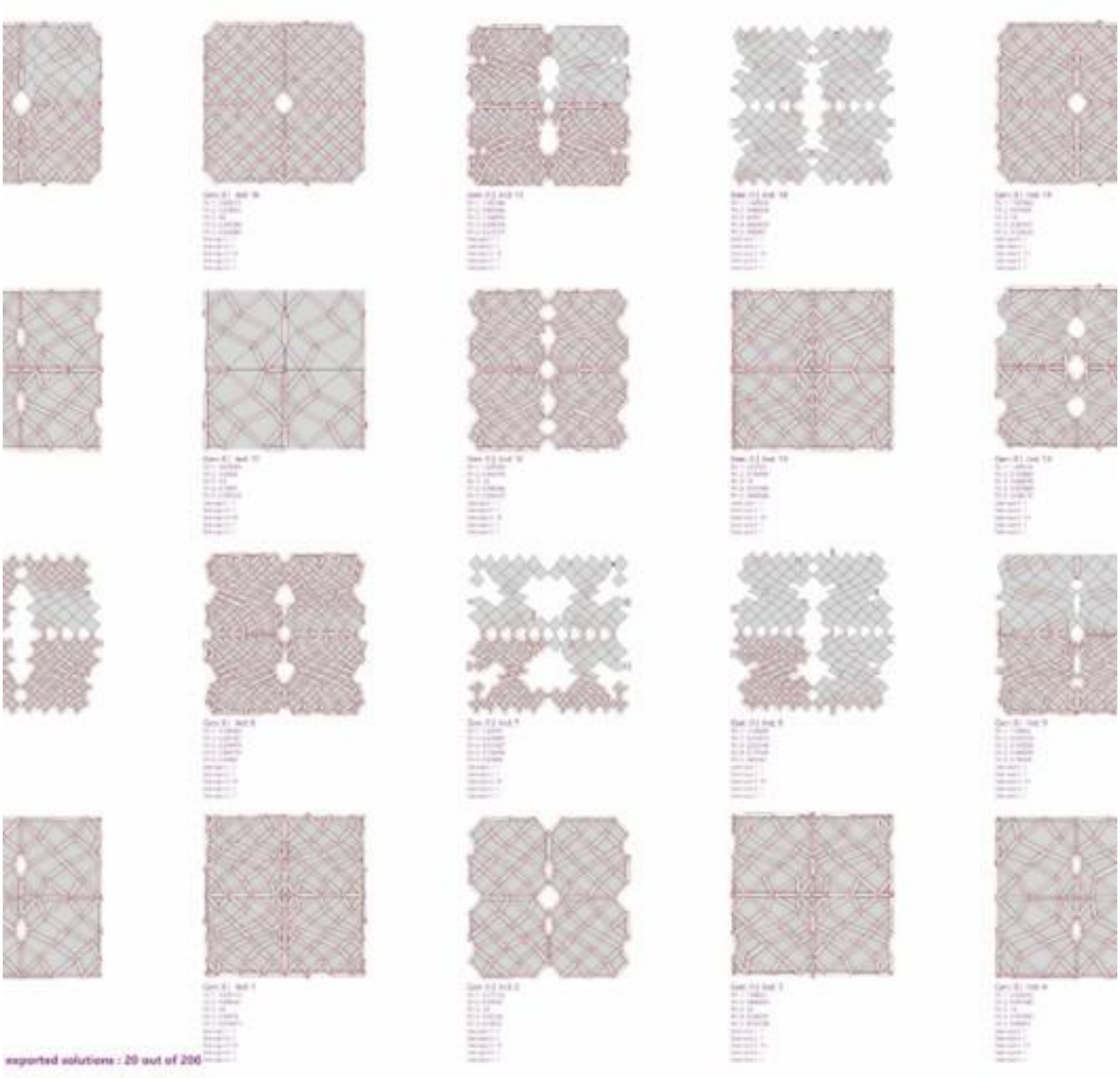

DESIGN FOR REUSE

INSTRUCTOR
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ISSUE

This course invites students to reimagine structural design at the end-of-life stage, focusing on the reuse of obsolete yet structurally sound concrete components. It emphasizes an integrated approach that balances aesthetics and functionality, covering topics such as form-finding, structural analysis, reuse matching, multi-objective optimization, and post-evaluation.
This course encourages students to explore how algorithmic methods and hands-on model making can be seamlessly integrated to transform discarded components into new structural forms, resulting in performance-driven, carbon-conscious, and visually striking designs.

DESCRIPTION

Historically, architectural design has transitioned from traditional methods to innovative approaches, incorporating materials science, structural engineering, and digital technology advances. This course positions itself at the intersection of sustainability and innovation by reinterpreting structural design principles through contemporary algorithmic tools and hands-on experimentation. It explores how digital and physical methods can be integrated to transform obsolete concrete components into high-performing, low-carbon, and aesthetically expressive structures.

1. Basic structural knowledge.
2. Basic skills in Rhino and Grasshopper.
3. An understanding of sustainability concepts in architecture.
4. Experience with group work and collaborative projects.

The overall aims of the course are to:
1. Encourage students to rethink and innovate in structural design.
2. Explore both aesthetic and functional aspects of structures.
3. Utilize digital design tools for structural form-finding, structural analysis, component matching and design optimization.
4. Translate abstract structural principles into practical, sustainable design solutions.
5. Enable students to transform digital models into physical prototypes.
6. Equip students with the ability to analyze and apply structural principles within performance-driven design frameworks.
7. Cultivate an integrated understanding of structure and architecture as interconnected elements.

This course complements other courses in the architectural programme by:
1. Building on core courses in design studios and structural design.
2. Providing advanced skills in digital tools and technology.
3. Enhancing understanding of sustainable and circular construction, tying in with environmental design and sustainability courses.
4. Offering practical, hands-on experience through concrete casting and 3D printing, which links to courses on construction methods and building materials.
5. Promoting interdisciplinary collaboration and innovation, aligning with courses that emphasize design thinking and collaborative projects.

IMPACT AND SUSTAINABILITY

In this course, you will explore the diversity and innovation of structures, enhancing your understanding and practical skills in sustainable design and circular architecture.
You will delve into the following areas in this course:
1. Integrated computational design methods for structure and architecture
2. Sustainable development in urban renewal
3. Strcutral design and optimization
4. Performance-driven optimization for structure design

Integration of Sustainable Design Principles
Circular Construction: Students explore principles of circular construction, which emphasize designing structures that can be reused. This approach minimizes waste and extends the lifecycle of building materials, aligning with sustainable practices.

Material Efficiency: By designing structural components that optimize material use, students learn to create buildings that require fewer resources without compromising on strength or aesthetics. This efficiency is a critical aspect of sustainable construction.

Use of Advanced Technologies
Digital Design and Analysis: Utilizing digital design software for structural analysis helps students to optimize their designs for both performance and material efficiency. This reduces the environmental impact by ensuring that structures are both resilient and resource-efficient.

Innovation in Construction Methods
Reassemble Structures: Designing structures that can be easily reassembled fosters a sustainable mindset. This method reduces the need for new materials by enabling the direct reuse of obsolete structure components, thereby extending their lifespan and supporting long-term sustainability.

COURSE SYLLABUS

TOPIC 1: FUNDAMENTALS AND APPLICABILITY OF STRUCTURAL COMPONENT REUSE
1. Case Studies and Precedents: Study real-world examples of structural reuse projects to understand practical applications and design strategies.
2. Principles of Structural Reuse: Understand the motivations, benefits, and challenges of reusing structural components in contemporary architecture and engineering.

TOPIC 2: DIGITAL DESIGN SOFTWARE
1. Basic 3D Software Skills: Develop foundational proficiency in digital design tools such as Rhino and Grasshopper for modeling and parametric design.
2. Structural Simulation and Analysis: Learn to simulate, analyze, and optimize structural behavior using Karamba3D within the Grasshopper environment.
3. Component Matching and Design Optimization: Apply customized Python scripts in combination with multi-objective optimization tools like Wallacei to match reused components with design requirements effectively.

TOPIC 3: STRUCTURAL DESIGN AND OPTIMIZATION
1. Methods of Structural Optimization: Learning how to improve the performance and aesthetic appeal of structures through design optimization.
2. Design Scheme Evaluation: Mastering methods to evaluate and refine design schemes.

TOPIC 4: SUSTAINABLE DESIGN AND CIRCULAR ARCHITECTURE
Principles of Circular Construction: Understanding the design methods for obsolete structures that can be reassembled, contributing to environmental sustainability.

METHODS

The course comprises seven stages: (1) foundational knowledge learning, (2) design exploration, (3) structural analysis, (4) reuse matching, (5) multi-objective optimzation, (6) design evlaution, and (7) physical model.

First, students can learn and understand the fundamentals of material circularity in structure design, mastering essential concepts. They focus on the basics of existing case studies/precedents and principles of structural reuse. Second, the students can find the interest in parametric design by basic Grasshopper scripts. Third, they can systematically study the basics of structural analysis. Fourth, students will engage with a packaged matching algorithm to explore how reused components perform in terms of geometry and structural behavior. Fifth, they will apply a multi-objective optimization plugin to refine design parameters and document the optimized outcomes. Sixth, a post-evaluation phase will help students assess the success of their designs using defined performance metrics. Seventh, constructing a physical model will allow students to better understand the relationship between design intent, material properties, and structural performance.

WORKSHOP
Several in-class workshops are planned to support students in computational design, analysis, optimization, and evaluation, as well as in the development of small-scale physical models.

FIELD TRIP
TBC

GUEST LECTURES
Input lecture regarding structural reuse (guest TBC)

EXHIBITION
All students' work is proposed to exhibited at CUHK as well as in 2025 Hong Kong Shenzhen Bi-City Biennale of Urbanism\Architecture (UABB) (time and format TBC).

DELIVERABLES

Stage 1 (Individual): Fundamental Skillup
1. Design Exploration: Use basic Grasshopper scripts to generate design variations aligned with structural analysis.
2. Design Optimization: Apply matching and optimization scripts to refine design options and achieve improved performance outcomes.
3. Design Evaluation: Assess structural efficiency, material waste, and carbon impact to understand the overall success of the design.

Submission 1
Individual Design Package: A-4 page A3 landscape booklet including:
1. Documentation of the design concept and form-finding results;
2. Structural analysis result;
3. Matching result and optimization result;
4. Evaluation results.

Accompanied by relevant Grasshopper scripts and Rhino files.

Stage 2 (Group work): Design Development and Material Experimentation
1. Design Development: Further develop a selected design (via group vote) based on the three main aspects from Stage 1. The goal is to create a 1:10 scale physical model, with consideration for joint design.
2. Material Experiment: Use 3D printing to represent the overall geometry. Create a 1:10 scale physical model of joints and perform concrete casting to represent reused framing elements.

Submission 2
Group Design Package: A 6–8 page A3 landscape booklet including:
1. Design concept and form-finding results;
2. Structural analysis results;
3. Matching and optimization results;
4. Evaluation results;
5. Photos of the physical model and documentation of the modeling process

Accompanied by relevant Grasshopper scripts.

Physical Models:
1. 3D printed model representing the overall geometry in grey;
2. 1:10 scale joint model with casted concrete elements;

LEARNING OUTCOMES
1. An understanding of structural form-finding.
2. An understanding of structural analysis.
3. An understanding of reuse matching.
4. An understanding of data-driven design optimization.
5. An understanding of sustainable design principles for reusable structures.
6. An understanding of technology's role in improving the construction process.
7. An understanding of the impact of local conditions on architecture
8. Able to work effectively in teams on design and research projects.
9. Able to adopt the taught methodology and skill sets to study architecture
10. Able to integrate structural concepts into architectural design.

ASSESSMENT SCHEME

1. Attendance and In-class Participation (10%)
2. Individual Exercise – Submission 1 (45%)
3. Group Project – Submission 2 (45%)

Total: 100%

COURSE FORMAT

Teaching Days
1. Students must attend for F2F teaching during these teaching hours.
   Teaching Day: Wednesday 11:30 am – 2:15pm
2. Teaching Venue: ARC G02
3. Field trips, lectures, and other learning activities may be scheduled outside of teaching days.

Student Study Effort_3 credit course (Total: 140 hrs)
1. Class Contact: 39 hrs (Lecture –TBC hrs, Tutorial – TBChrs, Critique – TBC hrs, Field Trip – TBC hrs)
2. Other Student Study Effort: 100 hrs (Studio / Self Study)

Assistant
ZHAO, Hanbing hanbingzhao@link.cuhk.edu.hk

REQUIRED READINGS

1. Edward Allen, Waclaw Zalewski. *Form and Forces: Designing Efficient, Expressive Structures*. Hoboken: John Wiley & Sons, 2010.
2. Aurelio Muttoni. *The Art of Structures: Introduction to the Functioning of Structures in Architecture*, EPFL Press, 2011.
3. Corentin FIVET and Jan BRÜTTING, "Nothing Is Lost, Nothing Is Created, Everything Is Reused: Structural Design for a Circular Economy." *The Structural Engineer* 98, no. 1, 2020, pp. 74-81.
4. Brütting, J., Desruelle, J., Senatore, G., & Fivet, C. Design of Truss Structures Through Reuse. *Structures*, 18, 2019, pp.128–137.
5. Stricker, Eva et al., eds. *Reuse in Construction : A Compendium of Circular Architecture*. Trans. by David Koralek, Ian Pepper, and Iain Reynolds. Zurich: Park Books, 2022.
6. Online source: *https://block.arch.ethz.ch/eq/drawing*

OTHER REFERENCES

1. Bjorn Normann Sandaker, *On Span and Space: Exploring Structures in Architecture*,1-18. London and New York: Routledge, 2008.
2. Eduard F. Sekler, "Structure, Construction, Tectonics." In *Structure in Art and in Science*, edited by Gyorgy Kepes, 89-95. New York: George Braziller Inc., 1965.
3. Schwartz, Joseph. "Structural Theory and Structural Design." In *Cooperation: The Engineer and the Architect*, edited by Aita Flury, 241-248. Berlin; Boston: Birkhäuser, 2012.
4. Bjørn N. Sandaker, Arne P. Eggen, Mark R. Cruvellier. *The Structural Basis of Architecture*, Routledge, 2011.
5. Cruvellier, Mark R., Luben. Dimcheff, and Bjorn N. Sandaker. *Model Perspectives: Structure, Architecture and Culture*, London: Taylor and Francis, 2017.Muttoni, A. *The Art of Structures: Introduction to the Functioning of Structures in Architecture*. Abingdon, Oxford, UK ; New York, NY: EPFL Press/Routledge, 2011.

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 Postgraduate studies can be found in the PG Student Handbook. https://www.gs.cuhk.edu.hk/

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 utilize 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 acknowledgment 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 utilized, 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
Unless approved by the Programme or School Director, any use of AI tools such as ChatGPT or image generation tools (Midjourney) etc. is strictly prohibited and may result in disciplinary action in accordance with university policy on academic honesty.

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 studio 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. In addition, a grade deduction of *one letter grade* will be made.

Term 1: 1 September 2025 (Monday) – 29 November 2025 (Saturday)

WEEK 01		
03.09	**LECTURE**	Course Introduction and Lecture on Structure Reuse
WEEK 02		
10.09	**LECTURE & TUTORIAL**	Introduction on Computational Framework Tutorial on Rhino/Grasshopper Basics Support for Software Installation
WEEK 03		
17.09	**TUTORIAL & WORKSHOP**	Tutorial on Form-Finding Student In-Class Exercise
WEEK 04		
24.09	**TUTORIAL & WOKRSHOP**	Tutorial on Structural Analysis (Karamba3D) Student In-Class Exercise
WEEK 05		
01.10	**NATIONAL DAY**	No Class
WEEK 06		
08.10	**TUTORIAL & WOKRSHOP**	Tutorial on Matching Algorithm (Customized Python Script) and Design Optimization (Wallacei) Student In-Class Exercise
WEEK 07		
15.10	**TUTORIAL & WOKRSHOP**	Tutorial on Evaluation Process Introduction of Submission 1 (Individual Project) Student In-Class Exercise
WEEK 08		
22.10	**CONSULTATION**	Design and Technical Support
WEEK 09		
29.10	**HOLIDAY**	NO CLASS
WEEK 10		
05.11	**REVIEW & SUBMISSION**	Mid-term Review Submission 1 In-Class Voting and Grouping Introduction of Submission 2 (Group Project)
WEEK 11		
12.11	**CONSULTATION**	Design and Technical Support
WEEK 12		
19.11	**WORKSHOP**	In-Class Exercise (Digital & Physical Experiment)
WEEK 13		
26.11	**WORKSHOP**	In-Class Exercise (Digital & Physical Experiment)
WEEK 14		
03.12	**REVIEW & SUBMISSION**	Final Review Submission 2

Grade	Descriptor	Criteria	Points
A	Excellent	Comprehensively excellent performance on all aspects of the design intention, development, technical resolution and presentation. Achieving all learning outcomes with distinction.	4
A-	Very Good	Generally outstanding performance on the design intention, development, technical resolution and presentation. Achieving all learning outcomes with merit.	3.7
B+	Good	Substantial performance on the design intention, development, technical resolution and presentation. Achieving all learning outcomes satisfactorily.	3.3
B			3
B-			2.7
C+	Fair	Fair performance on the design intention, 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 design intention, development, technical resolution and presentation. Achieving all learning outcomes at a barely satisfactory standard.	1.3
D			1
F	Failure	Unsatisfactory performance on the design intention, 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: