The Ganter Bridge on the Simplon Road, Switzerland, 1980, Eng. Christian Menn

BUILDING TECHNOLOGY II: MATERIALS AND CONSTRUCTION

INSTRUCTOR
WANG, Shuaizhong shuaizhongwang@cuhk.edu.hk

ISSUE

This course focuses on fundamental knowledge and design methods for architectural structures. By revealing and analysing the internal forces within architectural structures through graphic statics, the course introduces the basic principles, systems, and materials of architectural structures in both qualitative and quantitative ways. The aim is to connect structural forms and forces through graphical methods, making structural design an essential element that enhances spatial form, rather than an obstacle to design.

DESCRIPTION

This course will introduce you to the hidden world of internal force flow within structural systems. With the tool of Graphic Statics, you will grasp the interdependency of forms and forces, and analyse them in diverse structural typologies from funicular ones like cables and arches to everyday ones like beams, columns, and frames.

On the one hand, you will appreciate the efficiency of structural typologies with a clear understanding of their internal equilibrium and dynamics. On the other hand, you will transcend these prototypes and utilise their structural principles to analyse structural installations made from everyday objects, with equilibrium as a common ground.

Subsequently, equipped with the knowledge of materialisation, dimensioning, and structural materials, you will derive structural prototypes from the structural installations and apply them to design a pavilion, which could serve as inspiration for the studio work in ARCH 2112.

In this course, you will learn to analyse and design structures not only as an efficient supporting system but as a powerful instrument for defining architectural space.

IMPACT AND SUSTAINABILITY

In this course, you will gain a new perspective on structural design by understanding internal force flow. Move structural design beyond monotonous, passive and procedural formulas and calculations to a graphical tool that actively strengthens the design. Through the lectures, exercises in class and practice in the design studio, you will learn and explore the following areas:

1. The internal forces and their equilibrium within structural elements
2. The relationship between the form of a structure and the internal forces within it
3. Essential structural typologies
4. Diagrams and operations of the physical and psychological equilibrium of structures
5. The operation of structural design process
6. Basic dimensioning of structural elements
7. The integrated design approach to structure and architecture

This course begins with the basic principles of internal force equilibrium to provide a clear and direct understanding of the flow of forces. This approach allows for the minimisation of redundant materials in structural design, maximising the efficiency of structural forms. Through techniques like form-finding and structural analysis, students will learn to contribute to the sustainable use and reuse of structural materials in the future. Additionally, students can design innovative structural systems that enhance structural and spatial efficiency, thereby reducing material consumption in their designs and improving adaptability for use and maintenance.

The final project of this course invites students to derive structural prototypes from installations combining everyday objects. These prototypes will be finalised to meet the dimension of the studio project in ARCH2112, serving as structural inspirations and providing analytic tools for the studio work.

METHODS

The course consists of two stages: lectures & exercises on structural design based on Graphic Statistics and large-scale conceptual design.

In the first stage, the course introduces students to structural design and static equilibrium. In weeks 2, 3, 4, 5, 6, each lecture highlights the graphic static analyses of an essential structural typology, followed by corresponding exercises to be finished by individual students and critiqued in class. The remaining lectures supplement students with knowledge of materialisation, dimensioning, and structural materials, bridging the gap between conceptual design and real practice.

In the second stage, students will combine everyday objects into structural installations visualising interesting cases of equilibrium. Working in groups, they will analyse and develop the intuitive installations with structural principles learnt in the course and refine structural prototypes from them. The prototype will then be applied to design a pavilion corresponding to ARCH2112, which situates the prototype in a concrete scenario and allows for its materialisation. This approach integrates learned structural knowledge with real design challenges, deepening their understanding of structures while enhancing structural thinking in design.

GUEST LECTURES

TBD.

DELIVERABLES

Exercise 1 (Individual work):
Graphic static analyses of structural typologies
1. in-class exercises in weeks 2, 3, 4, 5, 6.
2. in-class quizzes in weeks 8,10.

Exercise 2 (Group work):
Students are divided into 12 groups (about 4 students per group).

Stage 1: structural installations
Combine everyday objects to make structural installations visualising interesting scenarios of equilibrium. Use graphic statics to assist in the analysis and development of the structural installation.
1. Final structural installation
2. Line drawings of the final installation, with preliminary static analysis
3. Serial photographs and line drawings of installation development (at least 6 variations)

Stage 2: structural prototypes
Derive structural prototypes from the structural installations in Stage 1 by refining the corresponding structural principles. Apply the structural prototypes to design a pavilion. Properly materialise the structural elements.
1. Structural prototype with graphic static analysis

2. detailed model of the pavilion considering material and dimensioning (1:10)
3. plans, sections, and elevations of the pavilion (1:20)
4. static analysis and dimensioning of the pavilion

LEARNING OUTCOMES

At the end of the courses, students will be able to:

1. visualise the internal forces within structural elements.
2. understand the relationship between the form of a structure and the internal forces within it.
3. modify the design of a structure in order to improve it.
4. identify the most important structural typologies
5. use graphic statics for the form-finding and analysis of structures.
6. carry out basic dimensioning of structural elements.
7. integrate structural thinking in their architectural design project.

ASSESSMENT SCHEME

SPECIFIC ASSESSMENT

Specific assessment methods/tasks	**% weighting**
In-class Exercises and Quizzes	40%
Final Project	60%
1. Midterm Review	*10%*
2. Final Review	*20%*
3. Final Booklet	*30%*

Total: 100%

Each assessment result will be released to students upon completion accompanied by written comments based on student progress and performance.

COURSE FORMAT

Teaching Days
1. Students must attend for F2F teaching during these teaching hours.
   Teaching Day: Wednesday 2:30 - 5:15pm
   Teaching Venue: ARC G01
2. Field trips, lectures, and other learning activities may be scheduled outside of teaching days.

Student Study Effort (Total: 140 hrs)
1. Class Contact: 44 hrs (Lecture 33hrs, Tutorial 5.5hrs, Critique 5.5hrs, Field Trip)
2. Other Student Study Effort: 100 hrs (Studio / Self Study)

Assistant
LIN, Kaiyi (kaiyilin@cuhk.edu.hk)

REQUIRED READINGS

Edward Allen, Waclaw Zalewski. *Form and Forces: Designing Efficient, Expressive Structures*. Hoboken: John Wiley & Sons, 2010.
Aurelio Muttoni. *The Art of Structures: Introduction to the Functioning of Structures in Architecture*, EPFL Press, 2011.
Bjørn N. Sandaker, Arne P. Eggen, Mark R. Cruvellier. *The Structural Basis of Architecture*, Routledge, 2011.
Maria Vrontissi, Juan J. Castellón González, Pierluigi D'Acunto, Lluís E. Monzó, and Joseph Schwartz. "Constructing Structural Concepts by Means of Physical Models," *International Association for Shell and Spatial Structures (IASS)*, Madrid, 2018.
Online source: *https://block.arch.ethz.ch/eq/drawing*

OTHER REFERENCES

Cruvellier, Mark R., Luben. Dimcheff, and Bjorn N. Sandaker. *Model Perspectives: Structure, Architecture and Culture*, London: Taylor and Francis, 2017.
Eduard Franz Sekler. "Structure, Construction, Tectonics," In G. Kepes (Ed.), *Structure in Art and Science*, Braziller, New York, 1965, pp. 89-95.
Shuaizhong Wang, Toni Kotnik, Joseph Schwartz, and Ting Cao. "Equilibrium as the common ground: Introducing embodied perception into structural design with graphic statics," *Frontiers of Architectural Research*, 11 (3), 2022: 574-589.

IMPORTANT NOTE TO STUDENTS

Expectations for Professional Conduct
The motto of The Chinese University of Hong Kong (CUHK) is "Through learning and temperance to virtue". This motto places equal emphasis on the intellectual and moral education of students. In addition to pursuing academic excellence, students of CUHK are expected to maintain and uphold the highest standard of integrity and honesty in their academic and personal lives, respect the rights of others and abide by the law. More information on undergraduate studies can be found in the UG Student Handbook. https://rgsntl.rgs.cuhk.edu.hk/aqs_prd_applx/Public/Handbook/

Attendance
Class attendance is required in all courses. For an excused absence, the instructor must be notified and presented with documentation of illness or personal matter. Please note: **Three (3)** or more unexcused absences may result in a failing grade for the course.

Academic Honesty
The Chinese University of Hong Kong places very high importance on honesty in academic work submitted by students and adopts a policy of zero tolerance on academic dishonesty

Attention is drawn to University policy and regulations on honesty in academic work, and to the disciplinary guidelines and procedures applicable to breaches of such policy and regulations. Details may be found at: http://www.cuhk.edu.hk/policy/academichonesty/.

With each assignment, students may be required to submit a statement that they are aware of these policies, regulations, guidelines and procedures.

Third-Party Assistance
All intellectual work essential to the design project must be completed by the student and cannot, under any circumstance, be outsourced to a third party (including, but not limited to a company, consultant, alumni, and/or friend).

In the design studio context, students may utilise external resources, such as printing services for presentation materials, and/or laser cutting and 3D printing services for prototyping purposes. Use of such third-party services constitutes non-intellectual work done by others. It is only permitted with prior written consent from the studio tutor and acknowledgement of such work done by the third party.

Assistance from other students or friends for aspects of project production also constitutes non-intellectual work done by others; this is allowed only if declared and acknowledged in a written statement attached to any such work that has received assistance.

Under all circumstances, students must declare all work done by others by completing the school's designated form before assessment. This form must include a detailed explanation of the third party's identity (name and relationship to the student), when and how they were utilised, and the specific tasks they performed in the project. The completed form, signed by the student, must be endorsed by the tutor and presented during the final review. The school will collect and retain this form for record-keeping purposes.

Failure to follow this code of conduct may be considered a case of academic dishonesty, to be reviewed by a disciplinary board, and possible failure of the course.

Artificial Intelligence
Students may use some AI tools in some learning activities and/or assessments on the condition that they make explicit acknowledgement and proper citations of the input from AI tools.

Students are required to acknowledge all functional uses of an AI tool and cite it when they paraphrase, quote, or incorporate into their own work any content (whether it is text, image, data, or other format) that was created by it.

An example of acknowledgement
'I acknowledge the use of (name of AI tool – e.g. ChatGPT (https://chat.openai.com/) to (specify the support, e.g. plan my essay, generate some ideas for the content, ask for examples of data collection instruments, get the dates of historical events, etc.).

An example of citation
OpenAI. (2023). ChatGPT (Mar 20 version). https://chat.openai.com/chat
(Students are reminded that due to the rapid developments of AI tools, some citation formats may be updated regularly.)

An example of including texts generated by an AI tool in their work
"The following text was generated by an AI tool/language model (ChatGPT):"
[Insert the text generated by ChatGPT here.]

An example of including texts generated by an AI tool and the prompts that were used to elicit the text from the AI tool
"[The prompt], as generated by an AI language model (ChatGPT):"
[Insert the text generated by ChatGPT in response to the prompt.]

Students are reminded to learn and use the AI tools responsibly and ethically and be aware of the limitations. Improper/unauthorised use of AI tools in learning activities and assessments will constitute acts of academic dishonesty which will be handled in accordance with the University's Procedures for Handling Cases of Academic Dishonesty. Students are reminded to clarify with the course teacher and obtain permission if necessary when in doubt.

Students may refer to Approach 3 of the CUHK 'Use of Artificial Intelligence tools in Teaching, Learning and Assessments' – A Guide for Students.

Student Work
Submission of course work documentation must be complete and correctly formatted. Missing or incomplete submission of the documentation folder will result in the grade for the course being withheld. This will prevent registration for the following term or delay graduation.

External Examination
Of paramount importance to the academic rigour and professional relevance of the architecture programme, the external examination process serves as a critical and impartial review mechanism. An invited panel of distinguished practitioners, academics, and industry experts convenes to rigorously evaluate the school's pedagogical ecosystem. This comprehensive audit scrutinises the fairness and consistency of the internal assessment process, benchmarks the standard and ambition of student work against national and international norms, and provides invaluable feedback on the intellectual and pedagogical direction of the curriculum itself.

As a cornerstone of this process and a mandatory graduating requirement, final-year students from both the Bachelor of Social Sciences (Architecture) and Master of Architecture programmes must present their final project and portfolio work in person. This formal defence before the external panel not only validates the authenticity and depth of their learning but also simulates a professional practice environment, demanding they articulate their design rationale, critical thinking, and technical resolution to an authoritative audience, thereby preparing them for the collaborative and discursive nature of the architectural profession.

SCHEDULE

Important Dates

Mid-term Review	25 March 2026 (WED)
Final Review	22 April 2026 (WED)
Project Book Submission	24 April 2026 (WED)

Term 2: 7 January 2026 (Wednesday) – 22 April 2026 (Wednesday)

WEEK 01		
07.01	**Lecture**	Introduction to Structural Design
WEEK 02		
14.01	**Lecture and Exercise**	Equilibrium and Graphic Statics
WEEK 03		
21.01	**Lecture and Exercise**	Cables
WEEK 04		
28.01	**Lecture and Exercise**	Arches
WEEK 05		
04.02	**Lecture and Exercise**	Arch-Cables
WEEK 06		
11.02	**Lecture and Exercise**	Trusses, Introduction of the Final Project
WEEK 07		
18.02	**LUNAR NEW YEAR VACATION**	
WEEK 08		
25.02	**Lecture and Quiz**	Beams, Frames and Columns
WEEK 09		
04.03	**READING WEEK**	(Optional) Final Project Tutorial
WEEK 10		
11.03	**Lecture and Quiz**	Materials and Dimensioning
WEEK 11		
18.03	**Tutorial**	Final Project Tutorial
WEEK 12		
25.03	**MID-TERM REVIEW**	
WEEK 13		
01.04	**Lecture and Tutorial**	From 2D to 3D, Final Project Tutorial
WEEK 14		
08.04	**Tutorial**	Final Project Tutorial

WEEK 15		
15.04	**Tutorial**	Final Project Tutorial
WEEK 16		
22.04	**FINAL REVIEW**	Project Book Submission (24.04)

Grade	Descriptor	Criteria	Points
A	Excellent	Comprehensively excellent performance on all aspects of the structural principle, structure-space integration, design development, technical resolution and presentation. Achieving all learning outcomes with distinction.	4
A-	Very Good	Generally outstanding performance on the structural principle, structure-space integration, design development, technical resolution and presentation. Achieving all learning outcomes with merit.	3.7
B+	Good	Substantial performance on the structural principle, structure-space integration, design development, technical resolution and presentation. Achieving all learning outcomes satisfactorily.	3.3
B			3
B-			2.7
C+	Fair	Fair performance on the structural principle, structure-space integration, design development, technical resolution and presentation. Achieving all learning outcomes at a passing standard.	2.3
C			2
C-			1.7
D+	Pass	Barely satisfactory performance on the structural principle, structure-space integration, design development, technical resolution and presentation. Achieving all learning outcomes at a barely satisfactory standard.	1.3
D			1
F	Failure	Unsatisfactory performance on the structural principle, structure-space integration, design development, technical resolution and presentation. Not achieving all learning outcomes.	0

Written Feedback to Students

Term: _____ **Grade:** _____

Course Code: _____

Review: _____

Tutor: _____

Student Name: _____

Student ID: _____

Feedback from Course Instructor:

Achievements:
Challenges: