Structural Design D-Baug/MIBS – HS2022

Chair of Structural Design Prof. Dr. Joseph Schwartz
Chair of Architecture and Structures Prof. Dr. Philippe Block

Introduction

The goal of the course is to introduce students to Structural Design as a discipline that relates structural behavior, construction technologies and architectural concepts. The course encourages students to develop an intuitive understanding of the relationship between the form of a structure and the forces within it by promoting the development of design projects in which the static and architectural aspects come together. The course is a combination of lectures and exercises on graphic statics[1], which becomes the main tool to visualize the relationship between form and forces.

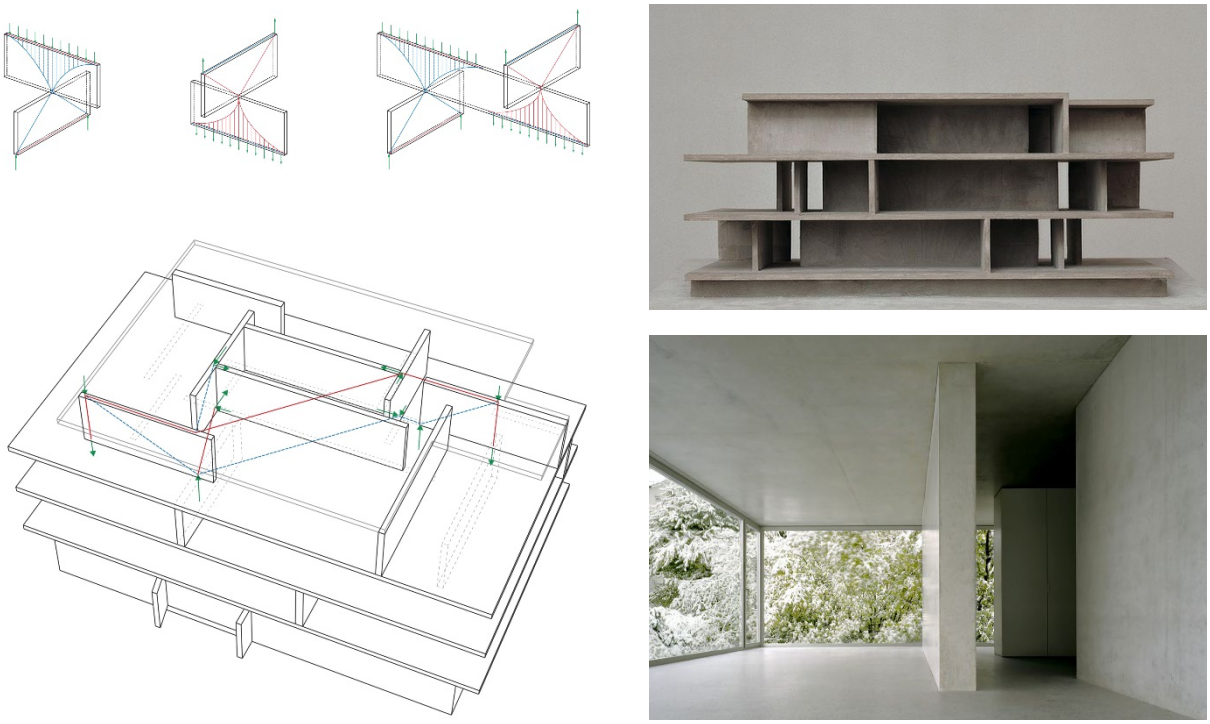

Figure 1: House Forsterstrasse (arch.: C. Kerez, eng.: J. Schwartz). (Photo: C. Kerez)

[1] Graphic statics is a graphical method developed by Prof. Karl Culmann and first published in 1864 at ETH Zurich. In this approach to structural analysis and design, geometry-based graphical constructions are used to visualize the relation between the geometry of a structure and the forces acting in and on it.

The first part of the course focuses on the main principles of graphic statics, illustrating them through a series of frontal lectures and exercise sessions. Students will get familiar with the topic by solving exercises and completing simple design tasks. In the final part of the course, students will be asked to develop a small design project in which they will apply the knowledge gained in the first part of the course. The chosen typology for the design task of this year is a multistory office building.

Design task

The scope of the design task is to investigate the relationship between architectural space and load-bearing structures by developing a design proposal for a new multistory office building in Zurich. In particular, the design proposals must consider the following points:

- Vertical loads — how are vertical loads transferred to the foundations
- Horizontal loads — how are horizontal loads transferred to the foundations

- Spatial layout — how the required functions are arranged in the floor plans
- Circulation strategy — how the different spaces are connected one to each other
- View out — what is the indoor-outdoor visual relationship in the different spaces

The first part of the design task is to discuss the points above and to formulate a consistent design concept that is the result of the envisioned design intentions.

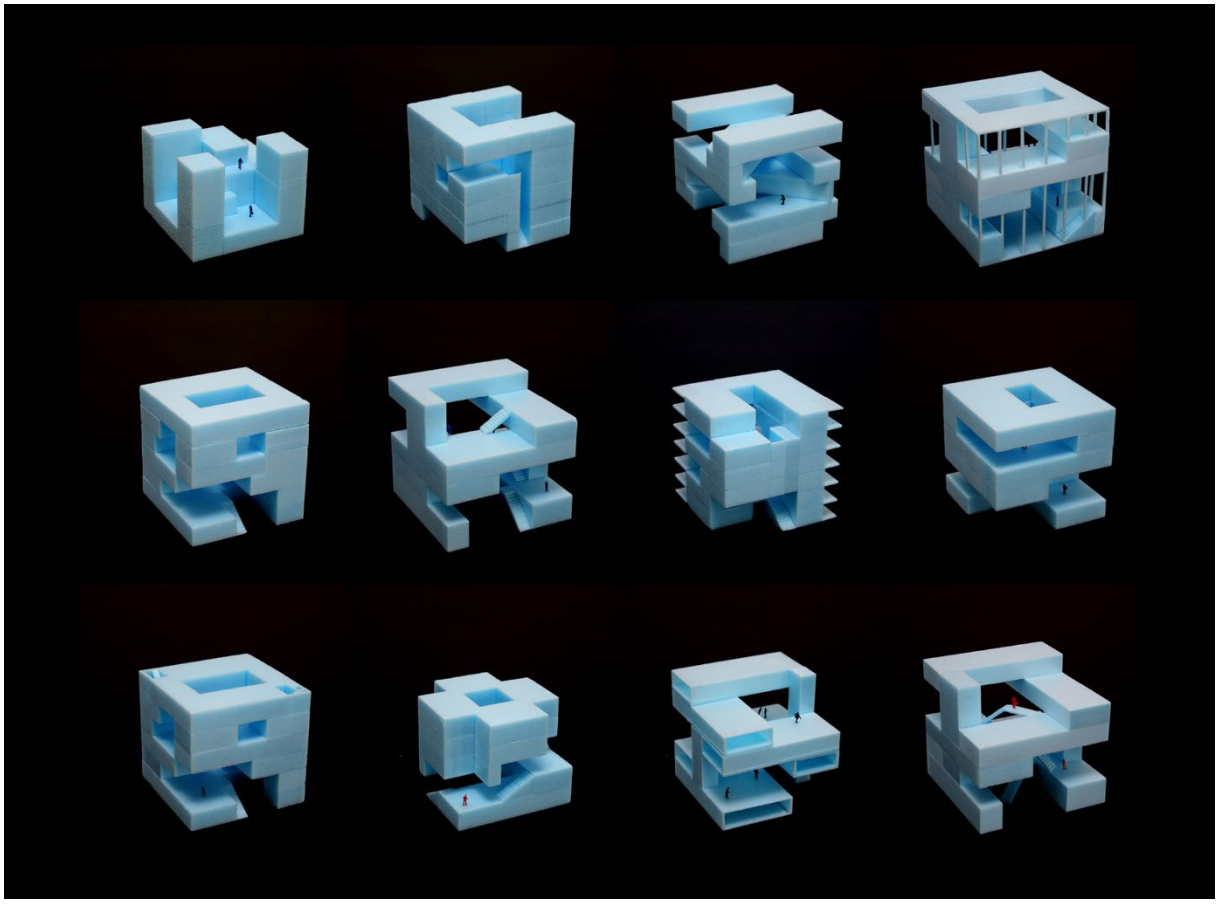

Figure 2: Design explorations for the International Sports Sciences Institute in Lausanne (© Karamuk Kuo Architects)

Site and program

The chosen site for the design exercise is located in Zurich, next to the main train station. A physical model of the site is available in the HIB building, E floor. Students are warmly encouraged to use it during the design process.

Figure 3: Site for the design exercise

The maximum number of floors is not fixed. However, a minimum floor height of 3.5 meters must be respected. The maximum height of the building cannot exceed that of the neighboring buildings.

The building must be structurally independent from the neighboring buildings.

The multistory office building must host the following functions:

- Lobby/hall
- Individual offices
- Open space offices
- Meeting rooms
- Restrooms

Schedule

		Lecture	Exercise session / Task	Submission
Week 1	22.9.	Introduction		
Week 2	29.9.		Basics of graphic statics	
Week 3	06.10.		*Task 0*	
Week 4	13.10.	Theory of Plasticity		Submission of Task 0
Week 5	20.10.		Strut-and-tie models	
Week 6	27.10.		*Design exercise (Task 1)*	
Week 7	03.11.		*Design exercise (Task 1)*	
Week 8	**10.11.**		**Midterm review**	Submission of Task 1
Week 9	17.11.	Stress fields		
Week 10	24.11.		From STM to stress fields	
Week 11	01.12.			
Week 12	08.12.		*Design exercise (Task 2)*	
Week 13	15.12.			Submission of Task 2
Week 14	**22.12.**		**Final review**	

Submissions

Students are asked to work in small groups (3-4 people). The class includes 3 mandatory submissions[2]:

Submission 0 (deadline: 14/10 h 23:59) – Analysis of a given building

The scope of this submission is to apply the knowledge gained in the first part of the course for the analysis of a given multistory building provided by the tutors.

Students must submit:

- Drawings (form and force diagrams related to the global structural behavior using the template provided)
- Physical model with form diagrams depicting the global structural behavior (to be drawn on the model)

Submission 1 (deadline: 11/11 h 23:59) – First design proposal

The scope of this submission is to propose and discuss a first design proposal related to the given design task.

Students must submit:

- Hand sketches/text/images to illustrate the design concept
- Hand sketches/drawings to illustrate several design iterations
- Drawings (form and force diagrams related to the global structural behavior using the template provided)
- Physical model with form diagrams depicting the global structural behavior (to be drawn on the model)

Submission 2 (deadline: 21/12 h 23:59) – Final design proposal

The scope of this submission is to develop further and refine the first design proposal.

Students must submit:

- Hand sketches/text/images to illustrate the final design concept
- Hand sketches/drawings to illustrate several design iterations
- Drawings (form and force diagrams related to the global AND local structural behavior using the template provided)
- Physical model with form diagrams depicting the global structural behavior (to be drawn on the model)

In order to obtain the 3 ECTS the project must be evaluated with a mark of 4.0 or above. Evaluation criteria include, but are not limited to:

- Submission of all the required deliverables (complete and on time)
- Active participation in the design exercise sessions
- Originality of design concept
- Correct development of form and force diagrams
- Overall quality of the submission (precision and clarity of drawings, image resolution…)

The grading will take into account both the development of the project as well as the final submission.

[2] A template will be provided for each submission

On the physical models

The scope of the physical models is to better understand the spatial qualities and structural behavior of the building. These are intended to be simple working models, they are not meant to be for presentation purposes.

For each one of the 3 models you will need:

- 1 foam core board[3] (50x70, white, 5mm)

- Cutter and cutting board
- Glue / pins
- Printouts of the project in scale (e.g. floorplans)

General information

Registration

Registration at http://www.mystudies.ethz.ch/ is required.
Additionally, students are asked to register their group in the list provided via email.

Lectures

Thursdays, 9:45-11:30
Room: HPT C 103

Coordination

Federico Bertagna bertagna@arch.ethz.ch
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Web resources

https://www.schwartz.arch.ethz.ch/
https://block.arch.ethz.ch/eq/course/182

[3] You can find it at ETH store as “Modellbautafel”

Selected References

[1] Allen, E. and Zalewski, W. (2009) *Form and Forces: Designing Efficient, Expressive Structures*. John Wiley & Sons.

[2] Block, P., Gengangel, C. and Peters, S. (2013) *Faustformel Tragwerksentwurf*. Deutsche Verlags-Anstalt.

[3] Muttoni, A. (2011) *The art of structures : introduction to the functioning of structures in architecture*. EPFL Press.

[4] Sandaker, B. N., Eggen, A. P. and Cruvellier, M. (2019) *The Structural Basis of Architecture*. Routledge.

[5] Sandaker, B. N., Kleven, B. and Rohde Wang, A. (2022) 'Structural typologies and the architectural space — studies of the relationship between structure and space by application of structural types to multistory buildings', *Architecture, Structures and Construction*. Springer International Publishing. doi: 10.1007/s44150-022-00034-z.

[6] Schwartz, J. (2011) *Tragwerksentwurf I-II*. ETH Zurich.

[7] Schwartz, J. (2011) *Tragwerksentwurf III-IV*. ETH Zurich.