Spring 2024

Arch 537-002: Cable and Tension Structures

Rima Taher

NJIT SPRING 2024
INSTRUCTOR: Rima Taher, PhD, PE, Senior University Lecturer

ARCH 537 - 002:

Cable & Tension Structures

Face-to-Face Course – 3 Credits – Tuesday & Friday from 1:00 pm to 2:20 pm – Weston 210

COURSE OVERVIEW:

The course covers the structural technology, history and design considerations of cable-suspended, cable-stayed, tensioned fabric and air-supported structures, and the use of light-tensile structures in architecture. The course also offers an overview of the engineering standards that provide guidelines and recommendations for their design. A long list of well-known cable and tensioned fabric structures will be used to illustrate the structural design concepts. The examples focus mainly on buildings and roof structures. The tensioned fabric roof examples include some of the impressive projects of Geiger Berger Associates and Horst Berger Partners who pioneered the evolution of tensioned fabric structures in the US and elsewhere.

PREREQUISITE:

Structures I

LEARNING OBJECTIVES:

1) Develop the ability to select and design a structural system using cables and tensioned fabric for a building or an open outdoor structure.

2) Develop the ability to use some established rules of thumb for the selection of structural members.

3) Develop skills for using some analytical methods to help prove the design decisions beyond the general rules of thumb.

4) Develop the ability to apply the theoretical concepts and methods using some practical design projects.

5) Learn about the various materials used in the design and construction of tensile structures.

NAAB PROGRAM CRITERIA

The National Architectural Accrediting Board (NAAB) accredits NJIT's architecture program. The NAAB has Shared Values of the Discipline and the Profession that must be covered by any architectural curriculum to attain their approval. This course satisfies the following shared values:

Design: Architects design better, safer, more equitable, resilient, and sustainable built environments. Design thinking and integrated design solutions are hallmarks of architecture education, the discipline, and the profession.

Equity, Diversity, and Inclusion: Architects commit to equity and inclusion in the environments we design, the policies we adopt, the words we speak, the actions we take, and the respectful learning, teaching, and working

environments we create. Architects seek fairness, diversity, and social justice in the profession and in society and support a range of pathways for students seeking access to an architecture education.

COURSE REQUIREMENTS:

Students are expected to take a midterm and a final exam and to work on three projects. The projects will require building a structural model in addition to producing some drawings. Students are required to upload their project files to Canvas in PDF format by the posted due date. No late assignments will be accepted. Students should not e-mail their files to the instructor. All e-mailed assignment files will be ignored and deleted. Projects will be graded on Canvas. Grades and comments will also be posted on Canvas.

All students are expected to take the midterm and final exams on the scheduled date and during the scheduled time. No make-up exam will be given if students do not show up as scheduled unless the student has a compelling and valid reason that can be substantiated. Proof of hardship must be presented to the Dean of Students. The use of electronic devices will not be permitted during the exam. Only a basic scientific non-communicating calculator will be allowed. Students will have 1 hour and 20 minutes for the midterm exam. The final exam is 2.5 hours and will be given during the final exams' week.

Students enrolled in this course are not to schedule vacation and holiday trips while the course is ongoing, and on dates that coincide with due dates. Airline tickets must not be booked until the course is completely over.

Attendance is mandatory. An attendance record will be kept. The instructor can lower the student's grade based on the attendance record as permitted by the university policies.

MEANS OF EVALUATION:

Project 1: 15% - Tentative Date: Friday February 13
Mid-Term Examination: 25% - Tentative date: Friday March 22nd
Project 2: 15% - Tentative Date: Friday April 5
Project 3: 15% - Tentative Date: Tuesday April 30
Final Exam: 30% - During the final exams' week

TEXTBOOKS:

1. The Tensioned Fabric Roof, by Craig G. Huntington, ASCE Press (American Society of Civil Engineers), 2004.

2. Simplified Structural Analysis and Design for Architects, Revised Second Edition, by Rima Taher, Cognella, Inc., ISBN # 978-1-5165-1057-3

USEFUL REFERENCES:

1. Tensile Fabric Structures – Design, Analysis and Construction, prepared by the Task Committee on Tensioned Fabric Structures, Edited by Craig Huntington, Structural Engineering Institute of ASCE, ASCE (American Society of Civil Engineers) 2013.

INSTRUCTOR:

Rima Taher, PhD, PE, Senior University Lecturer

Instructor will be available for counseling on Tuesday from 11:45 to 12:45 or by appointment.

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ACADEMIC INTEGRITY:

Academic Integrity is the cornerstone of higher education and is central to the ideals of this course and the university. Cheating is strictly prohibited and devalues the degree that you are working on. As a member of the NJIT community, it is your responsibility to protect your educational investment by knowing and following the academic code of integrity policy that is found at: ***http://www5.njit.edu/policies/sites/policies/files/academic-integrity-code.pdf***.

Please note that it is my professional obligation and responsibility to report any academic misconduct to the Dean of Students Office. Any student found in violation of the code by cheating, plagiarizing or using any online software inappropriately will result in disciplinary action. This may include a failing grade of F, and/or suspension or dismissal from the university. If you have any questions about the code of Academic Integrity, please contact the Dean of Students Office at dos@njit.edu.

WEEK-BY-WEEK SCHEDULE:

Week	Date	Topic/*Assignment*
1	1/14 to 1/20	**Classification of Cable Roof Structures:** • Cable-Suspended Structures • Cable-Supported or Cable-Stayed Structures • Air-Supported or Pneumatic Roofs
2	1/21 to 1/27	**Structural Cable Systems** • Simply Suspended Cable Structures • Pretensioned Cable Beam Structures • Pretensioned Cable Net Structures • Pretensioned Cable Grid Structures • General Structural Characteristics
3	1/28 to 2/3	**Examples of Cable Roofs** • North Carolina State Fair Building • Villita Assembly Hall, San Antonio, Texas • Automobile Museum, Petit Jean Mountain, Arkansas • Pan American Terminal, JFK Airport, NYC • Travelers Insurance Companies World's Fair Pavilion • Madison Square Garden, NYC • Utica Memorial Auditorium, Utica, NY

4	2/4 to 2/10	**Examples of Cable Roofs (Continued)** • Cable-Stayed Cantilevered Hangars: TWA Hangar, Philadelphia – Pan Am Hangar – US Navy Hangar • Yale University Skating Rink • Tulsa Exposition Center, Tulsa, OK • Cyclorama Building, Gettysburg, PA • Dulles International Airport Terminal, VA **Project 1: Design of a Cable Roof Structure**
5	2/11 to 2/17	**Cables and Terminals – Tension Anchors** • Wire Strand Rope/Steel • Manufacture of Cables and Cable Properties • Cable Termination • Prestressing • Types of Tension Anchors **Project 1: Design of a Cable Roof Structure**
6	2/18 to 2/24	**Basic Design Principles of Cable Roofs** • Statics and Dynamics – Methods of Analysis **Project 1 Due: Friday 2/23 – Project 1 Presentation**
7	2/25 to 3/2	**Tensioned Fabric Roofs:** **The Tensioned Fabric Roof** • Design Priorities • Appreciation of Tensioned Fabric Structures
8	3/3 to 3/9	**Elements of Form and Design** • Principles of Design • Generating Anticlastic Shapes **Tensioned Fabric Structural Systems** • Cones: National Semiconductor Amphitheater – The Weber Points Events Center – Kaleidoscope Shopping Center. • Suspended Roofs: Milano Fair Ground Roof – Hajj Terminal, Jeddah, Saudi Arabia – England's Millenium Dome. **Project 2: Design of a Tensioned Fabric Roof Structure/ Cone System**
9	3/10 to 3/16	**Spring Recess – No Class**
10		**Midterm Exam: Friday March 22** **Tensioned Fabric Structural Systems**

	3/17 to 3/23	• Ridge and Valley Systems: Denver Airport Roof – San Diego Convention Center. • Cantilevered Canopies: Jameirah Beach Hotel – King Fahd Stadium, Saudi Arabia – Stanford University's Avery Aquatic Center. **Project 2: Design of a Tensioned Fabric Roof Structure/ Cone System**
11	3/24 to 3/30	**Tensioned Fabric Structural Systems (Continued)** • Arch Systems: Hanover Park, Illinois, tennis facility – Pizzitola Athletic Facilty – Bueno Ventura Shopping Center, California – Lindsay Park Sports Center, Calgary, Alberta – Munich Ice Rink, Germany. • Air-Supported Roofs: Walter Bird's First Radome/ Radome Technology – The US Pavilion in Osaka, Japan – The Pontiac Silverdome. **Friday 3/29: Good Friday – No Class**
12	3/31 to 4/6	**Last Day to Withdraw: Monday April 1st.** **Tensioned Fabric Structural Systems (Continued)** • Air Inflated Lenses: The Ancient Amphitheater at Nimes, France. • Cable Domes: Florida's Tropicana Dome – The Giorgia Dome in Atlanta. Cable Nets: Munich's Olympic Stadium. **Project 2 Due: Friday 4/5 – Project 2 Presentation**
13	4/7 to 4/13	**Materials** • Fabric Performance Parameters • PVC-Coated Polyester • PTFE-Coated Fiberglass • Silicone-Coated Fi berglass • Films, Meshes, Knits and Other Materials **Project 3: Design of a Tensioned Fabric Roof Structure/ Arch System**
14	4/14 to 4/20	**Erection** • Layout and Erection • Construction Coordination • Maintenance **Project 3: Design of a Tensioned Fabric Roof Structure/ Arch System**
15	4/21 to 4/27	**Form Finding and Analysis** • Analytical Procedures • Computerized Techniques **Connections** • Fabric Joints and Terminations

16	4/28 to 5/4	**Project 3 Due: Tuesday 4/30 – Project 3 Presentation** **Review for the Final Exam** **Last Day of Class at NJIT: Tuesday 4/30 – Friday Schedule** **Reading Day 1: Wednesday May 1st** **Reading Day 2: Thursday May 2nd** **Last Lecture: Tuesday 4/30**
17		**Final Exam Week: From Friday May 3 to Thursday May 9**