Master of Science in Structural Engineering

CURRICULUM

Faculty of Science and Technology
Pokhara University

2017

POKHARA UNIVERSITY
Master of Science in Structural Engineering

1. Program Objectives

The Master of Science in Structural Engineering program focuses in providing students adequate knowledge and skills that allow them to have a meaningful career in structural analysis, design and construction, including earthquake resistant, economic design in industrial and academic fields. The course offers several optional modules in the field of Structural Engineering. The specific objectives of the program are to provide high skilled human resources capable to perform following tasks.

- Acquiring depth knowledge and understanding of the structural behavior, the students will be able to analyze and design different types of structural forms and materials.
- Acquiring adequate skills, students will be able to perform independently planning and implementation tasks at professional level in structural engineering including the use of appropriate software.
- Students will able to conduct independent research in topics related to structural engineering.

2. Curricular Structure

The curriculum is designed to equip students with competencies, knowledge, skills, and attitudes needed for success in engineering profession. The coursework gives students a broad and holistic view of the complexity of technologies concerning different structural analysis and design in today's world. The curriculum comprises the following distinct components

- **Foundation & Analytical Courses**: The foundation and analytical courses provide the necessary academic background and analytical tools which are pre-requisite to advanced core courses.
- **Core and Functional Courses:** The core and functional courses provide students with the concept of advanced structure analysis, prevailing concept in earthquake resistance design, depth knowledge in advanced concrete technologies and practices, fundamentals of international code of practices and use of advanced software.
- **Elective Courses:** Students are required to take five courses of three credit hours each as electives. One of the electives chosen should be of general nature such as management.
- **Thesis**: Students are required to undertake a graduate research related to structural engineering that may involve site visit, data collection and its analysis, analytical studies and laboratory verification. Students are given choices to carry out the depth research work in any field ranging from materials structures, processing and formation of various structural elements, strength, durability as well as their durability aspects. This component covers 12 credit hours.

3. Program Features

The features of the program are competitive learning environment, research-oriented concentrations and program certainty. The M. Sc. in Structural Engineering is a two-year program spread over four semesters. Each student needs to successfully complete 48 credit hours of course work and 12 credit hours of thesis.

The program will use a range of pedagogical inputs that includes on-campus learning through classroom discussions, presentations, group work, case analysis and guest lecture series, and off-campus learning through project work, on-line instructions.

4. The Semester System

In the program, each course has a certain number of credits assigned to it depending on its lecture, tutorial and practical work hours in a week. One lecture hour per week per semester is assigned one credit. That is, for a theory course, a three-credit hour course has 45 lecture hours in a semester.

Some of the prominent features of the semester system are the process of continuous evaluation of a student's performance and the flexibility to allow him/her to progress at a pace suited to his/her individual ability, subject to the regulation of credit requirements.

5. Entry Requirements and Admission Procedures

Eligibility

Candidates with Bachelor's Degree in Civil Engineering are eligible to join the program. The applicants must have along with the above requirements a minimum of 16 years formal education (12 years of schooling plus four years of undergraduate studies). The applicants must have secured a minimum CGPA of 2.0 out of 4.0 or at least second division marks at the Bachelor's degree.

Documents Required

Applicants are required to submit the following documents with the application form made available by the concerned college by paying a predetermined fee:

- Completed and signed application form.
- Attested transcripts from all the academic institutions attended.

Enrolment is conditional upon completion of all admission formalities including payment of fees as determined by the college. Incomplete applications shall not be processed.

Admission Procedures

A notice inviting applications for admission is publicly announced. Application forms and information brochures are provided, on request, after the payment of the prescribed fee. The concerned college scrutinizes the application. The eligible candidates are informed to take the entrance test. The date and time for the entrance test are informed to the applicants by the concerned colleges.

Final selection of students will be made on the basis of their aggregate scores in the entrance test, experience and their previous academic records. A college may, however, modify the selection procedure to suit its needs with prior approval of the Dean.
The candidates, who are given provisional admission under special condition, are required to submit all necessary documents within a month of the beginning of regular classes. Otherwise, the admission will be canceled.

6. Academic Schedule and Course Registration

The academic year consists of two semesters. The admission to the program will be given twice a year as per the schedule published by the college.
Students are required to register courses at the beginning of each semester. Since registration is a very important procedural part of the credit system, all students must present themselves

at the college for registration. Registration in absence may be allowed only in rare cases at the discretion of the principal. A student's nominee cannot register for courses but will only be allowed to complete other formalities.

7. Addition and Withdrawal from Courses

A student would have the option to add or drop from the course. This can, however, be done only during the first week of the semester. A student wishing to withdraw from a course, should apply on the prescribed from within two weeks from the starting date of the semester. A full-time student has to take a minimum of 12 credits in a semester.

8. Attendance Requirements

The students must attain every lecture, tutorial and practical class. However, to accommodate for late registration, sickness and other such contingencies, the attendance requirements will be a minimum of 80% of the classes actually held. Students will get NOT QUALIFIED (NQ) status in a course if s/he fails to maintain 80% attendance in the course.

9. Normal and Maximum Duration of Study

The normal duration and the maximum duration for the completion of the requirements for the programs are as follows:

Normal duration: 24 months (4 semesters)
Maximum duration: 4 + 1 years from the date of registration

(All the courses have to be completed within 4 years, and additional 1 year can be given to thesis work on special request upon the approval of concerned authority).

10. Evaluation System

A student's academic performance in a course is evaluated in two phases as:

- Internally by the concerned faculty member and
- Externally by the office of the Controller of Examinations through semester-end examinations.

A sixty percent weight is given to internal evaluation and forty percent weight is given to external evaluation. The pass marks for both the internal evaluation and external evaluation is sixty percent. A student must qualify in both evaluations separately to get a pass grade in a particular course. The final grade awarded to a student in a course is based on his/ her consolidated performance in both internal and external evaluations.

The internal evaluation may consist of various components like project works, quizzes, presentations, written examinations, reflection notes preparation, and the like. A student will get NOT QUALIFIED (NQ) status in the internal evaluation if his/ her performance falls below the minimum requirement. Such students will not be allowed to appear in the semester-end examination of the particular course.

11. Repeating a Course

A course may be taken only once for grade. Since passing of all courses individually is a degree requirement, students must retake the failing course when offered and must successfully complete the course. A student will be allowed to retake maximum of two passed courses to achieve a minimum CGPA of 3.0. The grade earned on the retake examination will substitute the earlier grade earned by the student in that course. A student can retake a course only when it is offered by the college/ university.

12. Grading System

Pokhara University follows a four-point letter grade system. The letter grades awarded to students will be as follows:

Letter Grade	Grade Point	Description
A	4.0	Excellent
A-	3.7	
B+	3.3	Good
B	3.0	Fair
B-	2.7	
C+	2.3	
C	2.0	Pass in Individual Course
F	0.0	Fail

If a student cannot finish all the assigned works for a course, he/she will be given an incomplete grade 'I'. If all the required assignments are not completed within the following semester, the grade of 'I' will automatically be converted into 'F'.

The performance of a student is evaluated in terms of two indices: (a) Semester Grade Point Average (SGPA) which is the grade point average of the particular semester, and (b) Cumulative Grade Point Average (CGPA) which is the grade point average of all the semesters.

$$\text{SGPA} = \frac{\text{Total honor points earned in a semester}}{\text{Total number of credits taken in a semester}}$$

$$\text{CGPA} = \frac{\text{Total honor points earned}}{\text{Total number of credits completed}}$$

Where,

Honor point = Grade point earned in a course × Number of credits assigned to that course.

13. Degree Requirements

To graduate from the M.Sc. program, a student should have

- 'C' or better grade in each of the courses as specified in the curricular structure;
- Completed all the courses, and thesis as specified in the curricular structure within the maximum time period specified;
- Final CGPA of 3.0 or better on the University's 4.0 grade scale.

14. Distinction and Dean's List

A student who obtains a cumulative GPA of 3.75 or better will receive the M.Sc. degree with distinction. The Dean's list recognizes outstanding academic performance. To qualify to this list, a M.Sc. student must have a CGPA of 3.80 or better.

15. Credit Transfer and Withdrawal

A maximum of 25% of the total credit hours of course work completed by a student in an equivalent program of a recognized university/ institution may be transferred/ waived for credit by the Dean on the recommendation of the principal/ head of the school/ college. However, for such transfer of credit, a student must have received a grade 'B' or better in the respective course. Courses taken more than two years earlier than the date of application will not be accepted for transfer of credit.

Credit transfer will also be allowed from different programs of Pokhara University. In such cases, all credits earned by students in compatible courses with a minimum grade of B may be transferred to the new program.
The student may apply for withdrawal from the entire semester only on medical grounds.

16. Unfair Means

The following would be considered as adoption of unfair means during examination:

- Communicating with fellow students for obtaining help
- Copying from another student's script/report/paper
- Copying from disk, mobile, palm of hand or other incriminating documents and equipment
- Possession of any incriminating documents, whether used or not
- Any approach in direct or indirect form to influence teacher concerning grade
- Unruly behavior which disrupts academic program

If the instructor detects a student using unfair means, the student may be given an 'F' grade at the discretion of the Examination Board. Adoption of unfair means may result in the dismissal of the student from the program and expulsion of the student from the college and as such from Pokhara University.

17. Dismissal from the Program

A student is normally expected to obtain a SGPA of 3.0 in the semester-end examinations of the M.Sc. program. If a student's performance falls short of maintaining this continuously over the semesters, he/she may be advised to leave the program or dismissed from the program.

18. Detailed Curricular Structure

Students of M.Sc. Structural Engineering program are required to complete 48 credit hours of coursework and 12 credit hours of thesis.

The first semester is focused on developing the foundation required for learning the core/functional area with laboratory-oriented course.

Curricular Structure and Course Cycle

Semester I			Semester II		
Course Code	Course Description	Credit Hours	Course Code	Course Description	Credit Hours
STR 501	Advanced Structural Analysis	4	STR 506	Finite Element Method	3
STR 502	Dynamics of Structures	3	STR 507	Earthquake Resistant Design	3
STR 503	Solid Mechanics	3	ACT 508	Advanced Concrete Technology	3
MTH 504	Numerical Methods and Analysis	3		Elective I	3
GTH 505	Foundation Analysis and Design	4		Elective II	3

Semester III			Semester IV		
Course Code	Course Description	Credit Hours	Course Code	Course Description	Credit Hours
STR 509	Advanced Structural Design	4	STR 511	Thesis	12
STR 510	Structural Engineering Laboratory	3			
	Elective III	3			
	Elective IV	3			
	Elective V	3			

Elective Courses

Initially the following courses have been identified for electives. These courses offer students the flexibility to customize their needs and meet their career interests and goals. These are basically sectorial and application courses which address the systematic integration across structure related disciplines. Additional elective options may be offered by a college/school with the prior approval of the Subject Committee and the Dean.

Elective I & II (Each 3 credits)			
Course Code	Course Description	Course Code	Course Description
STR 601	Applied Seismology	MSE 605	Research Methodology
STR 602	Rock Mechanics	SHA 606	Seismic Hazard Analysis
STR 603	Theory of Plates and Shells	DSM 607	Disaster Management
CAD 604	Computer Added Design		

Elective III, IV & V (Each 3 credits)			
STR 701	Bridge Analysis and Design	STR 710	Fracture Mechanics of Concrete
MSE 702	Pre-Stressed Concrete	STR 711	Health Monitoring of Structures
MSE 703	Design of Industrial structure	STR 712	Advanced Design of Steel Structures
HYD 704	Hydraulic Structures	STR 717	Tunnel Engineering
MSE 705	Design of high rise building	STR 714	Optimization in Structural Design
MSE 706	Geotechnical Earthquake Engineering	STR 709	Repair and Rehabitation of Structures

STR 707	Design of Thin Shell Structure	STR 715	Seismic Assessments and Retrofitting of Structures
STR 708	Design of Masonry Structures	SRA 716	Seismic Risk Analysis
STR 713	Non-Linear Analysis of Structures		

19. Thesis (Research Project)

In the fourth semester of their study period, participating students are required to undertake a research project and prepare an integrative research report in any appropriate area of Structural Engineering as approved by the college/school. Students are required to give a pre-defense presentation of their report as organized by the college/school. For the evaluation of the research report, the college/school shall appoint internal and external examiners. The external examiner shall be appointed from the list approved by the Office of the Dean.

The students have to prepare appropriate title of the study with appropriate literature survey and present proposal in the college. After approval of the proposal, student has to conduct the research under the guidance of the supervisor appointed by the college/school. After the field work is completed, data analyzed, report prepared, student has to present pre-defense presentation with the recommendation of the supervisor. After incorporating the comments students have to present the final defense, incorporate comments received and submit final thesis for evaluation in the college/school. To be eligible to final defense, students have to clear all the courses. The student has to use the approved format for the proposal and thesis as provided by the college.

Evaluation Scheme

S. N.	Activity	Maximum Marks allocated for scheduled submission or delayed submission
1.	Proposal submission final defense for approval	10
2.	Mid-term report presentation	15
3.	Workshop/seminar presentation	10
4.	Final thesis presentation	50
5.	Final report	15
	Total	**100**

STR 501: Advanced Structural Analysis (4 – 0 – 0)

Course Objectives:

The main objective of this course is to provide basic concepts for the structural analysis of structural elements. This course enables students to perform analysis of advanced structures.

Expected Learning Outcomes:

On completion of this course, the students will be able to:

- Generate stiffness matrix of a framed structure and use it for analysis of structure.
- Prepare the rational modeling of structures in reference with Finite Element Method.
- Use the basic methods and approach adopted in structural analysis software package.

Course Contents:

1. General Introduction (04 hrs)

Review of basic structural analysis, Flexibility and stiffness matrix method

2. Matrix Displacement Approach (12 hrs)

Introduction, Stiffness matrix of a bar element subjected to axial force, Co-ordinate transformation, Global stiffness matrix, Application to pin-jointed frames, Stiffness matrix of a beam element, Application to continuous beams

3. Matrix Displacement Analysis of Frames (12 hrs)

Matrix analysis of planar rigid-jointed frames, Axial strain in the analysis of planar rigid-jointed frames, Inclined supports, temperature effects, Sinking of supports, Fabrication errors

4. Matrix Displacement Analysis of Grillage, Plates and Shells of Revolution (10 hrs)

Co-ordinate transformation, Element Stiffness Matrix and its application, Conventional and numerical methods of analysis

5. Matrix Displacement Analysis of Three-dimensional Structures (12 hrs)

Co-ordinate transformations, Application to space trusses and space frames

6. Use of Computer Software Packages (10 hrs)

References:

1. Dawe, D. J. Matrix and Finite Element Displacement Analysis of Structures, Clarendon Press, The Oxford University Press, New York, 1984.
2. Wang C. K., Computer Methods in Advanced Structural Analysis, Intex Educational Publishers 1973.
3. Gere. J. M & Weaver. W., Matrix Analysis of Framed Structures3rd Edition, Van Nostrand Reinhold, CBS Publishers and distributors 1990.
4. Martin, H.C. Introduction to Matrix Methods of Structural Analysis, McGraw-Hill, 1966.
5. Jain, A.K., Advanced Structural Analysis with Computer Applications, Nem Chand & Bros., Roorkee, 2nd Ed.

STR 502: Dynamics of Structures (3 – 0 – 0)

Course Objectives:
The objective of this course is to impart knowledge of the conventional engineering solutions for the dynamic problems due to effects of earthquake, wind and impact.

Expected Learning Outcomes:
On completion of this course, the students will be able to:
- Describe the salient features of dynamic problems.
- Analysis the multi-degree lumped mass structures.
- Apply the time domain and frequency domain dynamic analysis methods.

Course Contents:

1. Introduction (02 hrs)
Sources of vibration, Problems related to structural dynamics, Degrees of freedom, Types of vibrations

2. Single Degree of Freedom (SDOF) System (10 hrs)
Simple harmonic motion, Equation of motion of discrete system, Modeling of single degree of freedom (SDOF) structures, Free vibration response (damped and un-damped) of SDOF system, Forced vibration response of SDOF system to harmonic forces, Forced vibration response of SDOF system to periodic forces, Forced vibration response of SDOF system to impulsive forces, Forced vibration response of SDOF system to general dynamic forces, Time domain analysis, Frequency domain analysis

3. Multi Degree of Freedom (MDOF) System (10 hrs)
Modeling of MDOF system structures, Equation of motion of MDOF system, Concept of generalized coordinate, Lagrange's equations of motion, Vibration absorption and orthogonality properties, Free vibration response (un-damped and damped) of MDOF system, Natural frequencies and mode shapes, Normal coordinates and Normal Mode Theory, Forced vibration response of MDOF system, Practical methods to determine natural frequencies and mode shapes by Stodola's, Holzer's and Transfer matrix methods

4. Dynamic Analysis for MDOF System (07 hrs)
Frequency domain analysis for general dynamic forces and support motion for MDOF, Time domain analysis using numerical integration scheme for general dynamic loading for MDOF system

5. Continuous System of Structures (08 hrs)
Partial differential equations of motion (for string, bar, beam), Axial vibration of a bar, Transverse vibration of a beam, Transverse vibration of an Euler beam, Torsional vibration of a bar, Approximate methods to determine natural frequencies and mode shapes in cases where orthogonality conditions are not satisfied

6. Introduction to Non-linear Dynamic Analysis (08 hrs)
Elastic and inelastic behavior, Incremental equations of equilibrium; Step-by-step integration method

References:

1. Clough R. W., Penzien J, Dynamics of Structures, McGraw Hill. international Edition1998.
2. Chopra Anil, Dynamics of Structures, McGraw-Hill International Edition, 1998.
3. Thomson W. T., Theory of Vibration with Applications, Prentice Hall, 5th Editon, 1997.
4. Paz, Mario, Structural Dynamics Theory & Computation, Von Nostrad Reinhold Company, Inc.
5. Humour, J.L., Dynamics of Structures, Second Edition, McGraw-Hill International Edition, 1989.

STR 503: Solid Mechanics (3 – 0 – 0)

Course Objectives:
The objective of this course is to make the students understand theoretical approach of advanced structural analysis and make them able to analyze material and structure under complex loading.

Expected Learning Outcomes:
On completion of this course, the students will be able to:
- Describe the stress and strain state of solids.
- Synthesize the effects of simple stress conditions in structural elements.
- Extend the elastic problems to the plastic state of materials.

Course Contents:

1. Analysis of Stress and Strains (5 hrs)
Concept of body force, Surface force and stress tensor, Stress at a point, Normal and shear stresses, Stress on an arbitrary plane, Stress components on a rectangular parallelepiped in Cartesian coordinate system, Derivation of stress equilibrium equations, Transformation of stresses, Stress invariants, Displacement relations, Strain at a point, Strain compatibility condition

2. Stress-Strain Relationship (6 hrs)
Generalized Hook's law for Isotropic, Orthotropic, Transversely Isotropic materials; Plane stress, strain; Problems in 2D Cartesian coordinate system; Airy's stress function, Bending of beams, Principle of virtual work and its application

3. Polar Coordinate System Equations (6 hrs)
Equilibrium equations, Partial differential equations and integral Equations, Strain displacement relations, Stress-strain relationship; Fourier integral, Functional Approximation Strain-displacement relationship for plane stress and plane strain conditions, Bending of curved bar, Stress concentration problems

4. Axisymmetric Problems (7 hrs)
Equilibrium equations, Strain displacement relations, Stress-strain relationship, Stress compatibility equations, Plane stress and Plane strain conditions, Cylinders and shell structure subjected to internal and external pressure, Plate bending theory

5. Torsion (8 hrs)
Assumptions and Torsion equation for general prismatic solid bars, Warping of Non-circular sections, St. Venant's theory, Prandtle's stress function approach, Torsion of Circular, Elliptical and Triangular cross-section bar, Torsion of thin-walled structures by membrane and bending analogy, Torsion of rolled sections and shear flow analogy

6. Beams on Elastic Foundation (8 hrs)
Differential equation, Elastic theory, Infinite beams with concentrated load, concentrated moment and uniformly distributed load, Semi-Infinite beams with free end subjected to uniformly distributed load, Hinged end, Finite beams with free end and hinged end, Finite beams with both end fixed

7. Introduction to problem in plasticity (5 hrs)

Physical assumptions criterion of yielding, Yield surface, Flow rule (plastic stress & strain relationship), Elasto- plastic problems of beams and frames in bending, Plastic torsion in non-circular section.

References:

1. Timoshenko and Goodier - Theory of Elasticity, McGraw-Hill Publications.
2. S. Crandall, N. Dahl and T. Lardner - Mechanics of Solids, McGraw Hill Publications.
3. Wang - Applied Elasticity, Dover Publications.
4. Irving Shames, Mechanics of deformable solids, Prentice Hall.
5. Sadhu Singh. Theory of Elasticity Khanna Publishers, 1979 - 658
6. Srinath L. S. Third Edition, Advanced Mechanics of Solids, Tata McGraw-Hill Publishing Company Limited.
7. Tek Raj Gyawali, Solid Mechanics Manual for ME Students.

GTH 505: Foundation Analysis and Design (4 – 0 – 0)

Course Objectives:

The course gives a basic understanding of the nature of soil, analysis and design of Sub-structures resting on various types of soil strata below ground level including selection of appropriate foundation type. This course also makes understanding of construction procedure of Foundation.

Expected Learning Outcomes:

On completion of this course, the students will be able to:

- Determine the requirements of subsoil and bases of structures.
- Analyze and design different kinds of foundation structures.
- Extend the theories to advanced type of foundation and retaining structures.
- Be familiar about the construction methods of foundation.

Course Contents:

1. Review of Soil Mechanics (04 hrs)

Phase relationship, Soil classification, Soil water interaction, Stress distribution, Shear strength and consolidation

2. Introduction to Soil Exploration (02 hrs)

Boring, Sampling and in-situ, Testing of soil

3. Basic Requirement and Types of Foundation (10 hrs)

General requirements for the design of foundations, Soil interaction theories for analysis of foundation, Different types of foundations; Types and suitability of shallow foundations, Review of: general principles, settlement and Lateral Pressure, factors affecting location and depth of foundation

4. Analysis of foundation (13hrs)

Bearing capacity and settlement analysis, Bearing Capacity theories: Tezaghi, Meyerhof, Brinch Hansen: foundations subjected to eccentric and inclined loads; foundations on slopes, Types of mat foundations; design of mat foundations by conventional method, elastic line method and finite difference method

5. Design of foundation (16 hrs)

Design of shallow foundation: spread footing, Strap footing, combined footings, Types and methods of designing pile foundations; bearing capacity and settlement analysis and design of piles and pile groups, laterally loaded piles, pile groups subjected to inclined loads, Pile testing, Design of bridge-sub-structures, Design of sheet pile walls, Design of Retaining wall, Soil Dynamics and Design of machine Foundation, Design of coffer dams and diaphragm walls

6. Construction of Foundation (13 hrs)

Construction of pile foundations, Combined design of pile and mat foundations, Types and components of well foundations, methods for the design of well foundations, Construction and/or well sinking problems and their solutions

7. Case Study **(02 hrs)**

Problem related to Foundation Failure, Piping Failure, Retaining Structure Failure

References:

1. Selva Durai, APS, *Elastic analysis of soil foundation interaction.* Elsevier Scientific Pub. Co., 1979 - Technology & Engineering
2. Poulos, HS & Davis EH, Pile *foundation analysis and design*1980 Wiley
3. Scot, R.F *Foundation Analysis*. Prentice-Hall, Jan 1, 1981 - Technology & Engineering
4. State of Art Report, Structure *Soil interaction*, Institution of Structural Engineers,1978
5. Joseph E. Bowles P. E, S. E. *Foundation Analysis and Design*, Fifth Edition, The McGraw Hill Companies, Inc.
6. Das Braja M. *Principles of Foundation Engineering*, Seventh Edition, Cengage Learning

MTH 504: Numerical Methods and Analysis (3 – 0 – 2)

Course objective:
The course aims to introduce numerical methods used for the solution of engineering problems. The course emphasizes algorithm development and programming and application to realistic engineering problems.

Expected Learning Outcomes:
On completion of this course, the students will be able to:
- Identify the need and application of numerical methods in structural engineering.
- Use various numerical techniques for solutions of structural related problems.
- Solve different linear and non–linear structural related equations.

Course Contents:

1. Introduction **(5 hrs)**
Introduction, History & Importance of Numerical methods, Approximation and Errors in computations, Analog and Numeric Data, Floating point representation and errors-Normalized floating-point forms, Errors in representing numbers, Floating point machine number and machine epsilon, Loss of significance and its avoidance, Use and importance of Computer Programming in Numerical Methods

2. Roots of Equation **(6 hrs)**
Introduction, Methods of solutions, Horner's Rule, Locating roots of f(x)=0 Bisection method and convergence analysis, Newton's method and convergence analysis, Failure of Newton's method due to bad starting points, Modification of Newton's method for multiple roots, Newton's method for System of Non-linear equations, Secant method and convergence analysis

3. Interpolation and Numerical Differentiation **(6 hrs)**
Newton's Interpolation (forward, backward), Polynomial interpolation and its existence Lagrange and Newton form of interpolating Polynomial, Divided difference and recursive property, Inverse interpolation, Error in Polynomial interpolation, First and Second derivative formulae via interpolation Polynomials, Least square method, Spline Interpolation, Monte Carlo Method

4. Numerical Integration **(6 hrs)**
Trapezoidal, Simpson's and adaptive Simpson rules and Error analysis, Romberg's method, two and three-point Gaussian quadrature formula, Double integrals using trapezoidal and Simpson's rules, Euler-Maclaurin series, Newton-cotes formula

5. Solution of Linear & Non-linear Equations **(8 hrs)**
Gaussian elimination and back substitution–partial and complete pivoting, Tridiagonal and pentadiagonal banded systems, Thomas algorithm, Doolittle, Cholesky and Crout LU decomposition methods, Jacobi and Gauss–Seidel iterative methods and convergence theorems, Power (and inverse power) method of obtaining largest (smallest) eigenvalue and corresponding eigenvector. Iterative methods, Numerical Analysis, Error estimates, solution of algebraic and transcendental equations, Iterative algorithms, convergence, Newton Raphson Procedure, Solution of polynomial equations, Methods of elimination, Method of relaxation, Iterative methods, ill-conditioned systems, computing the inverse matrix, Eigenvalues and

eigenvectors, matrix decomposition.

6. Ordinary and Partial Differential Equations (8 hrs)

Initial value problem, Picard's, Taylor series method, Runge-Kutta first, Second and fourth order methods, Adaptive Runge-Kutta method of fifth order (derivation of Runge-Kutta first and second order methods), Boundary value problems-shooting methods for linear differential equations, Multistep methods, Milne's and Adams-Bashforth predictor and corrector methods, Relaxation method, Solution of boundary value problems by different methods, Numerical solution of Partial differential equations (Elliptic, Parabolic, Hyperbolic)

7. Special Functions (6 hrs)

Legendre's formula, generating functions for Legendre's polynomials and recurrence formulae, Bessel's function, Recurrence formula, Bessel's function of integral order

References:

1. Veerarjan, T and Ramachandran, T. *Numerical methods with programming in "C"* Second Edition, Tata McGraw-Hill Publishing Co. Ltd. (2007).
2. Rajasekaran S, "*Numerical Methods in Science and Engineering-A practical approach*", AH wheeler & Co.
3. Grawal B.S., "Numerical *methods in Engineering and Science*", Khanna Publications.
4. Sankara Rao K, *Numerical Methods for Scientists and Engineers"* – 3rd edition Prentice Hall of India Private Ltd, New Delhi, (2007).
5. Chopra, S. C and Canale, R. P. "*Numerical Methods for Engineers*", 5th Edition, Tata McGraw-Hill, New Delhi, 2007.

Practical works

1. Write a program to find the roots of an equation f (x) = 0 using various method.
2. Write a program to find the integral of a function using various methods.
3. Write a program to solve the system of equations Ax = b in various algorithm.
4. Write a program to find the largest (or smallest) Eigen value and corresponding eigen vector of a square matrix using power (or inverse power) method.
5. Write a program to solve first and second order ordinary differential equations (initial value problem) using Runge-Kutta fourth order method.
6. Write a program to solve first o and second rder ordinary differential equations (initial value problem) using adaptive Runge-Kutta method.

STR 506: Finite Element Method (3 – 0 – 0)

Course Objectives:
The objective of this course is to make the students able for analysis of various structures in discrete form and negotiate to support with basic knowledge for further developed programming.

Expected Learning Outcomes:
On completion of this course, the students will be able to:

- Describe the basic principles of finite element method.
- Apply different elements and principles conducive to the type of structural analysis.
- Apply Finite Element Method in developing subroutines.

Course Contents:

1. Introduction to Finite Element Analysis (4 hrs)
Computational mechanics and FEM, Statics vs dynamics analysis; Linear vs non-linear analysis; Spatial discretization methods; What is finite element? Archimedes FEM; The physical FEM – computational steps; History of development & application of FEM; Advantages and disadvantages of FEM; DSM in FEM with numerical examples and exercises

2. Introduction to Elasticity and Solid Mechanics (4 hrs)
Stress and strain tensors; Strain displacement equations (compatibility); Generalized Hooke's law (Constitutive law); Plane stress problem; Plane strain problem; Stress transformation equilibrium; Yield conditions; Tresca and Von-Mises Criteria; Examples and exercises

3. 2 D Stress Analysis using CST (4 hrs)
Triangular element, Displacement field in terms of nodal displacements, Strains in terms of displacements, Constitutive law, Nodal forces using equilibrium, Assembly of element Stiffness, Boundary condition (Elimination & Penalty Approach), Solution for nodal displacements, Examples and exercises

4. Storage Schemes and Solution of Large System of Linear Equations (2 hrs)
Band matrix, Band width reduction, Skyline technique, Frontal solver, Sub structuring technique, Program writing for FEA Problems

5. Energy, Variational Principles and Ritz Technique (4 hrs)
Work, Energy and their complimentary counterparts, Principle of virtual work (Example), Principle of stationary potential energy; Minimization of total potential–stability of equilibrium (Example), Variation calculus– the minima of functional (Example); Ritz technique (Example); Galerkin approach

6. Higher Order Triangular Elements (4 hrs)
Linear strain triangle (LST stiffness using natural coordinates), Quadratic strain triangle (QST-I and condensed stiffness), Quadratic strain triangle (QST-II, Introduction), Comparison of CST, LST and QST computations; Rate of convergence; Numerical examples and exercises

7. Rectangular and Quadrilateral Elements (4 hrs)
Serendipity family, Linear serendipity rectangle, Higher order serendipity elements, Lagrangian family, Second order Lagrangian element, Hermitian family (Introduction),

Quadrilateral element from CST elements – example, Examples (shape function and nodal load vector), Comments and exercises

8. Three-dimensional elements – Axisymmetric Stress Analysis (4 hrs)
Introduction, Basic axi-symmetric elements, Axi-symmetric solid elements; Three-dimensional elements – Tetrahedral family, Rectangular hexahedral elements

9. Stress Analysis using Isoparametric Elements (4 hrs)
Shape function mapping, Uniqueness of mapping, Sub-Iso-super parametric elements, Isoparametric bar, Isoparametric quadrilateral, Numerical integration using Gaussian Quadratures, Numerical examples and Home works, Hexahedron element family, Order of quadrature needed, Incompatible elements

10. Finite Element Analysis of Plates & Shells (4 hrs)
Basic theory of plate bending, Displacement functions, Theory of shells, Plate elements, Shell elements

11. Buckling and Dynamic Analysis – The Eigen Value Problems (4 hrs)
Introduction, Linear stability analysis, Bifurcation problem and beam column problems, Dynamic analysis, Pin jointed truss element (Example), Beam element (Examples), Concept of master and slaves

12. Introduction to Nonlinear Stress Analysis (3 hrs)
Introduction, Solution algorithm and convergence criteria, Stress stiffening, Geometric non-linearity, Material nonlinearity, Problems of gap and contact, Strategy, Modeling and convergence, Applications

References:

1. Rjasekaran S., *Computer and Structural Analysis*, M. Mukhopadhyay, 1993, Oxford IBH publishing company.
2. Cook R.D., *Finite Element Modeling for Stress Analysis*, John Wiley and Sons, 1995.
3. Klaus Jurgen Bathe, *Finite Element Procedures*, Prentice Hall second edition, 1996.
4. Zienkiewicz O.C. and R. L. Taylor, The *Finite Element Method*, New York McGraw Hill, 1991.
5. Reddy J. N. 1993, *An Introduction to Finite Element Method*, Mc-Graw Hill, New York, second edition.

STR 507: Earthquake Resistant Design (3 – 0 – 0)

Course Objectives:
The course gives a basic understanding of the nature of earthquakes, analysis of structures subjected to earthquakes and design of structures to resist strong ground motions.

Expected Learning Outcomes:
On completion of this course, the students will be able to:

- Identify causes and effect of Earthquakes.
- Use different methods of analysis and design of earthquake resistant structures.
- Analyze and design buildings and other structures based on prevailing seismic codes.

Course Contents:

1. Introduction (2 hrs)
Effects of earthquakes, Theories and criteria of seismic design, Basic requirements for Seismic resistant structures.

2. Fundamentals of Earthquake Engineering (8 hrs)
Earthquakes and seismicity, Causes of earthquakes, Mechanism of earthquakes, Measures of earthquakes, Attenuation laws, Temporal and spatial models of earthquakes, Response spectrums of earthquakes, Seismic zoning**,** Seismic hazard analysis

3. Probability Theory (6 hrs)
Random variables, Distribution functions, Multi-dimensional random variables, Conditional probability, Statistical independence, Central limit theorem, Liapanov's and Linderberg Feller's Theorems

4. Response of Structures (4 hrs)
Review of single degree of freedom system to support movement, Mode shapes and frequencies of multi degrees of freedom system, Normal mode theory, Mode participation factors, Pseudo static force in each mode of vibration due to earthquake

5. Lateral Load Resisting Systems for Buildings (8 hrs)
Different structural systems for lateral loads, Floor diaphragms, Lateral load distribution with rigid floor diaphragms, Moment resisting frames, Lateral load distribution in frame buildings, RC shear walls, RC shear wall with openings, Frame– shear wall system, Load bearing unreinforced and reinforced masonry walls

6. Response Spectrum Analysis (4 hrs)
Response spectrum analysis for MDOF system for single point excitation, Time history analysis of MDOF system for single and multi-point excitations

7. Hydro Dynamic Effects of Earthquake (4 hrs)
Pressure against dam, Vibration of liquids in tanks, Vibrations of submerged structures like Piers and Caissons

8. Design of Structures for Earthquakes (6 hrs)
Plastic design of structures for earthquakes, Simplified design based on energy criterion, Ductility factor method, Code provisions

9. Introduction to Structural Control (3 hrs)

Active and passive control, Various technique of passive control, Overview of base isolation concept

References:

1. Newmark, N. M., and Rosenblueth, E., *Fundamentals of Earthquake Engineering*, Prentice-Hall, Inc. Englewood Cliffs, N. J., 1971.
2. S.L. Kramer, *"Geotechnical Earthquake Engineering"*, Prentice Hall, Upper Saddle River, NJ 1996
3. David Dowrick, *Earthquake Resistant Design and Risk Reduction*, 2009, John Wiley & Sons, Ltd.
4. W.F. Chen (Editor), E.M. Lui (Editor). *Earthquake Engineering for Structural Design*, CRC, 2005
5. H. Freeman, Bruce Bolt, *Earthquakes*, Fifth Edition W.; 5th edition, 2003

ACT 508: Advanced Concrete Technology (3 – 0 – 2)

Course Objectives:
The main objective of this course is to provide the advanced knowledge on importance of concrete with respect to design and quality control to be implemented in order to achieve required strength and durability of advanced structures.

Expected Learning Outcomes:
On completion of this course, the students will be able to:

- Design and construct different types of concrete products in different advanced structures.
- Quality control to be adopted in batching plant and construction sites.
- Develop new types of concrete to be required for infrastructure development of Nepal.

Course Contents:

1. Introduction (4 hrs)
Review of different standard design methods (DOE, ACI and IS) of concrete mix proportions, General review on strength and durability of concrete

2. Properties of Ingredients and Mix Design (5 hrs)
Types and characteristics of ingredients, Theoretical aspect of mix design, Practical aspect of mix design, Mix design change criteria in site

3. Mixing (6 hrs)
Dispersion and coating mechanism of particles, Mechanism of mixing, Types and efficiencies of mixers, Role of water particle and inter-particle forces, Quality control on ready mixed concrete (RMC) plant

4. Fresh Concrete (6 hrs)
Rheology of freshly mixed concrete, Importance of air content, Required quality control

5. Placing, Compaction and Curing (7 hrs)
Different types of construction methods, Total quality management (TQM) in construction, Safety management, Importance and types of curing

6. Different Types of Concrete and Construction Method (8 hrs)
Workable concrete, Dam concrete, Roller compacted dam (RCD) concrete, Self-compacting concrete (SCC), High strength concrete, Marine concrete, Fiber concrete, High ductile concrete (HDC), Recycled concrete, Concept for development of new types of concrete

7. Strength and Durability of Concrete (6 hrs)
Development mechanism of strength in concrete, Creep and shrinkage, Selection of materials for high strength and durable concrete, Affecting factors for durability

8. Update on Recently Developed Concrete Technologies (3 hrs)
Introduction of Recently Developed Technologies in Concrete, Review of International Journal Papers

Experiments and Tests:

1. Development of different types of concrete (workable, dam, high strength and self-compacting concrete etc.)
2. Development of light weight concrete
3. Development of different fiber concretes

References:

1. Treval C. Powers, *The properties of Fresh Concrete.* John Wiley & Sons, Inc.1968
2. A. M. Neville, *Properties of Concrete.* 5th Edition.
3. A. M. Neville, J. J. Brooks, *Concrete Technology*, Second Edition
4. Tek Raj Gyawali, *Concrete Manual for ME Students*

STR 509: Advanced Structural Design (4 – 0 – 0)

Course Objectives:
The main objective of this course is to provide basic concepts for the design of various reinforced concrete elements with codal provisions of structures of special nature

Expected Learning Outcomes:
On completion of this course, the students will be able to:

- Use different approaches of designing non-conventional structural elements.
- Analyze and design advanced structural elements with various methods.
- Co-relate the design methods with codal provisions.

Course Contents:

1. Introduction (06 hrs)
Review of limit state design for shear flexure torsion and combined stresses of beams, Slabs & slender columns according to IS 456-2000, Safety and serviceability, Calculation of deflection & crack width according to IS 456–2000

2. Design of Special RC Elements (18 hrs)
Design of slender columns, Grid floors, curved beams, Deep beams, Plain and reinforced concrete walls, Corbels & edge (Spandrel) beams, Reservoir, Shear wall

3. Slabs (18 hrs)
Design of circular & flat slabs, Yield line analysis of slabs

4. Folded Plates (10 hrs)
General features and types, Structural behavior, Analysis & design of sectoral plates, Design using program and CAD software

5. Pre-stressed Concrete Structure Design (08 hrs)
Design of statically determinate and indeterminate pre-stressed concrete structure

References:

1. Krishna, R. N., *Advanced Reinforced Concreted Design.* New Delhi: CBS Publishers& Distributors.2005
2. Varghese P. C., *Advanced Reinforced Concrete Design.* New Delhi: Prentice Hall of India. 2002
3. Bhavikatti S. S, *Advanced RCC design,* New Age International.2008

STR 510: Structural Engineering Laboratory (1 – 0 – 3)

Course Objectives:
This course gives knowledge of the experimental tests to assure the strength, stiffness and stability of structures under possible different actions.

Expected Learning Outcomes:
On completion of this course, the students will be able to:
- Test simple structural elements in a laboratory conditions.
- Verify the analytical results through experiments.
- Investigate existing structural conditions of structural elements through destructive/ Non-destructive methods.

Course Contents:

1. Concrete Lab (7 hrs)
Concrete: Properties, Tests for fresh and hardened Concrete, Mix design, Non-destructive testing, Slump test

2. Reinforced Concrete Lab (7 hrs)
Testing of RC beams and Columns, RC Slabs

3. Pre-stressed Concrete Lab (7hrs)
Testing of pre-stressed concrete beams

4. Metal and Timber Test Lab (4 hrs)
Testing of rebar, Steel, Timber and Aluminum sections, Model tests on plates and slabs

5. Dynamic Test Lab (4 hrs)
Dynamic test on SDOF system, Determination of mode shape frequencies of simple beam and frames

6. Stress Analysis Lab (4 hrs)
Two and three-dimensional photo-elasticity

7. Ultrasonic Pulse-Velocity Ratio Method, Schmidt Hammer Test, Performeter (6 hrs)
Conduct lab to find out strength of concrete and cracks within concrete elements

8. Tests on Masonry (Brick, Block and Stone Masonry) (6 hrs)
Wallet test in plane and out of plane and conduct shear strength of structural elements.

References:

1. Lang, K. Herwig, A. *Confinement of reinforced concrete columns* 2014, 16, 271-292, CRC Press, Boca Raton
2. Czaderski, C *Flexural and Shear Strengthening of Reinforced Concrete Structure*, The International Handbook of FRP Composites in Civil Engineering Part III Externally Bonded FRP Composite Systems for Rehabilitation