DESIGN OF TIMBER AND MASONRY STRUCTURES
ENCE 301
Year/Part: III/I

Teaching Schedule				Examination Scheme						
				Theory			Practical			Total
L	T	P	Total	Assessment Marks	Final Duration (Hrs)	Marks	Assessment Marks	Final Duration (Hrs)	Marks	
3	1	0	4	40	3	60	0	0	0	100

Depth Codes

E-Explanation	DES= Discussion	D-Definition	DM-Demonstration
DV-Derivation	DW-Drawing	P-Proof	I-Illustration
NUM-Numerical	PRG-Programming	S-State	ACT-Activity-based Learning
MP- Mini Project	EXP-Experiment	REV-Review / Recap	PS- Problem Solving
QA- Question Answer	Q- Quiz	ST- Surprise Test	MT-Mid Term Test

Unit	Topic/ Sub topic	Depth Code	Description of Depth	Actual plan			Week
				L	T	P	
1	**Structural timber**			**2**	**0**	**0**	**1**
	1.1 Introduction to timber structures	D, E	Definition, Uses of timber, examples, Characteristics of good timber Advantages and disadvantages Physical and mechanical properties of timber	0.5			
	1.2 Characteristics and classification of structural timbers	D, E	Classification of structural timber according to grade, location, durability, treatability, availability, refractoriness to air seasoning	0.5			
	1.3 Factors affecting the strength of structural timbers	D, E	Describe the factors affecting the strength of structural timber	0.25			
	1.4 Grade of structural timbers and permissible stresses	D, E	Grade of timber based on code provisions Permissible stresses for species of timber	0.25			
	1.5 Cross-laminated timber, glued-laminated timber, nail-laminated timber, and dowel-laminated timber	D, E	Definition, Uses	0.5			
	Evaluation	QA, Q					

Unit	Topic/ Sub topic	Depth Code	Description of Depth	Actual plan			Week
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2	**Joints in Timber Structures**			**4**	**1**	**0**	**1-2**
	2.1 Types of mechanical fasteners: Bolts, nails, screws	D, E	Definition, Introduction to traditional timber joineries	1			
	2.2 Behavior and design of bolted and nailed joints	D, E, NUM	Framed joints, Lap joints, Fish plate joints Design of bolted joints (pitch, gauge of bolts, end distance, edge distance) Design of nailed joints (Types of nails; Specifications for nailed joints, Strength of nailed joints) (Numerical on design of bolted joints)	1.5	1		
	2.3 Joint (Connection) detailing	D, E, I	Connection detailing, uses, figure	1.5			
	Evaluation	QA, Q					

Unit	Topic/ Sub topic	Depth Code	Description of Depth	Actual plan			Week
				L	T	P	
3	**Structural Elements of Timber Structures**			**8**	**3**	**0**	**2-4**
	3.1 Types of timber columns and columns bases	D, E, I	Describe the types of timber columns and column bases	1			
	3.2 Design of axially loaded columns	E, NUM	Design of solid column, built-up column, box column, spaced column	2	1		
	3.3 Design of column subjected to combined bending and direct stresses	E, NUM	Design of column subjected to combined bending and direct stresses	2	1		
	3.4 Types of timber beams	D, E	Describe the types of timber beams	1			
	3.5 Design of flexural members (Beams and flitched beams)	E, NUM	Design of flexural members and check for horizontal shear, bearing stress and deflection	2	1		
	Evaluation	QA, Q, MT					

Unit	Topic/ Sub topic	Depth Code	Description of Depth	Actual plan			Week
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4	**Masonry Structures**			**4**	**0**	**0**	**5-6**
	4.1 Introduction, history and use of masonry structures	D, E	Definition of masonry and masonry units, Uses of masonry structures, Types of masonry structures, Advantages and disadvantages, History of masonry structures in ancient and modern times, Structural limitations of masonry structures	0.5			
	4.2 Characteristics of brick, stone, concrete block, hollow block, and compressed earth block	D, E	Characteristics and construction methodology, Advantages and disadvantages of brick, stone, concrete block, hollow block, compressed earth block	0.5			
	4.3 Stone masonry structures: Types and characteristics	D, E	Characteristics and construction methodology, Advantages and disadvantages	1			
	4.4 Brick masonry structures: Types (English, Flemish and rat-trap bonds) and characteristics	D, E	Description of bricks, Stretcher, Header, Types of closer, Description of different types of bonds with figures	1			
	4.5 Reinforced and un-reinforced masonry	D, E	Definition, Types, Advantages and disadvantages	0.5			
	4.6 Confined masonry	D, E	Definition, Construction technology, advantages and disadvantages	0.5			
	Evaluation	QA, Q					

Unit	Topic/ Sub topic	Depth Code	Description of Depth	Actual plan			Week
				L	T	P	
5	**Design of Masonry Walls for Gravity Loads**			**8**	**8**	**0**	**6-8**
	5.1 Codal provisions	D, E	Introduction to various design codes for masonry design, Use of masonry structures as load bearing and non-load bearing walls	1			
	5.2 Design of solid walls under gravity loads	E, NUM	Design example of solid wall and cavity wall under gravity loads	1	2		
	5.3 Design of walls with openings	E, NUM	Design example of wall with openings	2	2		
	5.4 Design of walls subjected to eccentric loads	E, NUM	Design example of solid wall and cavity wall with eccentric loads	2	2		

Unit	Topic/ Sub topic	Depth Code	Description of Depth	Actual plan			Week
				L	T	P	
	5.5 Design of walls acting as columns	E, NUM	Design example of walls acting as columns	2	2		
	Evaluation	QA, Q					

Unit	Topic/ Sub topic	Depth Code	Description of Depth	Actual plan			Week
				L	T	P	
6	**Masonry Structures Under Lateral Loads**			**7**	**2**	**0**	**8-10**
	6.1 In-plane and out-of-plane behavior of masonry structures	D, E, I	Describe in plane and out of plane behavior and illustrate with figure. Types of failure modes subjected to in-plane loads	1			
	6.2 Typical damage patterns in masonry structures due to lateral loads	D, E, I	Types of failure behavior of masonry structure due to lateral loads, illustrate with figures	2			
	6.3 Ductile behavior of reinforced and unreinforced masonry structures	D, E, I	Description and explanation of ductile behavior of reinforced and unreinforced masonry structures	1			
	6.4 Lateral force distribution for rigid and flexible diaphragms	D, E, I	Theoretical concept on distribution of lateral forces based on flexibility of diaphragms	1			
	6.5 Design of masonry walls for wind loads	E, NUM	Design example of wall subjected to vertical load and wind pressure	1	2		
	6.6 Elements of lateral load-resisting masonry system	D, E, I	Describe the elements of lateral load-resisting masonry system with figures	1			
	Evaluation	QA, Q					

Unit	Topic/ Sub topic	Depth Code	Description of Depth	Actual plan			Week
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7	**Seismic Design and Strengthening of Masonry Buildings**			**8**	**1**	**0**	**11-13**
	7.1 Seismic behavior of unreinforced and reinforced masonry	D, E	Seismic behavior of masonry building during earthquakes	1			
	7.2 Seismic design principles for masonry construction	D, E, I	Principle of seismic design of masonry structures Basic practices in the design and construction of masonry structures	1			
	7.3 Seismic design of masonry walls	E, NUM	Design example of shear wall under seismic loading	2	1		

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	7.4 Codal provisions for seismic design of masonry	D, E, I	Codal provisions	2			
	7.5 Seismic strengthening measures of masonry structures	D, E, I	Different seismic strengthening measures of masonry structures (brick and stone masonry) Existing retrofitting practices of masonry structures in Nepal	2			
	Evaluation	QA, Q, MT					

Unit	Topic/ Sub topic	Depth Code	Description of Depth	Actual plan			Week
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8	**Testing of Masonry Elements**			**4**	**0**	**0**	**14-15**
	8.1 Compressive strength of bricks and walls	D, E, I	Procedure, sampling, calculation of compressive strength	1			
	8.2 Diagonal shear test	D, E, I	Procedure based on ASTM E519	1			
	8.3 Non-destructive tests: Ultra-sonic pulse velocity test; Elastic wave tomography; Semi-destructive tests (Flat-jack test, push shear test)	D, E, I	Procedure of performing the tests with figures	2			
	Evaluation	QA, Q					

References:

1. Arya, A. S. (1992). Masonry and timber structures including earthquake resistant design (Latest Edition). Nem Chand & Bros.
2. Dayaratnam, P. (2017). Brick and reinforced brick structures. Oxford & IBH Publishing.
3. Handry, A. W., Sinha, B. P., Davies, S. R. (1981). An introduction to load bearing brick design (Latest Edition). University of Edinburgh.
4. Drysdale, R. G., Hamid, A. A., Baker, L. R. (1999). Masonry structures: Behaviour and design (Latest Edition). Prentice Hall.
5. Tomazevic, M. (1999). Earthquake-resistant design of masonry buildings (Latest Edition). Imperial College Press.
6. IS 883 Code of Practice for Design of Structural Timber in Buildings
7. IS 1905 Code of Practice for Structural use of Unreinforced Masonry, Bureau of Indian Standards
8. SP 20 Explanatory Handbook on Masonry Code, Bureau of Indian Standards.
9. NBC 109 Nepal National Building Code
10. NBC 202 Guidelines on: Load Bearing Masonry
11. NBC 203 Guidelines for Earthquake Resistant Building Construction: Low Strength Masonry

Model Question

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- ***Use of IS: 1905 and IS: 883 are allowed***

QN	Question	Marks	Unit
1	Classify the structural timber based on grade of timber? Describe the factors affecting the strength of structural timber?	2+2	1
2	What are the specifications for nailed joints?	4	2
3	A timber column 4 m long has to support a load of 100 kN. Taking the column to be of Deodar wood, design the column as spaced column.	6	3
4	A timber beam is 160 mm wide and 300 mm deep and is simply supported on a span of 6m. It carries a uniformly distributed load of 3 kN/m run over the whole span and three equal concentrated loads W each placed at mid span and quarter span points. If the stress in timber is not to exceed 8 N/mm^2, find the maximum value of W.	6	3
5	Describe the importance of masonry structure in modern era. List the structural limitations of masonry structures.	4	4
6	A wall 250 mm thick, using modular bricks carries at the top a load of 300 kN/m having resultant eccentricity ratio of 1/12. Wall is 4 m long between cross walls and is 3.5 m clear height between RCC slabs at the top and bottom. What shall be the strength of brick and the grade of mortar? Assume that joints are not raked.	8	5
7	External wall of a single storeyed building is 250 mm thick and carries 100 kN/m load at the top of the wall with eccentricity of 12 mm. The plinth level is 1.5 m above the top of foundation footing and floor to ceiling height is 3 m. RCC slab rests on the wall and is 12 cm thick. Determine the maximum stress in the wall and calculate the strength of brick and grade of mortar required for the wall. Assume necessary data if required.	8	5
8	Explain with figure, failure behavior of masonry structures in lateral loads. What are the main elements that resist the lateral loads in buildings? Explain with sketches.	3+2	6
9	Describe in-plane and out of plane behavior of masonry structure.	3	6
10	Explain the procedure for repair and retrofitting of masonry building.	6	7
11	Explain compressive and diagonal shear tests in masonry structures.	3+3	8

Note: *Number of questions and distribution of marks are indicative only.*