Functions, cost and worth of functions, Effect of value improvement on profitability.

Unit 4 (VE techniques): FAST technique, ABC analysis, process mapping, Group Decision Support System (GDSS), Interactive Value Management System (IVMS), Constructability review, lean principles, IPD, life-cycle costing, Evaluation of value alternatives, criteria/importance weighting and matrix analysis, Sensitivity analysis, Utility transformation functions, Fast diagramming, Critical path of functions, DARSIRI method of value analysis.

Unit 5 (VE application in construction): Introduction to V.E. job plan / Functional approach to value improvement, various phases and techniques of the job plan, integrated VE – design ,construction, operation and maintenance. Value savings during construction.

Unit 6 (Value engineering program management): Value engineering requirements, Key stakeholders, VE Program intent, VE consultant selection, Training and qualifications of VE Engineers, VE change proposal, VE Program Implementation and Management, Case studies in Value engineering

Course Resources

a. Essential Reading

1. Class Notes
2. Kelly, J., Male, S., Graham, D. (2010). Value Management of Construction Projects, Wiley.

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3. Connaughton, N.J., Green, S.D. (1996). Value Management in Construction: A Client's Guide. Construction Industry Research & Information Association (CIRIA)
4. Dell'Isola,A. (1997).Value Engineering: Practical Applications...for Design, Construction, Maintenance and Operations, Wiley.

b. Recommended Reading

1. Thiry, M. (2013). A Framework for Value Management Practice. Project Management Institute.
2. Ray R. Venkataraman, Jeffrey K. Pinto. (2008). Cost and Value Management in Projects, Wiley.

d. Other Electronic Resources

1. Electronic resources on the module area are available at MSRUAS library

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Course Title	Construction Economics and Financial Management
Course Code	19CMC511A
Programme	Construction Engineering and Management
Department	Civil Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course aims at providing students with a working knowledge of economic principles, terminologies and methods enabling them to take decisions on problems of the present economy. Training will be provided to students in comparing and evaluating alternative proposals for investments and funds management. Through the study of Management Accounting, students will be able to record and summarize business and financial transactions and analyze, verify and report the results.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Develop and interpret cash flow diagrams and discuss their applications in effective financial management of projects
- **CO 2.** Calculate capital lockups and cash requirements of a project using economic principles and methods
- **CO 3.** Evaluate the opportunities and pitfalls of alternative engineering investments from an economic point of view by reducing them to a common platform
- **CO 4.** Analyze, interpret and present accounting information in order to assist management in the process of decision making, creation of policy and day to day operation of a project/ organization
- **CO 5.** Derive compound interest factors and their corresponding formulae to determine unknown amounts from known values of varying cash flows

Course Contents

Unit1 (Introduction): Definition and scope of economics, fundamental concepts in business economics.

Basics of Microeconomics: Demand and supply analysis, elasticity of demand, theory of production, cost analysis, market structure, perfect competition, monopoly, monopolistic competition and oligopoly market.

Basics of Macroeconomics: National economy, national income accounting, business cycle, monetary policy, fiscal policy, inflation, employment, price indices- wholesale price index- consumer price index.

Economics of Development: Causes and characteristics of underdevelopment, general theories of development, five - year planning and social development.

The Construction Industry: Nature, characteristics, size and structure; Role in economic development and employment generation, input industries, clients, contractors, consultants and workers and their organizations; Economics of ecology and environment, local material selection, form and functional designs.

Economics of Infrastructure in India: Roads and buildings, transportation and communications, irrigation and power, ports and aviation, health and education services; Economics of Civil and Social infrastructure, building service, facilities and services, urban infrastructure in India, Issues in developing, funding and managing infrastructure; International and national constraints and incentives, unique features of this business and their impact on savings, investments and other

economic phenomena; Support matters of economy as related to top Engineering, choice of technology, quality control and quality production, audit in economic law of returns.

Unit 2 (Financing): Types of finance- long term and short term finance, leasing, equity financing, internal generation of funds, external commercial borrowings, assistance from government budgeting support, international finance corporations, investment financing decision, financial control, job control and centralized management;

Funds management- working capital management, inventory valuation, mortgage financing, international finance management, foreign currency management, budgeting and budgetary control, performance budgeting

Unit3 (Basic principles):time value of money, nominal and effective interest, formulation of interest computation, single payment, equal payments and unequal payments, cash flow analysis.

Unit 4 (Comparing Alternative Proposals): Present worth comparison, future worth comparison, annual cost and return method, rate of return method, incremental rate of return, discounted cash flow, net present value, profitability index, ratio analysis, replacement analysis, break-even analysis.

Unit 5 (Evaluating Alternative Investments): Real estate, work pricing, contract bidding and award, revision due to unforeseen causes, depreciation and amortization, taxation and inflation, escalation, risks and uncertainties and management decision in capital budgeting, turnkey activities, project appraisal and project yield

Unit6 (Management Accounting): Basic financial and accounting concepts and methods, the company as an economic unit, project as a profit center; Basic concepts:- capital and revenue, financial accounting, cost accounting, management accounting; Accounting process: General Accepted Accounting Principles, double entry system, ten point programme in book keeping; Journal, ledger, cash book, trial balance, final balance, depreciation accounting provisions and reserves; Preparation of profit and loss account, balance sheet, income statement, cash flow and fund flow statements.

Unit7 (Budgeting): Types of budgets, procedure for master budget, budgetary control system, budget as a system of management control and corporate growth; Balance sheet reading, understanding health of an enterprise by study of its balance sheet; Interpretation of financial statements, balance sheet, Profit and Loss account, balance sheet as a valuation statement.

Unit8 (Lending to Contractors): Loans to contractors, interim construction financing, security and risk aspects.

Course Resources

a. Essential Reading

1. Class Notes
2. Halpin D. W.,(1985) Financial and Cost Concept of Construction Management, Willey.
3. Myers D.,(2004) Construction Economics: A new Approach, Taylor and Francis Publisher.
4. Jha K. N.,(2011). Construction Project Management: Theory and Practise, Pearson Education.

b. Recommended Reading

1. Ofory G.,(1990). The Construction Industry: Aspects of its Economics and Management. Singapore University Press.

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2. Patel B. M.,(2000). Project management- strategic Financial Planning, Evaluation and Control. Vikas Publishing House Pvt. Ltd. New Delhi.
3. Steiner H.M.,(1996). Engineering Economic principles. Mc-Graw Hill Book, New York.

c. Magazines and Journals

1. Journal of Financial Management of Property and Construction, Emerald Group Publishing Limited
2. Journal of International Real Estate and Construction Studies, Nova Publishers.

d. Other Electronic Resources

2. http://nptel.ac.in/

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Course Title	Resource Management in Civil Construction
Course Code	19CMC512A
Programme	Construction Engineering and Management
Department	Civil Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course deals with resources employed in construction comprising of materials, equipment, labour and time. Students will be taught methods of effective purchase, utilization and storage processes of materials and equipment management. In addition, manpower management aspects such as manpower planning, organization, human relations, welfare and development methods and management and control of time and cost in construction will be explained.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Solve resource planning, allocation and leveling problems of Civil Engineering projects
- **CO 2.** Compare and contrast between various methods of effective management of cost and time towards successful completion of the project
- **CO 3.** Discuss the various resources utilized in a construction project such as materials, equipment, labour and time
- **CO 4.** Analyze the various aspects of manpower management such as manpower planning, organization, human relations, welfare and development methods and their effects on a construction project
- **CO 5.** Explain and summarize purchase, utilization and storage processes and management of materials

Course Contents

Unit1 (Resource Planning): Types of resources- manpower, equipment, material, money and time; Resource planning, procurement, identification, personnel, planning for material, labour, time schedule and cost control; Systems approach in resource management, characteristics of resources- resource utilization, measurement of actual resources required- tools for measurement of resources.

Unit 2 (Material Management): Material classification- codification of materials, standardization, organizing for material management, basis for forming organizations, conventional and modern approaches to organizing materials management; Material procurement- procurement organization, procurement planning, norms of vendor rating, CEI methodology, material selection and development, purchasing procedure and methods, legal aspects, insurance of materials, supply management, source of supply, outsourcing, inventory control.

Storage of materials- management of stores, location, different types of stores, methods of storing, safety and security of materials, stores equipment, materials handling equipment, factors affecting material handling; Scrap and obsolete materials management- management of surplus, obsolete and scrap materials, reasons for accumulation of surplus, obsolete and scrap materials and methods of disposal, regulations and procedures

Unit3 (Equipment): Planning and selection by optimistic choice with respect to cost, time, source and handling. Human Resource Management:
Definition, scope, objectives, recruitment, selection, placement, training, manpower planning process, organizing and staffing, directing and controlling, estimation of manpower requirement, factors influencing supply and demand of human resources, role of HR manager, personnel principles; Labour management- systems approach, characteristics of resources,

utilization, measurement of actual resources required, Tools for measurement of resources, labour, classes of labour, cost of labour, labour schedule, optimum use of labour;
Management and development methods- wages and salary, employee benefits, employee appraisal and assessment, employee services, safety and health, discipline and discharge; Special Human resource problems, employee handbook and personnel manual, Productivity of human resources.
Industrial relations- trade unions, disputes and their resolution; Personnel time management and planning- managing time on the project, future forecasting , critical path measuring the changes and then effects; Organization- requirement of organization, organization structure, organization hierarchical charts

Unit 4 (Human Relations and Organizational Behavior (OB)): Basic individual psychology, job analysis and design and job redesign, significance of human relations; Nature of organizational behaviour; definition, key elements, scope, model, stages of evolution of OB, researches in OB; Foundations of individual behaviour- personality, perception, learning attitudes, values and job satisfaction, concepts of motivation; Foundations of group behavior; small groups in an organization, leadership- engineer as manager- all aspects of decision making, power and politics, communication, negotiation skills, conflict.

Unit 5 (Time Management): Personnel time, management and planning, managing time on the project, forecasting the future activities, critical path measuring the changes and their effects, cash flow and cost control

Unit6 (Resource Allocation and Leveling): Time cost tradeoff, computer applications, resource leveling, resource list, resource allocation, resource loading, and cumulative cost- value management.

Course Resources

a. Essential Reading

1. Class Notes
2. Gopal K r i s h n a n a n P . and S u n d a r e s a n M.,(1992) Material Management Integrated Approach, Prentice Hall India, New Delhi
3. Datta A.K. (1988) Material Management and Inventory Control: Principles and Practice, Jaico Publishing House, Bombay
4. Josy J. Familaro, (1987) Handbook of Human Resources Administration, McGraw-Hill International Edition
5. Aswathappa A.,(2000) Organizational Behaviour: Texts and cases, Himalaya Publishing House, Mumbai

b. Recommended Reading

1. Shah N.M., (1988) Integrated Concept of Material Management, Tata Mc Graw Hill 2. Michael R. Leenders and Fearn, (1996) Purchasing and Material Management, D.B. Tarporevale Sons and Co., Bangalore
2. Tersine and Richard J.,(1994) Principles of Inventory and Material Management, Prentice Hall International
3. Dwivedi R.S., (2005), Human Relations and Organisational Behaviour, Macmillian India Ltd
4. Carleton Counter II and Jill Justice Coutler, (1989) The Complete Standard Handbook of Construction Personnel Management, Prentice-Hall

c. Magazines and Journals

1. ACI Structural Journal, American Concrete Institute
2. Engineering Construction and Architectural Management, Wiley

d. Other Electronic Resources

1. http://nptel.ac.in/

Course Title	Construction Quality and Safety Management
Course Code	19CMC513A
Programme	Construction Engineering and Management
Department	Civil Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course deals with quality management and planning, scope and problem areas in construction safety. Students will be taught about type of organizations and the quality management systems adopted by them. They will also be taught the objectives and methods of achieving quality assurance and quality control in construction. Types and causes of construction accidents and safety measures to be adopted will be discussed.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Generalize the objectives of quality management, quality systems and methods of quality planning
- **CO 2.** Compare and contrast between the type of construction accidents, their causes and the scope of construction safety programme and problem areas in construction safety
- **CO 3.** Discuss the responsibilities and authorities of architects, engineers, contractors and consultants in quality management
- **CO 4.** Design safety procedures to be adopted for various construction operations
- **CO 5.** Suggest safety remedies for common hazards and accidents resulting from use of construction equipment

Course Contents

Unit1 (Construction Organization): Types of organization, inspection, control and enforcement, quality management systems and method; Responsibilities and authorities in quality assurance and quality control- Architects, Engineers, Contractors and Consultants, quality circle

Unit 2 (Quality Management, Quality Systems, Quality Planning): Introduction, definitions and objectives, factors influencing construction quality, responsibilities and authority, quality plan, quality management guidelines
Introduction, quality system standard, ISO 9000 family of standards, requirements, preparing quality system documents, quality related training, implementing a quality system, third party certification. Quality policy, objectives and methods in construction industry, consumer satisfaction; Economics, time of completion, statistical tolerance, taguchi's concept of quality; Codes and standards, documents, contract and construction programming, Inspection procedures, processes and products.

Unit3 (Quality Assurance (QA) and Quality Control (QC)): Objectives, regularity agent, owner, design, contract and construction oriented objectives; Methods, techniques and needs of QA/QC, different aspects of quality, appraisals; Critical, major failure aspects and failure mode analysis, stability methods and tools; Optimum design, reliability testing, reliability coefficient and reliability prediction.

Unit 4 (Quality Improvement Techniques): Selection of new materials, influence of drawings, detailing, specification, standardization, Bid preparation, construction activity; Environmental safety, social and environmental factors- Life cycle costing- value engineering and value analysis

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Unit 5 (Total Quality Management (TQM)): Understanding quality, TQM philosophy- concepts of Deming, Juran, Crosby, Imai, Ishikawa, Shingo philosophies, models and frameworks; TQM Tools:- an overview of flowcharts, check sheets, histogram; cause and effect diagrams; Pareto diagram, scatter diagram and control charts; Implementing TQM:- TQM and management of change, Planning and implementation of TQM, sustained improvement, TQM models in practice.

Unit6 (Human resource): Human resource management (introduction only), cultural change, innovation and learning, leadership and commitment; Standardization- selection of new materials, influence of drawings, detailing and specifications based on codal provisions; ISO 9000:- quality systems, six sigma practice, customer supplies chain, continuous improvement; ISO 14001:- quality systems; Case studies.

Unit7 (Construction Accidents): Accidents and their causes- human factors in construction safety- costs of construction injuries - occupational and safety hazard assessment- legal implications.

Safety Programmes: Construction safety: meaning and scope;

Problem areas in construction safety, elements of an effective safety programme, job-site safety assessment, safety meetings, safety incentives; Current situation in safety of construction:- technological aspects, organizational aspects, behavioral aspects; Fire prevention and control- causes, types of extinguishers and uses, fire prevention planning, fire prevention and control features; Safety measures and remedies for common hazards:- dust, vibration, lead poisoning, noise, movement, material and lighting; Safety in use of construction equipment;
Contractual obligations:- safety in construction contracts- safety clauses in contract document- substance abuse.
Designing for Safety: Safety policy, safety record keeping; Safety culture- safe workers, safety and first line supervisors, safety and middle managers, top management practices; Company activities and safety- safety Personnel- sub contractual obligation; Project coordination and safety procedures, workers compensation.
Planning for Safety in Construction Projects: Legal requirements, reporting occurrence of accidents and hazards, action to be taken by site engineer in case of accidents, first aid/ ambulance room/ dispensary; Role of various parties in construction safety management:- designers, workers, manufacturers/ dealers, employers, site safety management, site organization; Human factors in construction safety management:- motivation- management, supervisors, workers, motivational Scheme- possible areas of improvement.

Unit8 (Safety in Construction Operation): Drilling and blasting operation, excavation, concrete framed structure; Accident investigation records and cost: - purpose of investigation, measuring safety and records to be maintained; Hazard analysis techniques: Job hazard analysis, fault tree analysis, future mode analysis; IS codes for safety for buildings and Civil Engineering projects.

Course Resources

a. Essential Reading

1. Class Notes
2. Oakland, J. S., (2006) TQM Text with cases. Butterworth- Heinemann, Oxford
3. Mohamed, Z., (1992) Total Quality Management for Engineers, Aditya Books, New Delhi
4. Hinze J. W., (1997) Construction Safety, Prentice Hall Inc.
5. Coble R. J., Hinze J. and Haupt T. C.,(2001) Construction Safety and Health Management, Prentice Hall Inc.

b. Recommended Reading

1. Feigenbaum A. V., (1991) Total Quality Control, McGraw Hill International Edition
2. Suresh D. and Saurabh,(1997) ISO-9000 A Manual for Total Quality Management,

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3. S.Chand, NewDelhi
4. Logothetis N., (1997), Managing For Total Quality, Prentice Hall India, NewDelhi
5. Vaid K.N., (1988) Construction Safety Management, National Institute of Construction management, Mumbai
6. Krishna N.V.,(1983) An Introduction to Safety Engineering and Management, OPS Publishers Limited 14, Hare street, Calcutta

c. Magazines and Journals

1. ACI Structural Journal, American Institute of Concrete
2. The TQM magazine, Emerald publishing group
3. Benchmarking for Quality Management and Technology, Emerald publishing group

d. Other Electronic Resources

1. http://nptel.ac.in/

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Course Title	Bridge Engineering and Road Projects
Course Code	19CME531A
Programme	M.Tech in Construction Engineering and Management
Department	Civil Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course deals with design of various types of bridges and studies essential for a road project. Students will be taught the design of bridges and its foundation. Various traffic and material studies necessary for a road project are explained. Different types of surveys and details essential for the preparation of a Detailed Project Report (DPR) are also discussed.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Discuss the different types of bridges and loads and stresses acting on bridges.
- **CO 2.** Discuss various surveys and investigations used in feasibility report and detailed project report (DPR).
- **CO 3.** Design various types of foundation for a bridge structure.
- **CO 4.** Design various components of RCC and PSC bridges.
- **CO 5.** Analyse the social and environmental impact of a road project.
- **CO 6.** Prepare feasibility report and DPR.

Course Contents

Unit 1 Bridge Engineering
Types of Bridges: Consideration of loads and stresses in bridges, bridge loading as per IRC and IRC specifications, traffic lanes, footway, kerbs, railing and parapet loading, impact, wind load, longitudinal forces, temp effects, secondary stresses, erection stresses, earth pressure, effect of live load on back fill and on the abutment.

Unit 2 Design of RC Bridges: Slab culvert, box culvert, pipe culvert, T-beam bridge, super structure, design examples, brief introduction to rigid frame, arch and bow string girder bridges. Design of pre-stressed concrete bridges, pre-tensioned and post tensioned concrete bridges, analysis and design of multi-lane pre-stressed concrete T-beam bridge super structure.

Unit 3 Foundations: Types, general design criterion, design of well and pile foundations for piers and abutments.

Unit 4 Road projects
Introduction: Various steps of preparation and execution of road projects, Investigations for preparation of project reports for new and up gradation of roads. Objects and scope of pre – feasibility, feasibility and detailed studies for project preparation.
Typical HR structure for preparations and implementation of road projects
Concepts of Topographic surveys and investigations, Soil investigation, Material surveys and investigations Traffic studies and Traffic forecast.

Unit 5 Environmental and social impact studies- assessment relevant to road upgradation / new projects, Mitigation measures, Road safety audit. Collection of relevant data, analysis and interpretation for pre-feasibility and feasibility study reports of the proposed road project. Economic evaluation of different possible alternatives.
Preparation of drawings and project reports, Use of software

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Unit 6 Preparation of DPR- design details, estimates, BOQ, drawings and detailed project report, use of software

Unit 7 Planning of Low volume roads: Introduction to planning of low volume roads, concepts of network planning, selection of roadway alignment, factors affecting rout selection, engineering surveys for new road location.
Recommendations based on IRC SP-20 Rural Road manual

Course Resources

a. Essential Reading

1. Class Notes
2. Victor D. J., (1980) Essentials of Bridge Engineering, Oxford and IBH.
3. Krishna Raju N., (1988) Design of Bridges, Oxford and IBH.

b. Recommended Reading

1. Raina V. K., (2002) Concrete Bridge Practice: Analysis, Design and Economics, Tata McGraw Hill.
2. Fryba L., (1996) Dynamics of Railway Bridges, Thomas Telford.
3. IRC: SP:19 - 2001, Manual for Survey, Investigation and Preparation of Road Projects- (first revision), Indian Roads Congress
4. IRC: SP: 30 - 1993, Manual on Economic Evaluation of Highway- Projects in India (first revision), Indian Roads Congress
5. IRC SP – 38,Manual for Road Investment Decision Model-1992, Indian Roads Congress
6. IRC : 9-1972, 35 – 1997,38-1988, 39-1986, 52-2001, 54-974, 62-1976, 64-1990, 66-1976, 672001, 69-1977, 73- 1980, 79-1981, 80-1981, 86-1983, 98-1997, 99-1988, 103-1988, 1041988, 110-1996
7. MoRTH Specifications for Road, Bridge Works- 2001, fourth revision, Indian Roads Congress

c. Magazines and Journals

1. ASCE Journal of Bridge Engineering
2. The International Journal of Bridge Engineering

d. Other Electronic Resources

1. Electronic resources on the module area are available at MSRUAS library

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Course Title	Fire and Safety Engineering Design
Course Code	19STE534A
Programme	Structural Engineering
Department	Civil Engineering
Faculty	Engineering and Technology

Course Summary

The main objective of the course is to expose the students to the concept of fire resistant design of structures, to understand the behavior of structural systems and materials under the fire effects. Further objective is to learn basic fire safety design issues and gain an educational & comprehensive experience on fire resistance design concepts.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Interpret the intentions of code requirements for fire safety
- **CO 2.** Discuss the concepts of fire severity and fire resistance
- **CO 3**. Discuss the various methods of testing structures for fire resistance
- **CO4.** Calculate fire resistance, Depth of temperature reached, temperature in plane and bar type structures and change in strength of structures due to temperature variations
- **CO 5**. Design of concrete and steel structures to resist fire exposure

Course Contents

Unit 1: Classification of Buildings and Types of Production Processes
Types of construction and classification of buildings, Main building elements, Requirements of buildings, Combustibility and fire resistance

UNIT 2: Fire Safety in Buildings
Fire safety objectives, Life safety, Property protection, Environmental protection. Fire resistance, Objectives for fire resistance, Fire design time, trade-offs.

Unit 3: Calculation of Required Fire Resistance Limit of Building Structures
Initial condition for calculating fire resistance of structures, Duration of fire, Temperature of fire, Main points on the method of investigating temperature regimes of fires, Results of experimental investigations on fires, Simulation of temperature regimes of fires, Determination of fire in residential and public buildings, Determination of fire duration of fire in industrial buildings and warehouses

Unit 4: Methods of Testing Structures for Fire Resistance
Problems of testing for fire resistance, Set-up for testing fire resistance, Temperature regime of the tests, Test pieces of structures, Conditions of loading and supporting of structures

Unit 5: Fire Resistance of Reinforced Concreter Structures
Main aspects of the calculations for fire resistance, Thermo technical part of the calculation Boundary conditions, Calculation of temperature in plane structures (one- dimensional temperature field), Calculation of temperature in bar type structures (Two- dimensional temperature field), Calculation of depth at which a given temperature is reached, Effect of moisture in concrete on the heating of structures, Thermo physical properties of concrete at high temperatures ,Statics part of calculations, Change in the strength of reinforcement steel with increase of temperature, Change in the strength of concrete in compression with increase in temperature, Coefficients of thermal expansion of reinforcement bars and concrete, Axially loaded columns, Statically determinate elements subjected to bending stresses.

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Unit 6: Design of Structures Exposed to Fire

Design equation, loads for fire design, Structural analysis for fire design, Computer calculations. Material properties in fire,Testing regimes, Components of strain. Design of individual members exposed to fire, Tension members, Compression members, Beams. Design of structural assemblies exposed to fire, Frames, Redundancy, Disproportionate collapse, Continuity, Plastic design.

Course Resources

a. Essential Reading

1. Class Notes
2. Andrew H. Buchanan, "Structural Design for Fire Safety" John Wiley & Sons. Ltd – 2001.

b. Recommended Reading

1. U.S Bendev Etal, "Fire Resistance of Buildings"- Amerind Publishing Co. Pvt. Ltd
2. IS: Andrew H. Buchman "Structural design for fire safety, comprehensive overview of the fire resistance of building structures"-, John Wiley and sons., 2001.
3. IS John A. Purkiss "Fire Safety Engineering Design of structures"-, Butterworth Heinemann, 2009.

c. Other Electronic Resources

2. http://nptel.ac.in/

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Course Title	Smart cities and Sustainable Infrastructure
Course Code	19CME533A
Programme	Construction Engineering and Management
Department	Civil Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course is to make students understand the concepts and models of 21st century green and smart cities; know current international strategies regarding sustainable development of urban areas. Also the students should Student will be able to learn how to implement sustainability in planning process at different spatial scales.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Discuss the concepts concept and socio-economic policies of Sustainable Development
- **CO 2.** Discuss the various approaches of energy systems leading to smart city and sustainable planning
- **CO 3.** Discuss and assess appropriate strategies of eco development , resource conservation and management
- **CO 4.** Discuss principles and practice of sustainable development, within the context of planning
- **CO 5.** Recommend techniques and tools used for sustainability planning

Course Contents

Unit1 (Introduction): Understanding Smart Cities; Dimensions of Smart Cities; Global Experience of Smart Cities; Smart Cities–Global Standards and Performance Benchmarks, Practice Codes; India "100 Smart Cities "Policy and Mission; Smart City Planning and Development; Financing Smart Cities Development; Governance of Smart Cities

Unit 2 (Application of Solar Energy for Smart Cities): Conventional Vs Smart city components; Energy demand; Green approach to meet Energy demand, Index of Indian cities towards smartness- a statistical analysis; Energy scenarios of conventional cities, its consequences, alternative resources, reliability on predictability scale, solar options, PV and thermal, singular or Hybrid; Meeting energy demand through direct and indirect sources; structure of smart city grid, Indian perspective, advantages and limitations of implementations.

Unit3 (Sustainable development): Introduction to Sustainable Development Concepts and Theory, current urban problems and opportunities, History, definitions, and perspectives on Sustainability Theory and Background to Sustainability Planning,
The Three E's: Environment, Economics, ethics, and ecology of sustainable development.

Unit 4 (Environment, Ethics and Ecology): Analyzing the Three E's within an urban development debate, Ethics, Worldviews and Sustainability, Tools for Sustainability Planning: indicators, ecological footprint, other mechanisms, Planning, planners, and sustainability plans; Planning for Sustainability at Different Scales, Regional Planning and Sustainability,
Municipal Planning and Sustainability, Implementing sustainability, Sustainable Transportation Planning, Concept of New Urbanism and Smart Growth.

Unit 5 (Sustainable materials): Materials, Energy, and Food, The Natural step, Environmental issues, Concepts and Theory: Industrial Ecology and Green Development; Neighborhood Planning and Sustainability, Ecological Site Design and Architecture, Sustainable building, Green building concept,

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assessment; International development on Sustainability in Planning, International Institutions; Sustainability Planning in western world, Sustainability Planning in Developing Countries

Course Resources

a. Essential Reading

1. Class Notes
2. Gilg A. W. and Yarwood R., (2005), Rural Change and Sustainability - Agriculture, the Environment and Communities, CABI Edited by S J Essex
3. Ganesha S., and Sakarama S., Environmental Concerns and Sustainable development: Some perspectives from India, TERI Press, ISBN: 8179932249

b. Recommended Reading

1. James H. Weaver, Michael T. Rock, Kenneth Kustere, (1997), Achieving Broad-Based Sustainable Development: Governance, Environment, and Growth with Equity, Kumarian Press, West Hartford, CT.
2. Kirkby. J, O'Keefe P. and Timberlake, (1996), Sustainable development, Earth Scan Publication, London
3. Kerry Turner. R, Sustainable Environmental Management - Principles and Practice, Belhaven Press,ISBN:1852930039.

c. Other Electronic Resources

1. http://nptel.ac.in/

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Course Title	Environmental Impact assessment of Construction Projects
Course Code	19CME534A
Programme	Construction Engineering and Management
Department	Civil Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course provides guidance on Environmental Impact Assessment (EIA) in building construction projects. The course emphasis on the concepts, procedures and tools that are potentially relevant in preparing environmental impact assessment reports for clearance. The course covers a wide range of technical disciplines and students will gain the ability to describe, improve and suggest alternatives for the construction project to be more Environmentally sustainable

Course Outcomes

After undergoing this module students will be able to:

CO 1. Discuss the importance of EIA as an integral part of planning process of construction project
CO 2. Discuss methodologies to predict and assess the impacts of project on various aspects of environment
CO 3. Discuss the role of public participation in environmental decision making process
CO 4. Emphasis on environmental management plan and environmental health safety at construction project

Course Contents

Unit 1 Introduction

General Information on Building Construction, Environmental Clearance Process, Terms of Reference (TOR), Validity of Environmental Clearance, Post Environmental Clearance Monitoring, Transferability of Environmental Clearance, Generic Structure of Environmental Impact Assessment Document, Identification of Project Proponent

Unit 2 Description of Project Environment

Description of the Project, Site Selection, Manpower Requirement, Project Implementation Schedule Land Environment, Water Environment, Air Environment, Noise Environment, Biological Environment, Socio-economic Environment , Solid Waste, Environmental Impact Analysis and Mitigation Measures

Unit 3 Analysis of Alternatives -Technology and Site

Building Materials, Energy Conservation, Transportation, Environmental Monitoring Program, Risk Assessment and Disaster Management Plan (DMP), Natural Resource Conservation, R&R Action Plan

Unit 4 Potential Environmental Impacts

Introduction, Anticipated Environmental Impacts, Positive & Negative Environmental Impacts of Construction Activities, Operational Activities, Decommissioning Activities, impacts mitigation measures

Unit 5 Environmental Management Plan

Environmental Monitoring and Evaluation, EHS Management and Administration , Policy, Administrative and Legislative Framework ,Organization and implementation of the EHS Management Plan ,The Guiding Principles to be adopted , EHS management strategy to be adopted, Safety Agenda for both the proponent and contractor , Safety requirement at the project site during construction and operation Period, Welding at the construction site Emergency procedure during construction and operation, Decommissioning

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Course Resources

a. Essential Reading

1. Class Notes
2. Environmental Impact Analysis Handbook by Rau Whooten; McGraw Hill publications
3. Environmental Impact Assessment by Larry Canter; McGraw Hill publications

b. Recommended Reading

1. Environmental Impact Analysis – A Decision Making Tool by R K Jain
2. Handbook of Environment Impact Assessment by Judith Petts; McGraw Hill publications

c. Other Electronic Resources

1. http://environmentclearance.nic.in/
2. Electronic resources on the module area are available at MSRUAS library

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Course Title	Condition assessment, Repair, Rehabilitation and Artificial Intelligence
Course Code	19CME541A
Programme	Construction Engineering and Management
Department	Civil Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course introduces the basic concepts and techniques of Artificial Intelligence (AI), structural health monitoring and retrofitting. Topics covered are Expert systems, uncertainty, Neural Network, and fuzzy Logic, and their applications of AI in Construction Management. This module also provides an in depth knowledge about causes of structural failures and structural health monitoring of the structures. Students will be trained to develop Efficient and cost-effective approaches for repair, rehabilitation and retrofitting of structures. Students will be trained in forensic investigations, issue reports and provide expert testimony during depositions and trials.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Explicate characteristics of AI that make it useful to real-world civil engineering problems, different causes of structural failures of buildings, bridges and other constructed facilities, sensors
- **CO 2.** Discuss Artificial Neural Network (ANN), Fuzzy logic (FL) and expert systems (ES), sensors and Data acquisition systems and their applications in specialisations of civil engineering
- **CO 3.** Identify suitable Sensor and SHM technique for a given structure, and AI models for applications Specialisations of civil engineering
- **CO 4.** Design Efficient and cost-effective approaches for repair, rehabilitation and retrofitting of structures Conduct forensic investigations, issue reports and provide expert testimony during depositions and trials
- **CO 5.** Apply concepts of ANN, FL and ES in specializations of Civil Engineering
- **CO 6.** Compare and contrast different failures and recommend code standards and practices to avoid failures in the future

Course Contents

Unit1 (Artificial Intelligence):

Introduction to Artificial Intelligence (AI), branches of AI, and applications of AI to civil engineering Expert systems superiority over conventional software, components of an expert system, expert system life cycle, expert system development process, nature of expert knowledge, techniques of soliciting and encoding expert knowledge; Inference- Forward chaining, backward chaining, rule value approach.

Knowledge based approaches in engineering Expert Systems:

Fundamentals of Neural Networks: Research history, model of artificial neurons, neural networks architectures, learning methods in neural networks, single layer neural network system. Applications of Neural Networks in Structural engineering:

Introduction, Fuzzy set - Membership, Operations, Properties, Fuzzy Relations; fuzzy models in Structural Engineering Application of AI in Structural Engineering

Environmental Problems and Natural Hazards: Effect of corrosive, chemical and marine environment, pollution and carbonation problems, durability of RCC structures, damage due to earthquakes and flood, strengthening of buildings, provisions of BIS 1893 and 4326

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Unit 2 (Structural Health Monitoring) : Review of Structural Modelling and Finite Element Models: Modelling for damage and collapse behaviour of structures, finite element modelling, theoretical prediction of structural failures.

Unit3 (Classification of Techniques): Integrated Health Monitoring Systems: Intelligent Health Monitoring Techniques, neural network classification techniques, extraction of features from measurements, and case
studies.

Unit 4 (Information Technology for SHM): Information gathering, signal analysis,information storage, archival, retrieval, security; wireless communication, telemetry, real time remote monitoring, network protocols, data analysis and interpretation

Unit 5 (Classification of techniques project Based Health Monitoring): Health monitoring techniques based on case studies, practical aspects of testing large bridges for structural assessment, optimal placement of sensors, structural integrity of aging multistorey buildings, condition monitoring of other types of structures.
Case studies: Buildings- heritage buildings- high rise buildings, water tanks, bridges and other structure

Course Resources

a. Essential Reading

1. Class Notes
2. Krishnamoorthy C.S., Rajeev S., (1996)Artificial Intelligence and Expert Systems for Engineers, CRC Press, CRC Press LLC
3. Rajasekaran S. and VijayalaksmiPai G.A., (2005) Neural Network, Fuzzy Logic, and Genetic Algorithms - Synthesis and Applications, Prentice Hall
4. Adeli H., Karim A., (2001) Construction scheduling , cost optimisation, and management, Spon Press, New York York

b. Recommended Reading

1. Winston P.H., (1999) Artificial Intelligence, Pearson Education
2. Lugur G. F., (2002) Artificial Intelligence: Structures and Strategies for Complex Problem Solving, Addison – Wesley
3. Russel S. and Norvig P., (2002) Artificail Intelligence: A Modern Approach, Prentice Hall.

c. Other Electronic Resources

1. http://nptel.ac.in/

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Course Title	Condition assessment, Repair, Rehabilitation and Artificial Intelligence
Course Code	19CME541A
Programme	Construction Engineering and Management
Department	Civil Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course introduces the basic concepts and techniques of Artificial Intelligence (AI), structural health monitoring and retrofitting. Topics covered are Expert systems, uncertainty, Neural Network, and fuzzy Logic, and their applications of AI in Construction Management. This module also provides an in depth knowledge about causes of structural failures and structural health monitoring of the structures. Students will be trained to develop Efficient and cost-effective approaches for repair, rehabilitation and retrofitting of structures. Students will be trained in forensic investigations, issue reports and provide expert testimony during depositions and trials.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Explicate characteristics of AI that make it useful to real-world civil engineering problems, different causes of structural failures of buildings, bridges and other constructed facilities, sensors
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- **CO 5.** Apply concepts of ANN, FL and ES in specializations of Civil Engineering
- **CO 6.** Compare and contrast different failures and recommend code standards and practices to avoid failures in the future

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Unit1 (Artificial Intelligence):

Introduction to Artificial Intelligence (AI), branches of AI, and applications of AI to civil engineering Expert systems superiority over conventional software, components of an expert system, expert system life cycle, expert system development process, nature of expert knowledge, techniques of soliciting and encoding expert knowledge; Inference- Forward chaining, backward chaining, rule value approach.

Knowledge based approaches in engineering Expert Systems:

Fundamentals of Neural Networks: Research history, model of artificial neurons, neural networks architectures, learning methods in neural networks, single layer neural network system. Applications of Neural Networks in Structural engineering:

Introduction, Fuzzy set - Membership, Operations, Properties, Fuzzy Relations; fuzzy models in Structural Engineering Application of AI in Structural Engineering

Environmental Problems and Natural Hazards: Effect of corrosive, chemical and marine environment, pollution and carbonation problems, durability of RCC structures, damage due to earthquakes and flood, strengthening of buildings, provisions of BIS 1893 and 4326

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Unit 2 (Structural Health Monitoring) : Review of Structural Modelling and Finite Element Models: Modelling for damage and collapse behaviour of structures, finite element modelling, theoretical prediction of structural failures.

Unit3 (Classification of Techniques): Integrated Health Monitoring Systems: Intelligent Health Monitoring Techniques, neural network classification techniques, extraction of features from measurements, and case
studies.

Unit 4 (Information Technology for SHM): Information gathering, signal analysis,information storage, archival, retrieval, security; wireless communication, telemetry, real time remote monitoring, network protocols, data analysis and interpretation

Unit 5 (Classification of techniques project Based Health Monitoring): Health monitoring techniques based on case studies, practical aspects of testing large bridges for structural assessment, optimal placement of sensors, structural integrity of aging multistorey buildings, condition monitoring of other types of structures.
Case studies: Buildings- heritage buildings- high rise buildings, water tanks, bridges and other structure

Course Resources

a. Essential Reading

1. Class Notes
2. Krishnamoorthy C.S., Rajeev S., (1996)Artificial Intelligence and Expert Systems for Engineers, CRC Press, CRC Press LLC
3. Rajasekaran S. and VijayalaksmiPai G.A., (2005) Neural Network, Fuzzy Logic, and Genetic Algorithms - Synthesis and Applications, Prentice Hall
4. Adeli H., Karim A., (2001) Construction scheduling , cost optimisation, and management, Spon Press, New York York

b. Recommended Reading

1. Winston P.H., (1999) Artificial Intelligence, Pearson Education
2. Lugur G. F., (2002) Artificial Intelligence: Structures and Strategies for Complex Problem Solving, Addison – Wesley
3. Russel S. and Norvig P., (2002) Artificail Intelligence: A Modern Approach, Prentice Hall.

c. Other Electronic Resources

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Course Title	Circular Economy in Construction Industry
Course Code	19CME542A
Programme	M.Tech in Construction Engineering and Management
Department	Civil Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course emphasizes on circular economy, which is essential contribution to a more sustainable, low carbon, resource-efficient and competitive economy. Strategies over the full life cycle – from design and production to use, reuse, repair, remanufacturing and recycling. The students should be able to understand theory, methods and tools from product design, production engineering, waste management, industrial ecology, supply chain and change management and policy, presented in the context of the circular economy related to construction industry

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Discuss historic and future projections of natural resource use and associated sustainability challenges
- **CO 2.** Describe visions and underlying principles of various approaches to resource-efficiency and circular economy
- **CO 3.** Discuss the implications of increased resource-efficiency and circularity for sustainable development
- **CO 4.** Determine the role of actors, their options, barriers and drivers for transitioning to a more resource-efficient and circular economy.
- **CO 5.** Formulate strategies towards increased resource-efficiency and circularity based on relevant theories, methods and tools from multiple disciplines.

Course Contents

Unit 1 Introduction
Introduction- current status of Linear Economy-Benefits of Circular Economy-The roots of the Circular Economy in the fields of industrial ecology, cradle to cradle and biomimicry.
Sourcing of materials from extraction to refining processes as well as the complexity of material supply. Rationale for transformation to a Circular Economy.

Unit 2 Business value and long lasting products:
Managing change in business and through public policy; Product life extension through the eyes of designers and entrepreneurs; Concepts of Change management (CM) and Public policy (PP)

Unit 3 Circular Business models:
Detail design, manufacturing, use, reuse, repair and remanufacturing, recycling and waste management. Modules in this theme are Product design and development (PD), Production engineering (PE), User-oriented design (UD) and Waste management (WM)

Unit 4 Circular Design, Innovation and Assessment:
Functional materials and eco-design as well as methods to assess environmental impacts

Unit 5 Policies and Networks:
Role of governments and networks about policies and best practices to enable the circular economy; new norms, forms of engagement, social systems, and institutions, needed by the circular economy and role of individual towards circularity.

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Course Resources

a. Essential Reading

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1. Class Notes
2. Benton, D., Hazel, J. and Hill, J. (2014) The guide to the circular economy. Capturing value and managing material risk, Oxford: Do Sustainability, pp 17-55
3. Stahel, W. R. (2016). The circular economy. Nature News, 531(7595), pp 435-438. (Chalmers lib.)
4. Kirchherr, J., Reike, D., & Hekkert, M. (2017). Conceptualizing the circular economy: An analysis of 114 definitions. Resources, Conservation and Recycling, 127, pp 221-232. (Chalmers lib.)

b. Recommended Reading

1. Mishra, J. L., Hopkinson, P. G. and Tidridge, G. (2018), Value creation from circular economy-led closed loop supply chains: a case study of fast-moving consumer goods, Production Planning & Control, 29:6, 509-521 (Chalmers lib.)
2. Blackburn, J.D., Guide Jr., V.D.R., Souza, G.C. & Van Wassenhove, L.N. (2004), Reverse Supply Chains for Commercial Returns, California Management Review, vol. 46, no. 2, pp. 6-22. (Chalmers lib.)

c. Other Electronic Resources

1. Electronic resources on the module area are available at MSRUAS library

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Course Title	BIM and fabrication of steel structures
Course Code	19CME543A
Programme	Construction Engineering and Management
Department	Civil Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This module deals with Building Information Modelling of structures. Students will be able to understand the impact of Building Information Modelling on various other fields like Architecture, Constructopn Engineereing Management, Infrastructure Management etc. This course covers the preparation of structural steel drawings and bills of material for the purpose of fabrication and erection. Emphasis will be placed upon using structural design framing plans to develop detailed steel members, connections and assemblies.

Course Outcomes

After undergoing this module students will be able to:

- **CO 1.** Discuss the techniques, skills, and modern engineering tools necessary for engineering practice
- **CO 2.** Discuss the advantages of BIM for various areas and disciplines across the Architecture, Engineering and Construction (AEC) supply chain
- **CO 3.** Prepare of a Floor Plan, Column Plans and Steel Framing Plans of Structural drawings
- **CO 4.** Design and Detail structural elements from a design drawing
- **CO 5.** Interpret and draw design / erection drawing

Course Contents

Unit 1
Introduction to Building Information Modeling (BIM); Discussions of the Roles and Impacts of BIM in the Design, Construction Engineering and Management, Infrastructure Engineering, and Facility Management; Revit Architecture, Structure, and MEP; Creating Sets, Building Elements, Structural Systems, and MEP Systems; BIM and Clash Detection; BIM and Construction Cost Estimating and Scheduling; Future of Building Information Modeling. Prerequisite: consent of instructor.

Unit 2
Design of Industrial Building: Structural layout of industrial building; design of various systems like roofing system, bracing system, columns, gantry girder etc. Detailing of the Industrial structures.

Unit 3
Transmission Tower: Introduction; Loads on Tower;Analysis and Design of Transmission tower; Detailing of Transmission Tower.

Unit 4
Multistorey Buildings: Introduction;Types of loads; Analysis of multistorey buildings with Moment Resistant Joints for Lateral and Gravity loads; Detailing of different structural elements of Multistorey buildings.

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Unit 5
Structural Drafting: Principles of Modelling; Detail structural members like beams, colums and foundations from design / erection drawings; Detail standard and design specific connections like

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Beam to Beam connections, Beam to column connection, Column to foundation connection etc; Use standards and guidelines; Prepare design / erection drawings like general arrangement (GA) drawings, single part drawings, assembly drawings; Learn common terminology.

Course Resources

a. Essential Reading

1. Class Notes
2. Issa, R. R., & Olbina, S. (Eds.). (2015, May). Building Information Modeling: Applications and Practices.
3. Krygiel, E., & Nies, B. (2008). Green BIM: successful sustainable design with building information modeling.
4. Krishnamurthy D,Structural Design and Drawing Voll,IIandIII,CBS Publishers, 2010.
5. Dayarathnam P, Design of Steel Structures, S Chand and Company Ltd., New Delhi

b. Recommended Reading

1. Kazim S M A and Jindal R S, Design of Steel Structures, Prentice Hall of India, New Delhi.

2. IS 800-2007: General Construction in Steel Code Practice (Third revision), Bureau of Indian Standards, New Delhi.

3. Goetsch, D.L. (1994). Structural Drafting. (2nd ed.). Albany, NY: Delmar International Code Council. (2000). International Building Code. Falls Church, VA: Author

c. Magazines and Journals

1. Engineering Construction and Architectural Management, Wiley
2. Advanced BIM Applications in the Construction Industry
3. Journal of Management in Engineering

d. Other Electronic Resources

2. http://nptel.ac.in/

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Course Title	Advanced quantity surveying in civil engineering
Course Code	19CME544A
Programme	Construction Engineering and Management
Department	Civil Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

The course aims to provide students with a comprehensive and professionally oriented higher education experience in Quantity Surveying in construction projects. This course will teach students fundamentals of total cost management, project delivery types, cost planning and control, and project financial control and reporting. Modern tools and techniques in costing will be elaborated using case studies of different type of construction projects. Students will also get overview on industry practices in cost management.

Course Outcomes

After undergoing this course students will be able to:

CO 1. Understand the various standards and role of quantity surveyor in cost management.
CO 2. Apply different methods of cost estimation across various phases of construction projects.
CO 3. Apply project management principles to determine realistic cost estimation of projects.
CO 4. Analyze and evaluate the variations or deviations in projects to control the costs of project.
CO 5. Develop the total cost management framework for managing cost of construction projects.

Course Contents

Unit 1 (Roles and standards in cost estimation): Roles and responsibilities of quantity surveyor, architect, contractor, and client, building bye laws, National building code (NBC) 2016, IS Codes, ICMS, ICMIA, typical cost elements in construction project, estimation related clauses in contract, construction productivity, productivity measurement and benchmarking. Role of quantity surveyor

Unit 2 (Approximate and detailed estimation of RCC structures): Quantity estimation of labour, material, equipment for RCC structures, Approximate and detailed costing of projects – direct and indirect, BOQ preparations, owner estimation vs. contractor estimation

Unit 3 (Methods of estimation): Types of estimates – conceptual, plinth area, unit rate, detailed or item rate, supplementary estimate, Inputs to cost estimation, Methods of cost estimation - Analogous Estimating / Top-down Estimating, Parametric Modeling, Bottom-up Estimating, historic, Three-point estimates, Role of BIM in estimation, BIM-based estimation methodology, Application of AI techniques in estimation.

Unit 4 (Project Cost control): Cost control concept, factors effecting cost of project, type of costs, cost budgeting, estimated vs. actual cost comparison, type of variation/deviations – quantity variation, extra items, substitute items, design of project cost control, earned value management, escalation estimation, estimation accuracy, contracts, working capital management, understanding contingency and risk component in estimation.

Unit 5 (Integration of Project management): Relationship between project management and estimation, accuracy of estimation at different stages of project, activity based costing, work breakdown structure, cost coding systems, cost estimation deliverables. Digital tools in surveying.

Unit 6 (Preparation of project cost estimation reports): Carryout the rate analysis and costing for different stages of RCC work, preparation of accepted cost estimate, job cost report, running account bill creation, deviation statement creation, prediction of time and cost due to changes or delays, preparation and delivery of the bid or proposal of an construction project

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Course Resources

a. Essential Reading

1. Class Notes
2. Towey, D. (2017).Construction Quantity Surveying: A Practical Guide for the Contractor's QS
3. Leonard, H, E. John S , Dennis, G, Thomas, C. (2017). Construction Cost Estimating: Process and Practices, Pearson Education; First edition
4. Mubarak,S,A. (2019). Construction Project Scheduling and Control, 4th Edition, Wiley.

b. Recommended Reading

1. Stephenson, H.L. (2015). AACE International Total Cost Management Framework: An Integrated Approach to Portfolio, Program, and Project Management Second Edition.
2. Dutta, B. N., (2000), Estimating and Costing in Civil Engineering, UBS Publishers and Distributors Ltd.
3. CPWD. (2019). Manual for Standard Specification and Rate Analysis.

c. Other Electronic Resources

2. Electronic resources on the course area are available at MSRUAS library

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Course Title	Internship
Course Code	19CMP521A
Programme	M.Tech in Construction Engineering and Management
Department	Civil Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

The aim of this course is to make a student experience an industrial or business environment. The student will visit various departments of an industry/business and observe the activities in each department for a certain duration of time and try to relate his/her experience with the theory practiced back at the faculty. The student should develop a report and make a presentation on his/her experience at the industry/business.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Describe the organization structure of the industry/business
- **CO 2.** Identify Business objectives of the organization
- **CO 3.** Describe the various departments of the organization and their activities and responsibilities to meet the business objectives
- **CO 4.** Discuss the limitations and new opportuinites for growth of the organization
- **CO 5.** Express the education and skill requirement of graduates to pursue their career in industry

Course Contents

Industry Internship in the relevant organization

Course Resources

a. Essential Reading

1. Organization website
2. Discussions with Managers/Mentor/Supervisor of different departments of the organization

b. Other Electronic Resources

4. Electronic resources on the subject area are available at MSRUAS library

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Course Title	Group Project
Course Code	19CMP522A
Programme	M.Tech in Construction Engineering and Management
Department	Civil Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course is intended to provide student an opportunity to synergise their learning from the earlier courses through working in a team, sharing responsibilities, to conceiving, designing and fabricating a working prototype of a system related to an automotive application. The students will learn skills related to project identification, planning, management and execution, working in teams and verbal and written communication. During design, analysis and synthesis stage, they will get an opportunity to apply theoretical knowledge to develop real life product and prototyping stage will provide them experience of converting a design into a working system through use of various fabrication techniques available.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Work in a team and undertake a project in the area of Transportation Engineering
- **CO 2.** Apply Transportation Engineering methodologies and reconfigurable techniques for executing road project
- **CO 3.** Apply appropriate research methodology while formulating a project
- **CO 4.** Define Specifications, Synthesize, Analyse, Develop and Evaluate a project
- **CO 5.** Develop a video which explains the project, exhibit, make a presentation and document the work

Course Contents

Need for undertaking a project, design specifications, design, analysis, design evaluation and presentation.

Project Management Costing, Construction, Procurement, Project Development, Testing, Project Evaluation, Exhibition, Presentation.

Team building, Team work, Leadership skills.

Course Resources

a. Essential Reading

1. Assigned reading relevant to the group project.

b. Other Electronic Resources

5. Electronic resources on the subject area are available at MSRUAS library

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Course Title	Dissertation and Publication
Course Code	19CMP522A
Programme	M.Tech in Construction Engineering and Management
Department	Civil Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course is intended to give an insight to the students on application of principles of research methodology, preparation of research project proposal, research project management, execution of research project and effective technical communication and presentation. It also emphasizes the need and the relevance of a structured approach to identify a research topic and undertake research. This course provides an opportunity for students to apply theories and techniques learnt during programme work. It involves in-depth work in the chosen area of study.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** 1.Critically review scholarly literature collected from various sources for the project purpose and formulate a research problem
- **CO 2.** Prepare and present a research proposal
- **CO 3.** Conduct research to achieve research objectives
- **CO 4.** Propose new ideas/methodologies or procedures for further improvement of the research undertaken
- **CO 5.** Create research document and write research papers for publications
- **CO 6.** Defend the research findings in front of scholarly audience

Course Contents

- Research Methodology
- Information search, retrieval and review
- Project definition and project planning
- Use of conceptual models and frameworks
- Problem solving and Evaluation
- Interpretations and drawing conclusions
- Proposing ideas or methods for further work
- Thesis writing
- Oral presentation
- Authoring Research paper

Course Resources

a. Essential Reading

1. Lecture Sessions on Dissertation, Thesis Preparation delivered b y the concerned Head of Dept.

b. Other Electronic Resources

6. Electronic resources on the subject area are available at MSRUAS library

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