- **Introduction:**

Civil engineering technicians help civil engineers plan and design the construction of highways, bridges, utilities, and other major infrastructure projects. They also help with commercial, residential, and land development. This curriculum on civil engineering courses is designed as the continuation of curriculum of technical SLC with the purpose of producing middle level technical workforce equipped with knowledge and skills related to the field of Civil Engineering so as to meet the demand of such workforce in the country to contribute in the economic development of Nepal. Since most of the basic as well as fundamental courses on civil engineering had already dealt in TSLC curriculum, this curriculum mainly emphasizes on specialized knowledge required for a middle level technician to fulfill demand of market. The additional specialized teaching schedule in this stream are managed within the overall curriculum structures of higher secondary schooling (Grade 11 & 12) without impeding the vertical career path of the graduates.

- **Curriculum of Grade 9 and 10**

During Grade 9 and 10 studies, Civil Engineering stream students have gone through 12 number of fundamental courses on engineering field. The following table presents the course Structures of Grade 9 and 10 schooling.

Course Structure of Grade 9

S. No.	Subjects
1	English
2	Nepali
3	Mathematics
4	Science
5	Computer Application
6	Engineering Drawing
7	Construction Technology
8	Engineering Surveying
9	Water Supply and Sanitary Engineering
10	Workshop Practice

Course Structure of Grade 10

S. No.	Subjects
1.	English
2.	Nepali
3.	Mathematics
4.	Science
5.	Engineering Drawing
6.	Engineering Surveying
7.	Building Construction
8.	Water Resources Engineering
9.	Highway Engineering
10.	Estimating Costing and Supervision

- **Objective of Courses**

After the completion of integrated courses from grade 9, 10, 11 and 12 the graduates will be able to perform the following job of an middle level technician:

- Read and review project blueprints to determine dimensions of structures
- Confer with their supervisors about preparing plans and evaluating field conditions
- Inspect project sites and evaluate contractors' work in order to detect problems with a design
- Test construction materials—especially concrete—and soil samples in laboratories
- Help to ensure that projects conform to design specifications and applicable codes
- Develop plans and estimate costs for installing systems and operating facilities
- Prepare reports and document project activities and data

- **Entry qualification:**

  Entry qualification of the applicant for higher secondary stream in civil engineering programme should be Technical SLC (TSLC) in Civil Engineering field.

- **Teachers**

  The Civil Engineering subjects' related teachers should be a Bachelor's degree holder in Civil engineering with three years experience in field.

- **Course Structures**

  GRADE XI

Teaching Schedule					Examination Schemes						Total	Remarks
S. N.	Subjects Titles	Contact Hours			Theory			Practical				
		L	P	total	Internal marks	Final		Internal Marks	Final			
						Duration Hrs	Marks		Duration Hr	Marks		

									s			
1	Geo-Technical Engineering	3	2	5		3	75	15		10	100	
2	Road Construction materials and Testing	1	6	7		1.5	25	50		25	100	
	Total	4	8	12							200	

GRADE XII

Teaching Schedule					Examination Schemes						Total	Remarks
S. N.	Subjects Titles	Contact Hours			Theory			Practical				
		L	P	total	Internal marks	Final		Internal Marks	Final			
						Duration Hrs	Marks		Duration Hrs	Marks		
1	Structural Analysis & RCC Design	3	2	5		3	75	15		10	100	
2	Maintenance & Rehabilitation of Structures	3	2	5		3	75	15		10	100	
	Total	6	4	10							200	

- **DETAIL CURRICULUM**

GEO-TECHNICAL ENGINEERING

(GRADE XI)

Full Marks: 100 (75T + 25P),Pass Marks: 26 T + 12P

Periods per week: 3T + 2P

Teaching Hours: 150 [Theory (T) 90 + Practical (P) 60]

I. Introduction:

This course deals with Geotechnical virtue of surrounding required for civil engineering construction. The Geotechnical engineering deals with the physical properties of soil, permeability of soil and seepage analysis, shear strength of soil, bearing capacity of soil, compaction of soil and stabilization, Site Investigation And Sub Soil Exploration to information system, Earth pressures and design of retaining walls, slope stabilization and bio-engineering techniques, River Training Works and hands on practice of its implementation.

II. Objectives:

After the completion of course the students will be able to:

- Explain soil as three phase system and establish relationship between properties of Soil.
- Determine properties of soil by following standard test., procedure and plot particle size distribution curve.
- Determine permeability by constant head and falling head test using Darcy's Law
- Calculate shearing strength of soil, using Coulomb's law
- Determine structure/foundation/soil interactions
- Explain variety of foundations and retaining walls
- Apply Bio-engineering technique for slope stabilization.
- Implement gabion works for river training works, revetments, retaining structures.

III. Course Contents Theory

Specific Objectives	Contents	Contact Hours
• States basic of geo-technical engineering	**Unit 1: Overview Geotechnical Engineering** 1.1 Engineering definition of soil 1.2 Importance of soil in Civil Engineering as construction material in Civil Engineering Structures, as foundation bed for structures 1.3 Field application of geotechnical engineering foundation design, pavement design, design of earth retaining structures, slope stability	**4**
• Identify and describe different engineering properties of soil.	**Unit 2: Physical Properties of Soil** 2.1 Soil as a three phase system 2.2 Water content, Determination of water content by oven drying method as per code 2.3 Void ratio, porosity and degree of saturation, density index 2.4 Unit weight of soil mass – bulk unit weight, dry unit weight, unit weight of solids, saturated unit weight, submerged unit weight 2.5 Determination of bulk unit weight and dry unit weight by core cutter method and sand replacement method as per code 2.6 Specific gravity, determination of specific gravity by pycnometer. 2.7 Consistency of soil, stages of consistency, Atterberg's limits of consistency viz. Liquid limit, plastic limit and shrinkage limit, plasticity index. 2.8 Determination of liquid limit, plastic limit	**8**

	and shrinkage limit as per code. 2.9 Particle size distribution, mechanical sieve analysis as per code particle size distribution curve, effective diameter of soil, Uniformity coefficient and coefficient of curvature, well graded and uniformly graded soils. 2.10 Particle size classification of soils &classification of soil	
• Identify and describe seepage in soil.	**Unit 3: Permeability of Soil & Seepage Analysis** 3.1 Definition of permeability 3.2 Darcy's law of permeability, coefficient of permeability, typical values of coefficient of permeability for different soil 3.3 Factors affecting permeability 3.4 Determination of coefficient of permeability by constant head and falling head permeability tests, simple problems to determine coefficient of permeability. 3.5 Seepage through earthen structures, seepage velocity, seepage pressure, phreatic line, flow lines and equipotential lines. 3.6 Flow net, characteristics of flow net, application of flow net (no numerical problems)	**6**
• Explain and determine the strength of soil	**Unit 4: Shear Strength of Soil** 4.1 Shear failure of soil, field situation of shear failure 4.2 Concept of shear strength of soil 4.3 Components of shearing resistance of soil – cohesion, internal friction 4.4 Mohr-coulomb failure theory, Strength envelope, strength equation 4.5 Purely cohesive and cohesion less soils	**6**

	4.6 Laboratory determination of shear strength of soil – Direct shear test, Unconfined compression test &vane shear test, plotting strength envelope, determining shear strength parameters of soil	
• Comprehend and determine the bearing capacity of soil	**Unit 5: Bearing Capacity of Soils** 5.1 Concept of bearing capacity, ultimate bearing capacity, safe bearing capacity and allowable bearing pressure 5.2 Terzaghi's analysis and assumptions made. 5.3 Effect of water table on bearing capacity 5.4 Field methods for determination of bearing capacity – Plate load test and standard penetration test. Test procedures as Per code. 5.5 Typical values of bearing capacity from building code 5.6 Definition of active earth pressure and passive earth pressure, structures subjected to earth pressure in the field	**6**
• Elaborate and implement variety of site investigations of soil	**Unit 6: Site Investigation And Sub Soil Exploration** 6.1 Necessity of site investigation & sub-soil exploration. 6.2 Types of exploration – general, detailed. 6.3 Method of site exploration open excavation & boring 6.4 Criteria for deciding the location and number of test pits and bores 6.5 Disturbed & undisturbed soil samples for lab testing. 6.6 Field identification of soil – dry strength test, dilitancy test &toughness test 6.7 Empirical correlation between soil properties and SPT values.	**8**
• Explain and	**Unit 7: Design of retaining walls**	**10**

implement the steps in the design of retaining walls	• Functions • Sites • Practical Features • Special features of dry masonry retaining walls 7.5 Special features of gabion construction 7.6 Front-battered or Back-battered 7.7 Common causes of Retaining wall Failure 7.8 Some Construction techniques for increasing stability of Masonry Retaining Walls 7.9 Design of a retaining wall	
• Equip and implement the steps in the design of retaining walls	**Unit 8: Survey information and design consideration for Check dam** • Introduction • Practical Features • Design consideration of check dam • Hydrological Aspects • Hydraulic Elements • Spillway Section • Scour Holes • Strain Cases for Check Dams • Static and Soil Mechanical Calculation • Stabilization of Gully head • Scouring Problem • Foundation • Maintenance	**10**
• Explain and implement the steps in	**Unit 9: Gabion Structures** • Advantages	**7**

the design of gabion works	• Construction • Wire used in weaving gabion Baskets • Type of mesh and mesh opening • Design consideration • Characteristics of fill material • Design drawing and implementation of gabion spurs, revetments	
• Explain and implement the steps in the design of Bio - engineering system	**Unit 10: Bio Engineering** • Definition • Causes and Mechanism of Slope failures • Functions of Bio-engineering system • Small Scale Civil Engineering System • Vegetative System • Interaction between Civil and vegetative system • Selection of Species • Propagation methods • Selection of Optimal technique	**12**
• Identify and describe construction of variety of foundations.	**Unit 11: Foundations** • Construction of spread footings • Construction of mat foundations • Construction of pile foundation • Pile load tests • Damage, alignment and effect of pile driving • Construction of Pier	**8**

	foundations • Sinking of caissons • Ground Water in excavations and methods of its control	
• Explain and implement Geosynthetics in construction.	**Unit 12: Geosynthetics** • Types of Geosynthetics • Application of Geosynthetics • Design Considerations • Construction Requirements	**5**

IV. Course Contents Practical

Following practical works shall be conducted to equip student hands on practice of knowledge acquired in theory classes:

Practical	**Contact Hours**
1. Determination of water content of given soil sample by oven drying method as per code.	2
2. Determination of bulk unit weight dry unit weight of soil in field by core cutter method as per Code.	2
3. Determination of coefficient of permeability by constant head test	2
4. Determination of coefficient of permeability by falling head test	2
5. Determination of shear strength of soil using direct shear test.	2
6. Construction of Gabion walls/revetment, gabion spurs.	12
7. Construction of Bio-engineering system (Grass planting, Brush layering, Bolsters and French Drains)	12
8. Structured industrial visits be arranged and report of the same should be submitted by the individual student, to form a part of the practical work. The industrial visits may be arranged in the following areas i) Bridge foundation under construction ii) Construction of basement/retaining wall	14

iii) Sub – Soil Exploration iv) Bio-Engineering Site v) Construction of River Training Works (Spurs, Embankment, Revetment)	
9. Survey, design and estimates of Gully protection works.	12

V. Instructional Materials:

- Over Head Projector, Multimedia Projector and equipment and materials listed in Annex I

VI. Instructional Techniques:

The instructional techniques for this course are divided into two groups. First group consists of general instructional techniques applicable to most of the units. The second group consists of specific instructional techniques applicable to specific units.

6.1 General Instructional Techniques

- Providing the reading materials to the students to familiarize the units.
- Lecture, question-answer, discussion, brainstorming, practical, and buzz session.

6.2 Specific Instructional Techniques

Unit I

- Lecture
- Discussion

Unit II, III, IV, VI, VII, VIII, IX, X

- Lecture
- Practical
- Discussion
- Group work

Unit V, XI, XII

- Lecture
- Discussion
- Group work

VII. Marks and hours distribution

Groups	Unit	Marks Distribution	Number of Hours

		Theory	Theory
Group A	I	15	4
	II		8
	III		6
Group B	IV	15	6
	V		6
	VI		8
Group C	VII	15	10
	IX		7
Group D	VIII	15	10
	XI		8
Group E	X	15	12
	XII		5
	Total	75	90

VIII. Evaluation Schemes

- **Theory Evaluation:**

S. No.	**Topics**	**No. of Questions**	**Marks**	**Total**
1	Very Short Questions	5	3	**15**
2	Short Questions	6	5	**30**
3	Long Question (Analytical)	3	10	**30**
	Total			**75**

- **Practical Evaluation:**

Internal Evaluation Marks	External Evaluation Marks
5	10

Practical Internal Examination Evaluation Scheme (15 Marks)

Internal evaluation will be conducted by course teacher based on following activities:

• Attendance and Class Performance	3 Marks
• Lab/Field/Case Study Report	2 Marks
• Practical First Exam	5 Marks
• Practical Second Exam	5 Marks
Total	15 Marks

Practical External Examination Evaluation Scheme (20 Marks)

• Practical Exam	6 Marks
• Viva voce	4 Marks
Total	10 Marks

IX. Reference Books:

- Dr. B. C. Punmia, Soil Mechanics & Foundation Engineering, Standard Book house, New Delhi
- Murthi, Soil Mechanics & Foundation Engineering, Tata McGraw Hill , New Delhi

- B. J. Kasmalkar, Soil Mechanics, Pune Vidhyarti Griha, Pune
- Gulhati & Dutta, Geo-technical Engineering ,Tata McGraw Hill , New Delhi
- Department of soil and conservation, Swiss Association for Technical Assistance, Manual Calculation of Check Dams.
- Department of Roads, Nepal, Roadside Bio-engineering
- http://www.enviromeshgabions.co.uk/, Volume I, A Reference Guide for the Designing of Mass Gravity Gabion Walls.
- http://www.sheltercentre.org/, Spur and dyke for flood water protection
- Hand book for flood protection, anti-erosion and river training works, Central Water Commission, New Delhi.

ROAD CONSTRUCTION MATERIAL AND TESTING

(GRADE XI)

Full Marks: 100 (25T + 75P),Pass Marks: 9T + 37.5P

Periods per week: 1T + 6P

Teaching Hours: 210 [Theory (T) 30 + Practical (P) 180]

I. Introduction:

The course deals with the introduction of the construction materials used in road construction and introduction of bituminous premixes. It also includes the tests on different materials for sub-grade soils, road aggregates for different pavement layers, road binder (bitumen) and bituminous premixes for wearing course.

II. Objectives:

After the completion of this course, the students should be able to: -

- Introduce the knowledge of road construction materials.
- Enable the students in applying knowledge of different road construction materials for different road construction activities.
- Enable the students to know the suitability of the appropriate construction material for different road construction activities.
- Equip fundamental knowledge to conduct different laboratory and field tests on materials required for preparation of sub-grade, sub-base course, base course and wearing course.

III. Course Contents Theory

Specific Objectives	Contents	Contact Hours
• Identify road construction materials.	**Unit 1: Introduction** • General introduction of the alignment development • Familiarize with typical section of the pavement	**4**

	• Familiarize specification of road construction materials • Classification • Mineral materials • Binding materials Other construction materials	
• Comprehend Sub-grade soils	**Unit 2: Sub-Grade Soil** 2.1 General 2.2 Characteristics of Soil 2.3 Classification of soil 2.4 Desirable Properties sub-grade soil	**2**
• Demonstrate quality of road aggregate.	**Unit 3: Road Aggregate** **3.1** Definition and Classification of Road Aggregates. • Desirable Properties of road aggregate.	**2**
•	**Unit 4: Tests on Aggregates and their significance** • Descriptive tests • Non – destructive Quality Tests • Durability Tests. • Specific Gravity Test 4.5 Bitumen Adhesion Tests	**6**
• Perform tests for bituminous road binders.	**Unit 5: Bituminous Road Binders** **5.1** Definition and Classification • Bitumen • Petroleum Bitumen • Liquid Bitumen 5.4.1 Cutback Bitumen 5.4.2 Bitumen Emulsion	4
•	**Unit 6: Tests on Bitumen** 6.1 Consistency Tests 6.2 Composition Tests 6.3 Specific Gravity Test 6.4 Flash and Fire Point (Safety) Tests	**4**
• Perform steps required for the application of	**Unit 7: Bituminous Premixes** • Definition and Types of Bituminous Premixes	**8**

Bituminous Pre mixes	• Premix Ingredients • Premix Design • Premix Production • Premix Laying 7.6 Tests on Premixes	

IV. Course Contents Practical

Practicals	Contact Hours
PART - I. LABORATORY TESTS **Section – A. Laboratory Tests on subgrade soils** • Grain size analysis • Atterberg's limits • Soil compaction test (Proctor density light and heavy compaction) • California Bearing Ratio test	**20**

Section - B. Tests on Aggregates used in Road Construction
• Gradation test
• Aggregate Impact value (AIV) test
• Aggregate crushing value (ACV) test
• 10% fineness value test
• Los Angeles abrasion test
• Shape tests
  • Flakiness Index test (FI)
  • Elongation Index test (EI)
  • Angularity Number (AN)
• Soundness test
• Specific gravity and water absorption of aggregates
• Binder adhesion test.
	35

Section - C. Tests on Bituminous Materials • Penetration test	**45**

• Ductility test • Viscosity test • Softening point test • Distillations test • Water content • Loss on heating test • Solubility test • Specific gravity test • Flash and fire point test	
Section – D. Test on Bituminous Mixes • Marshall Stability and Flow Test • Binder Extraction and Grading analysis after Extraction test	**20**
Section - E. Test on cement and cement concrete • Test for fineness of cement • Test for consistency of standard cement paste • Test for setting time of cement paste • Test for soundness of cement • Test for compressive strength of cement • Test for fineness modulus of aggregate • Test for bulking of fine aggregate • Test for consistency of fresh concrete • Test for compressive strength of cement concrete	**30**
Part II. Field Tests on Pavement Layers • Determination of field density of layers by sand replacement method • Dynamic cone penetration test • Tests on bituminous pavement layers • Field visit to the road construction site.	**30**

V. Instructional Materials:

- Over Head Projector, Multimedia Projector and equipment and materials listed in Annex I

VI. Instructional Techniques:

- Providing the reading materials to the students to familiarize the subject.

- Lecture, question-answer, discussion, brainstorming, practical, and buzz session.

VII. Marks and hours distribution

Groups	Unit	Marks Distribution	Number of Hours
		Theory	Theory
Group A	I	5	6
	II		
Group B	III	5	6
	V		
Group C	IV	5	6
Group D	VI	5	6
	VII		
Group E	VII	5	6
	Total	25	30

VIII. Evaluation Schemes

- **Theory Evaluation:**

S. No.	Topics	No. of Questions	Marks	Total
1	Very Short Questions	6	1	**6**
2	Short Questions	3	3	**9**
3	Long Question (Analytical)	2	5	**10**
	Total			**25**

- **Practical Evaluation:**

Internal Evaluation Marks	External Evaluation Marks
50	25

Practical Internal Examination Evaluation Scheme (50 Marks)

Internal evaluation will be conducted by course teacher based on following activities:

- Attendance and Class Performance 5 Marks
- Lab/Field/Case Study Report 5 Marks
- Practical First Exam 20 Marks
- Practical Second Exam 20 Marks

Total	50 Marks

Practical External Examination Evaluation Scheme (25 Marks)

- Practical Exam 20 Marks
- Viva voce 5 Marks

Total	25 Marks

IX. Reference Books:

- "Highway Engineering" Gurucharan Singh, Standard Publishers Distributors, Nai Sarak, Delhi.
- "Highway Engineering" Khanna S.K & Justo CEG, Nemchand and Bros. Roorkee.
- "Principles and practice of Highway Engineering" Dr. L.R.Kadyali and Dr.N.B.Lal, Khanna publishers, Delhi.
- "Highway Materials and Surface Testing " B.L. Gupta/Amit Gupta, Standard Publishers Distributors

STRUCTURAL ANALYSIS AND RCC DESIGN

(GRADE XII)

Full Marks: 100 (75T + 25P)

Pass Marks: 27T + 12.5P

Hours per week: 3T + 2P

Teaching Hours: 150 [Theory (T) 90 + Practical (P) 60]

I. Introduction:

This course deals with the analysis of statically determinate structures and design of different components of RC structures such as beams, columns, footings and slabs. This course also furnishes the important information related to ductility requirements on earthquake resistant design of RC structures.

II. Objectives:

After the completion of this course, the students should be able to: -

- to acquire the knowledge of statics of structures and support reactions
- to determine the axial and shear forces, bending moment diagram for simple beams
- to apply the knowledge of statically determinate and indeterminate structures in beams, frames, trusses and arches,
- to carry out design and drawing of different components of RCC structures
- to understand ductility requirements on RCC structures

III. Course Contents: Theory

Specific Objectives	Contents	Contact Hours
• State the knowledge of different structural systems, their design process basic	**Unit 1: Introduction** • Historical Development of Structural Systems • The Design Process: Relationship	**4**

structural elements and design loads.	of Analysis and Design, Conceptual Design, Preliminary Design and its Analysis, Redesign of the Structures, Evaluation of Preliminary Design, Final Design and Analysis Phase, Strength and Serviceability. • Basic Structural Elements: Hangers, Suspension Cables, Beams, Trusses, Arches, Rigid Frames, Plates or Slabs, Thin Shells (Definition and Example) • Assembling of Basic Elements to Form a Stable Structural Systems (Illustration only) • Design Loads: Different Types of Loads-dead loads, live loads, wind loads, earthquake loads, other loads; building and design codes; load combinations • Calculation of design live load supported by floor beams, girders and columns.	
• Define different types of supports, equilibrium, stability, determinacy and indeterminacy of structural systems.	**Unit 2: Statics of Structures – Reactions** • Forces, Resultants of Planar force system, computation of a resultant, resultant of a distributed load, principle of transmissibility. • Supports – hinged, roller and fixed supports and their characteristics, Idealization of structural systems, Free-Body Diagrams – definition and examples, Equations of static equilibrium, Equations of conditions • Classification of structural	**6**

	systems – Statically determinate and indeterminate structures, Influence of reactions on stability and determinacy of structures, instability of structural systems, Comparison between determinate and indeterminate structures with examples.	
• Define, derive and determine canter of gravity and moment of inertia.	**Unit 3: Centre of Gravity and Moment of Inertia** • Centre of gravity – definitions, Lamina – Centre of gravity of laminae of various shapes – rectangle, triangle, circle, semicircle, trapezium, built-up sections • Moment of inertia of a lamina – definition, radius of gyration – Parallel axes theorem – Perpendicular axes theorem – moment of inertia of laminae of various shapes – moment of inertial of composite sections – Problems for exercise.	**8**
• Determine member forces in the roof truss.	**Unit 4: Plane Trusses** • Introduction – details of a truss, welded, riveted and bolted joints and their idealization as frictionless pins, forces in the members of a truss, types of trusses – simple, compound and complex trusses (sketch only) • Analysis of trusses: assumptions, Method of joints, Method of sections, Application of two methods for the determination member forces in the truss. • Zero bars, determinacy and	**8**

	stability of planar trusses.	
• Draw shear force and bending moment diagrams for determinate beams and draw the deflected shapes.	**Unit 5: Axial Force, Shear Force and Bending Moment.** • Definition, Physical Meaning, and Sign Convention • Beams and Frames – Definitions and Common types of beams and frames, internal forces in the members of beams and frames • Writing expressions for shear and moment at a section of a beams in terms of applied loads • Construction of shear force and bending moment diagrams (curves) for statically determinate beams (simply supported, overhang and cantilever), sketching the deflected shapes of loaded beams (elastic curves) • Relationship between load, shear and moment; concept of shear center; principle of superposition • Degree of indeterminacy for beams and simple frames.	**10**
• Analyze the cables and arches.	**Unit 6: Cables and Arches** • Cables – introduction, characteristics of cables, variation of cable force, analysis of a cable supporting vertical (gravity) loads, general cable theorem, determination of maximum tension in the cable. • Arches – Introduction, types of arches, three-hinged arches, determination of reactions, shear force, bending moment, normal thrust and radial shear in the three hinged arch when the supports are	**6**

	in the same level.	
• Explain different stresses and strains, determine slope and deflections of simple beams; analyze column for buckling.	**Unit 7: Stresses, Strains, Flexure, Torsion, deflections of beams and Buckling of Column** • Definitions of stresses and strains; normal stress and normal strain; shear stress and shear strains; Hooke's law; Poisson's ratio, Young's modulus of elasticity, modulus of rigidity and their relation; bulk modulus; Typical stress-strain curve for mild-steel indicating salient points. • Flexural rigidity, Derivation of flexural formula • Theory of torsion, torsion formula • Differential equation of elastic curve • Calculation of slope and deflection using double integration method for simply supported and cantilever beam subjected to uniformly distributed load and single point load. • Moment area method: Two theorems of moment area method – definition, derivation and applications; slope and deflection calculation by the use of moment area theorem (for simple and cantilever beam) • Conjugate beam method – definition; differences between real beams and conjugate beams, and real support and conjugate supports; slope and deflection calculation using conjugate beam method for simple and cantilever beams.	**12**

	• Analysis of columns: Long and short columns, buckling of columns, Euler's formula for critical loads for different conditions.	
• Introduce basic knowledge of reinforced concrete design and design simple beams for flexure and shear.	**Unit 8 : Design of reinforced concrete structures** • Different design philosophies • Working stress method of design – assumptions, permissible stresses and factor of safety. • Limit state method of design – objectives, assumptions, stress and strain distributions; moment of resistance; knowledge of different limit states-collapse and serviceability; concept of singly and doubly reinforced sections; behavior of a RC beam in bending; balanced, under-reinforced and over-reinforced beams • Use of different Codes (NNS Codes, and IS codes) for the design of RCC structures. • Design and analysis of simple RC beams for flexure • Shear failure of RC beams; limit state design of shear reinforcement • Reinforcement detailing of a beam – cross section and longitudinal sections	**16**
• Design and draw different RC structural elements.	**Unit 9: Design of different RC structural elements using Limit State Method** • Design and drawing of singly and doubly reinforced simple beams	**14**

	• Design and drawing of continuous, one-way and two-way slabs. • Design and Drawing of axially loaded wall and column footings • Design and drawing of short columns. • Use of codes for the design	
• State the knowledge of bond, development length and ductility in RC structures.	**Unit 10: Bond, Development Length and Ductility** • Definitions • Development bond and flexural bond • Lap splices and development length • Definition of ductility and strength • Ductility requirements of different RCC structural elements for earthquake resistance – dimensions and detailing	**6**

IV. Course Contents Practical

Practical	**Contact Hours**
Verification of Maxwell's theorem of reciprocal deflections using beam bending apparatus.	2
Determination of horizontal reactions of Three-Hinged and Two-Hinged Arches.	4
Determination of reactions and forces in Suspension Bridge.	2
Practical for buckling of column: Determination of critical load for the buckling of a column.	2

Torsion Test: Determination of shear stress, shear strain, and modulus of rigidity of metallic specimen using torsion test apparatus.	2
Determination of bar forces in the members of the truss.	2
Verification of Hooke's law.	2
Establish the stress-strain relationship for mild-steel specimen using tensile testing equipment.	4
Determination of bond strength and development length of RC beam specimen.	10
Three point bending test of RC beam.	10
Tutorial on the design of beam, columns, slabs and footings.	20

V. Instructional Materials:

Over-head projector, Multimedia projector, Blackboard-Chalk-duster, white board, marker, Books, Teaching manuals, Hand-outs, etc.

VI. Instructional Techniques:

Lecture, Tutorial, Discussions, Quizzes, Assignments, Assessments, Group works, etc.

VII. Marks and hours distribution

Groups	**Unit**	**Marks Distribution**	**Number of Hours**
		Theory	**Theory**
Group A	I	15	4
	II		6
	III		8
Group B	IV	15	8
	V		10
Group C	VI	15	6
	VII		12
Group D	VIII	15	16
Group E	IX	15	14

	X		6
	Total	75	90

VIII. Evaluation Schemes

- **Theory Evaluation:**

S. No.	Topics	No. of Questions	Marks	Total
1	Very Short Questions	5	3	**15**
2	Short Questions	6	5	**30**
3	Long Question (Analytical)	3	10	**30**
	Total			**75**

- **Practical Evaluation:**

Internal Evaluation Marks	External Evaluation Marks
15	10

Lab Exercises are guided by marks distribution and Teaching Manual.

Practical Internal Examination Evaluation Scheme (15 Marks)

Internal evaluation will be conducted by course teacher based on following activities:

- Attendance and Class Performance 3 Marks
- Lab/Field/Case Study Report 2 Marks
- Practical First Exam 5 Marks
- Practical Second Exam 5 Marks

Total	15 Marks

Practical External Examination Evaluation Scheme (10 Marks)

- Practical Exam 6 Marks
    - Viva-Voce 4 Marks

Total	10 Marks

IX. Reference Books:

- Ramamrutham, S. (2014). "Engineering Mechanics", Sixth edition, New Delhi: Dhanpat Rai Publishing Company (P) Ltd.
- Leet, KM, Uang, CM, Gilbert, AM (2008). "Fundamentals of Structural Analysis", Third edition, Mc Graw Hill higher Education.
- Jain, Ashok Kumar (2012) "Reinforced Concrete (Limit State Design)", 7th edition, Nemchand and Bros, Roorkee, India
- Ramamrutham, S. (2010) "Design of Reinforced Concrete Structures." Dhanpat Rai Publishing Company, New Delhi, 7th edition.
- Khurmi, R.S. "Applied Mechanics".
- Nepal National Building Codes
- IS 456: 2000, Code of Practice for plain concrete
- IS 456: 2000 (Design Aids, SP16)

MAINTENANCE & REHABILITATION O STRUCTURE

(GRADE XII)

Full Marks: 100 (75T + 25P)

Pass Marks: 26 T + 12P

Periods per week: 3T + 2P

Teaching Hours: 150 [Theory (T) 90 + Practical (P) 60]

I. Introduction:

The course deals with the important issues pertaining to the maintenance, repairs, rehabilitation and minor works of building. The course systematically covers the issues like identification of defect or deterioration, Causes of deterioration, identification of materials for the repairs and adoption of the method of renovation and carry it out. The course also covers another important subject like planning of minor works like compound walls, rain water harvesting systems, water tanks etc.

II. Objectives:

After the completion of this course, the students should be able to:-

- Distinguish between different types of causes of damage.
- Decide the appropriate technique according to failure.
- Identify causes of failure of masonry building & its retrofitting.
- List causes of failure of R.C.C. building and its retrofitting.
- Find the strength, age of building & maintenance of life lines.
- Prepare estimates & tenders for structure damage due to hazards.
- Plan minor works

III. Course Contents Theory

Specific Objectives	Contents	Contact Hours
• States basic of maintenance and repairs of structures.	**Unit 1: Introduction** 1.1 Necessity, operation, maintenance &repairs of structures 1.2 Classification of maintenance, 1.3 Rehabilitation (restoration), strengthening, retrofitting. 1.4 Methodical approach to repairs, inspection-annual, emergency, special, repairs-minor, special and renovation. 1.5 Keeping Records of maintenance	**4**
• Describe the paintworks in buildings.	**Unit 2 : Painting of Buildings** 2.1 Introduction 2.2 General Considerations 2.3 Description of Paintwork of walls in Buildings 2.4 Painting Iron	**5**
• Explain the steps involved in detection of damages.	**Unit 3: Causes & detection of damages:** 3.1 Causes of damages, damages due to earthquakes, fire hazards, flood, hazards, dilapidation, 3.2 List of basic equipments for investigation.	**4**
• Identify and demonstrate the use of various materials for repairs.	**Unit 4 : Materials for repairs**: 4.1 Introduction 4.2 Most Common Concrete Repair Chemicals 4.3 Application of Repair Chemicals 4.4 Some examples of Concrete Chemicals for repair 4.5 Shot-creting 4.6 Mechanical anchors.	**5**
• Elaborate and implement the remedial measures for strengthening damaged	**Unit 5: Masonry walls** 5.1 Damp walls, causes effects, remedies, eradication of efflorescence	**5**

masonry walls.	5.2 Cracks in walls, remedial &preventive measures bond between old &new brick work, reinforced brickwork.	
• Elaborate causes and mechanism of damage of foundation and implement the remedial measures for strengthening damaged foundation works.	**Unit 6: Repairs to foundation**: 6.1 Remedies, types &processes of settlement, foundation sinking 6.2 Examination of existing foundation, strengthening of foundation.	**6**
• Explain and implement steps involved in water proofing of Leakage in building	**Unit 7: Water proofing** 7.1 Repair of rain water Leakage in building 7.2 Repair and Renovation of Waterproofing works of RC Flat Roofs 7.3 Repair of Leakage of Basement due to Groundwater	**5**
• Explain and implement steps involved in repairs & strengthening of RCC structures	**Unit 8: Concept of repairs & strengthening of RCC structures:** 8.1 Concept of repairs of RCC structures 8.2 Physical examination of common defects, 8.3 Structural repairs &strengthening repairs by new developments.	**5**
• Explain and implement steps involved in repairs of RCC structures damaged due to fire.	**Unit 9: Damage due to fire:** 9.1 Fire resistance, effects of temp. of RCC, 9.2 Repairs to RCC structures damaged due to fire	**4**
• Elaborate advanced damage detection technique	**Unit 10: Advanced Damage detection techniques:** 10.1 Introduction 10.2 Important non-destructive Field tests 10.3 Test for in situ concrete strength	**5**

	10.4 Chemical analysis of Concrete 10.5 Corrosion Potential Assessment	
• Describe and implement various methods involved in strengthening of RCC beams, columns and Slabs.	**Unit 11: Strengthening RC beams, columns and slabs** 11.1 Introduction 11.2 Plate Bonding Method 11.3 RC Jacketing of Beams and Columns with Reinforced Concrete	**5**
• Explain and implement the methods of determination of strength, economic & age of building.	**Unit 12: Evaluation of strength, economic &age of building:** 12.1 Determination of approx. age of a building. 12.2 Determination of strength of structural member of old building. 12.3 Finding cost in use of an existing building.	**8**
• Comprehend and implement various maintenance processes of life lines of buildings.	**Unit 13: Maintenance of life lines:** 13.1 Maintenance of electric supply, water supply leaking pipe joints and sewerage systems, closed drains, sewers. 13.2 Maintenance of roads, road berms, side drain maintenance of bridges, culverts causeways	**5**
• Demonstrate the estimates and tendering procedures of repair works.	**Unit 14: Estimates and tendering:** 14.1 Estimates of annual repairs, special repairs and maintenance work. 14.2 Preparation of tender	**5**
• Explain and implement steps involved in construction and repairs of water tanks.	**Unit 15: Construction and repair of Underground Water Tanks with Weld Mesh and Overhead Water**	**5**

	Tanks with Ferrocement. 15.1 Introduction 15.2 Layout of Underground Water tanks 15.3 Conventional Type of Underground Water Storage Tanks	
• Explain and implement steps involved in construction rain water harvesting system	**Unit 16: Construction of Rain Water Harvesting System** 16.1 Introduction 16.2 Rooftop Harvesting for Reuse and Groundwater Improvement	**5**
• Explain and implement steps involved in planning and construction of compound walls.	**Unit 17: Construction of Compound Walls and Barbed Wire Fences** 17.1 Introduction 17.2 General Layout of ordinary compound wall 17.3 General layout of compound walls with bricks 17 4 Construction of compound walls with concrete hollow bricks 17.5 Barbed wire fences 17.6 Compound wall finish	**5**

IV. Course Contents Practical

Practicals	**Contact Hours**
• Inspection of any historical building which has limitations for alternation, finding damages, classifying minor &special repairs, decide suitable method of retrofitting, estimating cost of retrofitting.	15
• Finding the approximate strength of structural members in an existing building like beams, columns, slabs, calculating additional reinforcement &necessary improvement in section, estimating cost of strengthening.	20
• Determine approximate age and economics of an old house.	10
• Determine load carrying capacity of a slab, beam, column by using rebound	15

hammer.	

V. Instructional Materials:

- Over Head Projector, Multimedia Projector

VI. Instructional Techniques:

The instructional techniques for this course are divided into two groups. First group consists of general instructional techniques applicable to most of the units. The second group consists of specific instructional techniques applicable to specific units.

6.1 General Instructional Techniques

- Providing the reading materials to the students to familiarize the units.
- Lecture, question-answer, discussion, brainstorming, practical, and buzz session.

6.2 Specific Instructional Techniques

Unit I, XIII, XV, XVI, XVII

- Lecture
- Discussion

Unit II, III, IV, V, VI, VII, XI, XII

- Lecture
- Practical
- Discussion
- Group work

Unit VIII, IX, X, XIV

- Lecture
- Discussion
- Group work

VII. Marks and hours distribution

Groups	Unit	Marks Distribution	Number of

			Hours
		Theory	Theory
Group A	I	15	4
	II		5
	III		4
	IV		5
Group B	V	15	5
	VI		6
	VII		5
	VIII		5
Group C	IX	15	4
	X		5
	XI		5
Group D	XII	15	8
	XIII		5
	XIV		5
Group E	XV	15	5
	XVI		5
	XVII		5
	Total	75	90

VIII. Evaluation Schemes

- **Theory Evaluation:**

S. No.	Topics	No. of Questions	Marks	Total
1	Very Short Questions	5	3	**15**
2	Short Questions	6	5	**30**
3	Long Question (Analytical)	3	10	**30**
	Total			**75**

- **Practical Evaluation:**

Internal Evaluation Marks	External Evaluation Marks
15	10

Practical Internal Examination Evaluation Scheme (15 Marks)

Internal evaluation will be conducted by course teacher based on following activities:

- Attendance and Class Performance 3 Marks
    - Lab/Field/Case Study Report 2 Marks
    - Practical First Exam 5 Marks
- Practical Second Exam 5 Marks

Total	15 Marks

Practical External Examination Evaluation Scheme (20 Marks)

- Practical Exam 6 Marks
- Viva voce 4 Marks

Total	10 Marks

IX. Reference Books:

- P.K. Guha Maintenance and Repairs of Buildings New Central book Agencies

- Nayak B. S. Maintenance Engineering For Civil Engineers Khanna Publication
- Hutchin Son, BD Maintenance and Repairs of Buildings Newnes –Butterworth.
- Ransom W. H. Building Failures – Diagnosis and Avoidance E and F. N. Span.
- P.C. Varghese, Maintenance, Repair and Rehabilitation and Minor works of Buildings, PHI Learning Private Limited.

ANNEX- I

LIST OF MATERIALS AND EQUIPMENTS TO RUN THE COURSES

Subject: Geo-Technical Engineering

- Electric Oven (100 – 105^{o} C) - one set
- Balance - 2 sets
- Core Cutter and cylinder - 2 sets
- Permeability test apparatus - 4 sets
- Direct Shear Test Apparatus - 2 sets
- Woven gabion panels
- 16 mm rebars or high yield rod cut into 2m length
- Iron rods for cross ties (diameter= 0.5 – 0.7 cm)
- Tools for digging trenches and for working with gabion wire
- Sledge hammers
- Boulders : smallest dimension >100mm
- Grass plants raised in a nursery or cuttings obtained elsewhere and cuttings made from woody material
- Short planting bars
- Tape measure (30 m)

- A means of transporting plants to site
- Hessians and water to keep the roots moist
- Geo-textile and polythene sheets
- Sites for construction of Gabion Walls , Spurs, Revetment
- Sites for construction of Bio-engineering System
- Industrial Visit Sites

Subject: Road Construction Materials and Testing

Section – A. Laboratory Tests on subgrade soils

- **Grain size analysis**
    - Balance 30 kg capacity, accuracy to 1 gm
    - Thermostatically controlled oven to maintain temperature 110 to 110°C
    - Brass sieve 200 mm dia. Size: 4.75, 2.36, 1.18, 0.900, 0.600, 0.425, 0.300, 0.150, 0.075 mm, lid and pan
- **Atterberg's limits**
- Casagrande liquid limit device with grooving tools and counter
- Evaporating dishof about 120 mm diameter
- Ground glass plate 400 x 600 x 6 mm
    - Spatula 200 mm
    - Aluminium Moisture containers 75 x 50 mm
    - Balance 300 gm capacity accuracy to 0.01 gm
    - Thermostatically controlled oven to maintain temperature 105 to 110°C
- **Soil compaction test**

        - Mould capacity 1000 cm3 (light) and 2250 cm3 (heavy) with removable base plate and collar of 60 mm height
        - Rammer diameter 50 mm with a free drop of 310 mm, weight 2.6 kg (light) and rammer 50 mm diameter with free fall of 450 mm, weight 4.89 kg (heavy)
    - Steel straight edge having beveled edge for trimming the top of the specimen
    - Balance 10 kg and 200 grams capacity
    - Thermostatically controlled oven to maintain temperature 105 to 110°C
    - Sieves, mixing tools and moisture containers
- **California Bearing Ratio test**
        - CBR loading frame
        - Dial gauge for to measure load, to measure penetration and to measure to swell
        - Annular weights 2.5 kg
        - Central hole weight 2.5 kg
        - CBR moulds
        - Expansion and swell measuring unit
        - perforated brass plate
        - Spacer disc
        - Filter paper
        - Soaking tank
    - Sieves of 20 mm and 4.75 mm
    - Steel straight edge
    - Mixing tray

- Oven
- Balance
- Measuring cylinder
- Moisture container

Section - B. Tests on Aggregates used in Road Construction

- **Aggregate Impact value (AIV) test**
    - Aggregate impact value test apparatus set
    - Sieves 12.5 mm, 10 mm and 2.36 mm
    - Mixing tray
- **Aggregate crushing value (ACV) test**
    - Aggregate crushing value test apparatus set
    - Measuring cylinder and tamping rod
    - Sieves 12.5 mm, 10 mm and 2.36 mm
    - Mixing tray
    - Balance
- **10% fineness value test**
    - Aggregate crushing value test apparatus set
    - Measuring cylinder and tamping rod
    - Sieves 12.5 mm, 10 mm and 2.36 mm
    - Mixing tray
    - Balance
- **Los Angeles abrasion test**
    - Los Angeles abrasion test apparatus set
    - 12 nos. of Steel balls(Abrasive chargers)

- Sieves sizes of 80, 63, 50, 40, 25, 20, 12.5, 10, 6.3, 4.75, 2.36 and 1.7 mm
- Mixing tray
- Balance

- **Shape tests**
    - Flakiness Index test (FI). Elongation Index test (EI), Angularity Number (AN)
        - Thickness gauge, Sieves 63, 50, 40, 31.5, 25, 20, 16, 12.5, 10 and 6.3 mm
        - Length gauge, Sieves sizes of 50, 40, 25, 20, 16, 12.5, 10 and 6.3 mm
        - A metallic cylinder of height 15.64 and dia. 15.64 cm and tamping rod 16 mm dia. 60 cm in length
- **Soundness test**
        - Test containers for soundness test
        - Sieves sizes of 80, 63, 50, 40, 31.5, 25, 20, 16, 12.5, 10, 6.3 and 4.75 mm
        - Balance 5 kg capacity
        - Thermostatically controlled water bath
        - Drying oven
        - An hydrous or crystalline Na2So4 or MgSo4
- **Specific gravity and water absorption of aggregates**
        - Balance of capacity not less than 3 kg with accuracy of 0.5 gm and capable to weigh the sample container when suspended in water
        - Thermostatically controlled oven to maintain temperature 110 to 110°C
        - Two pieces of cloths of size 75 cm x 45 cm
        - Shallow tray having not less than 325 cm2
        - An airtight container having a capacity to take sample
        - Wire basket

- **Binder adhesion test.**
    - Thermostatically controlled water bath
    - Beaker, mixture

Section - C. Tests on Bituminous Materials and Bituminous Premixes

- **Penetration test**
    - Penetrometer with standard needle automatic
    - Sample containers
    - Transfer tray
    - Thermometer
- **Ductility test**
    - Sample (briquette) mould
    - Ductility testing machine set
- **Viscosity test**
    - Orifice viscometer set
    - Cannon – Manning viscometer set
    - Cannon – Fenske opaque viscometer set
    - oil bath
    - Thermostatically controlled oven to maintain temperature 135°C
    - Thermostatically controlled water bath
    - Thermometer
    - Stop watch
- **Softening point test**
    - Ring and ball apparatus consisting two steel balls, two brass rings, metallic support

- Thermometer
- Bath and stirrer

- **Distillations test**
  - Distillation set of flask capacity not less than one liter
  - Electric heater
- **Water content**
  - Dean and stark apparatus
  - Electric heater
- **Loss on heating test**
  - Aluminium shelf to place containers
  - Revolving oven to maintain temperature 163°C
  - Sample containers
- **Solubility test**
  - Beaker
  - Filter paper
  - Chemical solution trichloroethylene or carbon disulphide or toluene for solubility test
  - Balance 300 gm capacity accuracy to 0.01 gm
- **Specific gravity test**
  - Ordinary capillary type gravity bottle of capacity 50 cc with 6mm dia. neck or wide mouthed capillary type gravity bottle of 25 mm dia neck
  - Brass cube mould (12 x 12 x 12 mm)
  - Balance capable to weigh the sample container when suspended in water
- **Flash and fire point test**

- Pensky-Marten open or closed cup
- Cup with a lid
- Stirring device
- Flame exposure device
- Thermometer
- Stove/Heating device

Section – D. Test on Bituminous Mixes

- **Marshall Stability and Flow Test**
  - Compaction mould assembly consists of mould 101.5 mm dia. and height 75 mm
  - Collar extension and base plate
  - Compaction hammer with flat circular plate at its end of dia. 98.4 mm wt. of hammer 4.54 kg and height of fall 457 mm
  - Compaction pedestal and mould holder
  - Specimen extractor
  - Marshall stability testing machine
  - Dial gauges to measure deformation and mixture
- **Binder Extraction and Grading analysis after Extraction test**
  - Centrifuge type bitumen extractor
  - Beaker
  - Filter paper
  - Chemical solution trichloroethylene or carbon disulphide or toluene for solubility test
  - Balance

Section - E. Test on cement and cement concrete

- **Test for fineness of cement**

- Balance
- Sieve size 90 micron
- Mixing tray 30 x 30 cm

- **Test for consistency of standard cement paste**
    - Vlcat's apparatus with accessories
    - Balance 1 kg capacity
    - Measuring cylinder
    - Tray
    - Spatula
    - Thermometer
    - Stop watch
    - Non porous plate
    - Trowel
- **Test for setting time of cement paste**
    - Vlcat's apparatus with accessories
    - Balance 1 kg capacity
    - Measuring cylinder
    - Tray
    - Spatula
    - Stop watch
    - Non porous plate
    - Trowel

- **Test for soundness of cement**
    - Lechatilier's apparatus
    - Two glass plates
    - Tray
    - Thermometer
    - Measuring cylinder
    - Stove/Heating device
    - Non porous plate
    - Stop watch
    - Balance 1 kg capacity
- **Test for compressive strength of cement**
    - Cube mould 50x50x50 mm or 75x75x75 mm or 100 x100x100 mm
    - Apparatus for mix as tray, spatula, measuring cylinder and trowel
    - Compressive testing machine 32 ton capacity
- **Test for fineness modulus of aggregate**
    - Sieve sizes 80, 40, 20, 10, 4.75, 2.36, 1.18, 0.600, 0.300, 0.150 mm
    - Balance 10 kg capacity
- **Test for bulking of fine aggregate**
    - Metallic vessel of appropriate volume
    - Steel scale
    - Measuring cylinder 250 cc
    - 6 mm dia. steel rod
- **Test for consistency of fresh concrete**

- Slump cone apparatus
- Tamping rod
- Tray
- Steel scale
- Trowel

- **Test for compressive strength of cement concrete**
  - Cube mould 150 x 150 x 150 mm
  - Apparatus for mix as tray, spatula, measuring cylinder and trowel
  - Compressive testing machine 120 ton capacity

Part II. Field Tests on Pavement Layers

- **Determination of field density of layers by sand replacement method**
  - Sand pouring cylinder of 150 mm dia. and 100 mm dia. for field density checking
  - Metal tray with central hole
  - Hand tools excavating and digging hole
  - Almunium sample container
  - Balance 10 kg capacity
  - Plastic containers
  - Clean and clear sand
- **Dynamic cone penetration test**
  - Dynamic cone penetrometer set
- **Tests on bituminous pavement layers**
  - Core cutter machine for core analysis

Note : School may have to use nearby well equipped established material testing laboratory or nearby field laboratory at Road construction sites.

Subject : MAINTENANCE & REHABILITATION OF STRUCTURE

- **Rebound Hammer - 4 sets**
- **Sites for field works**

Subject: Structural Analysis and RCC Design

S. N.	List of Equipment	Quantity Required	Remarks
1	Beam set with various support condition	3 sets	
2	Beam bending apparatus	3 sets	
3	Column behavior and buckling apparatus	3 sets	
4	Torsion testing machine	1 set	
5	Hooke's Law Apparatus	3 sets	
6	Universal Testing Machine (100 KN)	1 set	
7	Compression Testing Machine (2000 KN)	1 set	
8	Plane Truss for Measurement of Bar Forces and Deflections.	3 sets	
9	Three-Hinged Arches (Symmetrical &unsymmetrical)	1 set each	
10	Two-Hinged Arches (Symmetrical &unsymmetrical)	1 set each	
11	Suspension Bridge	2 set	
12	Continuous Beams	2 sets	
13	Dial Gauges	12 sets	