Gyanmanjari Innovative University

Course Syllabus
Gyanmanjari Institute of Technology
Semester-7 (B. Tech.)

Subject: Design of Storage Structure– BETCV17336
Type of Course: Professional Core
Prerequisite: Knowledge of Structural Mechanics, Design of Structure

Rationale: Most storage structures such as water tanks, silos, bunkers, and industrial storage systems are critical infrastructure components that safeguard essential resources like water, food grains, cement, and petroleum products. Their design demands a clear understanding of hydrostatic and granular pressure behaviour, crack control, durability, and serviceability requirements. Unlike ordinary buildings, storage structures are governed not only by strength but also by water tightness, flow mechanics, and long-term performance. The Limit State and Working Stress philosophies, as applicable under IS 3370 and IS 4995, form the technical backbone of this course. This subject equips students with analytical, design, and detailing skills necessary for safe, durable, and functionally reliable storage infrastructure.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks					Total Marks
				Theory Marks		Practical Marks		CA	
CI	T	P	C	ESE	MSE	V	P	ALA	
4	0	2	5	60	30	10	20	30	150

Legends: CI-Classroom Instructions; T – Tutorial; P - Practical; C – Credit; ESE - End Semester Examination; MSE- Mid Semester Examination; V – Viva; CA - Continuous Assessment; ALA- Active Learning Activities.

GYANMANJARI INNOVATIVE UNIVERSITY BHAVNAGAR

Course Content:

Sr. No.	Course Content	Hrs.	% Weightage
1	**Fundamentals of Storage Structures** Classification of Storage Structures, Based on stored material, geometry, location and construction material. Behaviour of Stored Materials, Hydrostatic Pressure, Granular Pressure, Janssen's Theory and Airy's Theory. Derivation of hydrostatic bending moment, Load Cases in Storage Structures Failure Modes, Introduction of IS 3370 for liquid tanks, IS 4995 for silos/bunkers, IS 1893 for seismic loads.	10	20 %
2	**Design of Silos and Bunkers** Nature of Granular Materials: Bulk Material Characteristics, Classification of Storage Bins, Load Cases in Silos, Column-supported vs wall-supported silos, Overpressure factors during discharge, Structural Design of Circular RC Silos, Rectangular Silos and Bunkers, Hopper Design (Gravity Discharge), Steel Silos.	15	30 %
3	**Special Storage Structures and Industrial Applications** Industrial Silos and Heavy-Duty Bunkers, Characteristics of Industrial Storage, Design Considerations for Heavy-Duty Silos, Abrasive Wear and Durability Measures. Hopper Steepness and Flow Assurance, Steel Plate Tanks, Ferro-Cement and Plastic Tanks, Deflection and Crack Control in Tall Tanks and Silos, Maintenance and Inspection Requirements, Industrial Silo Functional Requirements.	15	20 %
4	**Advanced Topics and Case Studies in Storage Structures** Prestressed Concrete Storage Tanks, Circumferential prestress calculation, Loss estimation example, Net stress verification, Seismic Behaviour of Storage Structures, Sustainability in Storage Structures, Structural Health Monitoring (SHM), Needs, Advanced sensors of PZT (Piezoelectric) Sensors and Fiber Optic Sensors. Case Studies of Storage Structure Failures: Tank Failures, Silo Failures and Earthquake Damage.	20	30 %

Continuous Assessment:

Sr. No.	Active Learning Activities	Marks
1	**Comparative Design Study of Circular vs. Rectangular water tank:** Compare on filed site circular and rectangular RCC tanks in terms of structural behaviour, crack control, and economy. Students are required to prepare detailed observation presentation reports and upload them in Presentation format on the GMIU web portal.	10
2	**Silo Pressure Analysis & Structural Design:** Faculty will assign a study to understand Janssen's and Airy's pressure theories and their impact on design. Students will assume necessary data, perform calculations, carry out the design, and present conclusions. Hand calculations must be scanned and uploaded in PDF format on the GMIU web portal.	10
3	**Case Study & SHM Proposal:** Faculty will assign students to develop failure analysis and modern monitoring approaches. Students will select one real storage structure failure, identify its purpose, and refer to seismic provisions of IS 1893. A 2-page technical summary must be prepared and uploaded in PDF format on the GMIU web portal.	10
TOTAL		**30**

Suggested Specification table with Marks (Theory): 60

Distribution of Theory Marks (Revised Bloom's Taxonomy)						
Level	Remembrance (R)	Understanding (U)	Application (A)	Analyze (N)	Evaluate (E)	Create (C)
Weightage %	5%	10%	25%	25%	20%	15%

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Course Outcome:

After learning the course, the students should be able to:	
CO1	Apply hydrostatic and granular pressure theories to analyze storage structures under relevant loading conditions.
CO2	Design silos and bunkers for bulk materials using appropriate pressure theories and codal provisions.
CO3	Design RCC and prestressed liquid-retaining structures in accordance with related standards.
CO4	Assess advanced design considerations including prestressing, durability, sustainability, and structural health monitoring for long-term performance of storage infrastructure.

List of Practical

Sr. No.	Descriptions	Unit No.	Hrs.
01	Calculation manually of hydrostatic pressure distribution and bending moment diagram for a rectangular tank wall.	01	02
02	Calculation of Excel sheet hydrostatic pressure distribution and bending moment diagram for a rectangular tank wall.	01	02
03	Computation of granular pressure using Janssen's theory and comparison with linear pressure assumption.	01	02
04	Design of a circular RCC water tank: wall thickness, hoop reinforcement, crack width check as per IS 3370.	02	04
05	Design of base slab of underground tank considering soil pressure and uplift; stability check against flotation.	02	04
06	Design of circular RC silo wall: pressure calculation, hoop tension, reinforcement detailing.	03	02
07	Design of hopper bottom and ring beam for a rectangular bunker including punching shear verification.	03	04
08	Preliminary design of industrial steel plate tank: shell thickness calculation and wind stability check.	04	04
09	Durability assessment report for heavy-duty silo.	04	02
10	Ductile Detailing drawing of various storage tank	ALL	04
TOTAL			**30**

Instructional Method:

The course delivery method will depend upon the requirement of content and need of students. The teacher in addition to conventional teaching method by black board, may also use any of tools such as demonstration, role play, Quiz, brainstorming, MOOCs etc.

From the content 10% topics are suggested for flipped mode instruction.

Students will use supplementary resources such as online videos, NPTEL/SWAYAM videos, e-courses, Virtual Laboratory.

The internal evaluation will be done on the basis of Active Learning Assignment.

Practical/Viva examination will be conducted at the end of semester for evaluation of performance of students in the laboratory.

Reference Books:

[1] Concrete Structures for Storage of Liquids (IS 3370) – Commentary & Worked Examples, Structural Publications, India.

[2] Design of Concrete Silos and Bunkers, Bureau of Indian Standards & Allied Publishers, India.

[3] Limit State Design of Steel Structures, S. K. Duggal, Tata McGraw-Hill Education, New Delhi.

[4] Design of Concrete Structures, N. Subramanian, Oxford University Press, New Delhi.

[5] Structural Analysis, R. C. Hibbeler, Pearson Education, India.

[6] Prestressed Concrete, N. Krishna Raju, McGraw-Hill Education, New Delhi.

[7] Design of Concrete Structures, N. Subramanian, Oxford University Press, New Delhi.