On the Architectural Engineering Competences in Architectural Design

MSc in Engineering with Specialization in Architecture

Kirkegaard, Poul Henning

Published in:
Nordisk Teknikklærermøte 2007

Publication date:
2007

Document Version
Accepted author manuscript, peer reviewed version

Poul Henning Kirkegaard
Department of Civil Engineering
Aalborg University, Denmark

On the Architectural Engineering Competences in Architectural Design - MSc in Engineering with Specialization in Architecture

In 1997 a new education in Architecture & Design at Department of Architecture and Design, Aalborg University was started with 50 students. During the recent years this number has increased to approximately 100 new students each year, i.e. approximately 500 students are following the 3 years bachelor (BSc) and the 2 years master (MSc) programme. The first 5 semesters are common for all students followed by 5 semesters with specialization into *Architectural Design*, *Urban Design, Industrial Design or Digital Design.* The present paper gives a short summary of the architectural engineering competences related to the specialization in *Architectural Design.* A detailed presentation can be found at the homepage: *www.aod.aau.dk.*

The Education in Architecture & Design at Aalborg University
Close to 14,000 students are enrolled at Aalborg University, ranging from students at preparatory courses through doctoral-level candidates. Approximately 3,500 students are enrolled at the Faculty of Humanities, 4,600 students at the Faculty of Social Sciences and 5,500 at the Faculty of Engineering, Science and Medicine. Aalborg University encompasses the following three faculties: *The Faculty of Humanities*, *The Faculty of Social Sciences* and *The Faculty of Engineering, Science and Medicine*. The three faculties offer in total 65 different educational programmes within four scientific fields; *Humanities, Social Science, Natural Science*, *Engineering and Medicine*.

The education in Architecture & Design at Aalborg University is organized on a core concept of "integrated design" based on project-organized problem-based learning (PBL). This implies a combination of creative and analytical skills, aesthetic confidence and technical competence. The BSc and MSc programme aims to empower students to transform function, aesthetics, production techniques and environmental protection into expressive architectural form, challenging designs, expressive urban environments or astonishing virtual worlds.

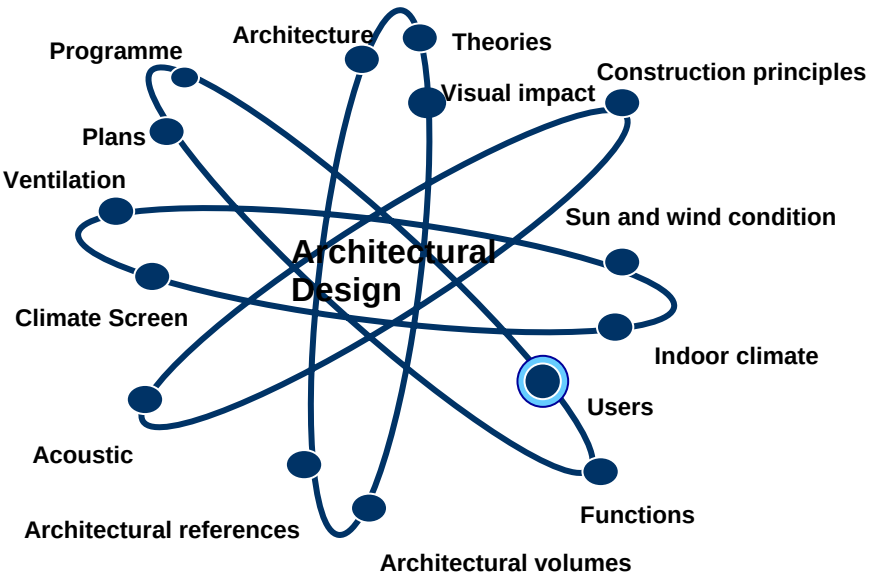

Figure 1: Architecture as integrated design. [1]

Teaching related to the specialization Architectural Design focuses on the integration of architectural design and practice with aspects of the civil engineering disciplines. The project work focuses on design solving in the areas of formal language and aesthetic quality, principles of construction engineering, environmental design, tectonic design, form and energy optimization, digital software and project leadership, giving graduates a high level of competence in the architectural and technical design of buildings in practice. A semester is generally divided into a main project (23 ECTS) and a minor project (7 ECTS) with project related courses and workshops. For the main project students are working together in groups with 4-6 students.

The teaching of technical subject is mainly given by teachers from the Department of Civil Engineering – Division of Architectural Engineering.

Division of Architectural Engineering – Department of Civil Engineering
The Architectural Engineering division is concerned with research and education in the analysis, design, construction, and operation of engineering systems for commercial, industrial, and institutional facilities. The Architectural Engineering division focuses on an integrated, multidisciplinary approach to achieve optimal building designs and pays special attention to their impacts on the indoor as well as the surrounding environment. This implies integration of architectural design with engineering systems like structural systems, communications and control, lighting, acoustics, fire protection, plumbing, heating, ventilation, and air conditioning as well as close cooperation with other key players in all areas of the building process.

To influence and contribute to the development of engineering education in the building area towards a more integrated, multidisciplinary approach with extended use of IT tools in the whole building process.

To develop, apply and disseminate knowledge in the architectural engineering field
To be recognized as the leading place in Denmark and among the best in Europe in architectural engineering education and in the selected key research areas in the architectural engineering field.

The Architectural Engineering division has selected the following key research areas:

- *Architectural and Structural Design*
  Research on digital architectural design of structures, tectonics, architectural acoustics and design of prefab dwellings.
- *Building Informatics*
  Research on design, integration and structuring of ICT tools, and product and process models in the entire building process. Focus is on model collaboration and knowledge transfer between participants in design, construction, O&M and use of buildings.
- *Indoor Environmental Engineering*
  Research on ventilation and air flow processes in buildings and building services and their impact on energy and mass flow in buildings, thermal comfort, indoor air quality and health. Research on energy efficient building design, interaction of passive energy technologies and building design, and optimization of interaction between building services and passive systems.

.

BSc programme in Architectural Design
The BSc programme is focused on design solving in the areas of formal language and aesthetic quality, function, social, engineering and environmental design demands.
The BSc programme has 6 semesters with the following content:

- *1st and 2nd Semester: Reality in Models*
  The first two semesters focus on the on the interaction between form, function and technique. At each semester the students make a main project supported by courses in design methods, 3D modeling tools, mathematics and tectonic. Further, several courses are given to introduce methods related to problem-based learning.
- *3rd Semester: Experience and product*.
  The 3rd semester is an introduction to the specializations in Industrial Design and Digital Design, i.e. the students are introduced to modeling and design of products and digital design concepts.
- *4th Semester: Building and Urban design*
  The 4th semester is an introduction to the specializations in *Architectural Design and Urban Design*. The main project deals with architectural design of a building which is incorporated into an urban and landscape design proposal for the site.
- *5th Semester: Conceptual Design*
  At this semester methods and theories for conceptual design are introduced. The students choose one of the specializations and make a conceptual design proposal related to the chosen specialization.

After the *5th semester the education is specialized. The Architectural Design* specialization has the content:

- 6th Semester: *Integrated building design*
  The students design a building with architectural quality integrating different technical and architectural design skills.

The courses with a technical content related to the BSc programme semesters are:

- *Tectonic (2 ECTS) 2nd semester*
  The aim of the course is to provide the students an understanding of tectonic design in relation to the entity of an architectural idea with respect to structural systems. This course is designed to provide the students with a fundamental demonstration of the theory and applications of engineering statics.
- *Structural Mechanics (1 ECTS) 3rd semester*
  Fundamental principles of solid and structural mechanics are presented. In particular, the notion of internal forces, and the concepts of stress and strain are introduced. Mechanical properties of solids are discussed, and the notion of statically indeterminacy is introduced. The methods of structural analysis are presented.
- *Building Technology and Architectural Design 1 (2 ECTS) 4th semester*
  By the end of this course, the student should be able to identify key points about foundations, walls and roofs in domestic buildings made in concrete, steel or timber. Basic knowledge about materials, acoustics, isolation and design codes is presented. Design of structural components and applications utilizing timber.

- *Building Technology and Architectural Design 2 (1 ECTS) 5th semester*
  Methods and principles for conceptual structural design are introduced related to structures design in concrete, steel or timber.

- *Building Technology and Architectural Design 3 (2 ECTS) 6th semester*
  Architectural design of structural components and applications utilizing concrete, steel or timber. Fire design of structural components. Design of structural joints
- *Indoor climate and ventilation (2 ECTS) 6th semester*
  Upon completing the course the student should have a throughout understanding of the effects of heating and ventilation on atmospheric indoor environment and comfort, perceived air quality, emission of contaminants from materials. An introduction to thermal building simulation and design of ventilation systems is given.

MSc programme in Architectural Design.

The MSc programme in Architectural Design has 4 semesters with the following content:

- *7th Semester: Tectonic Design: Architectural Form and Structure*
  This semester is intended to strengthen and broaden the student's ability to analyze and design a complex building constructively, functionally and architecturally. The project takes its point of departure in the tectonic design of a relatively complex construction with the involvement of scale considerations in a Nordic context. This semester also give the possibility for a one semester project traineeship at a Danish or international company or a stay at another Danish or international school or university.
- *8th semester: Architectural Form, Space and Environmental Design*.
  The 8th semester of the specialization program in Architectural Design focus on integrated design processes in the development of Sustainable Architecture in local environments. As per the curriculum for the semester the student should apply social, technical and environmental principles to a building with architectural quality integrating the different technical principles and design skills. The starting point for setting the curriculum objectives are the considerations of how life style changes will impact the meaning and design of our surrounding environments with special focus on sustainable principles
- *9th semester: Architectural Synthesis*.
  The project will integrate and optimize the interaction between numerous criteria that address central theoretical or methodological questions within the field of architectural design.
- *10th semester: Preparation of the Master Thesis*.
  There are no designated courses during this semester.

The courses with a technical content related to the MSc programme semesters are:

- *Building Technology and Architectural Design (2 ECTS) 7th semester.*
  The aim of the course is to provide the students an understanding enabling them to design tectonically in relation to the entity of an architectural idea with respect to structural systems and architectural room acoustics. This includes an understanding of the structural functionality of various construction systems build up as shells, plates, frames, beams etc. and the ability to competently understand and assess the aesthetic significance of these various systems in connection to the architectural idea of a project. In addition the student will learn fundamental concepts related to

architectural room acoustics which will make them able to work tectonically in the field of architectural acoustics

- *Finite Element Design (1 ECTS) 7th semester*
  An introduction to Finite Element modeling. The physical and mathematical background for using and understanding FE-modeling is given, and the basic terms and equations are introduced. Throughout the course practical examples are solved using commercial FE-programs. The aim is to give the student a useful tool for analyzing large complex structures, and in a relatively easy way come up with realistic dimensions of structural elements.
- *Form Findings (1 ECTS) 7th semester*
  To develop a synthesis between aesthetic and constructive form-making in a process of physical, virtual, and calculation modeling techniques.
- *Passive Energy Technology and Energy Simulation (2 ECTS) 8th semester*
  Concepts of integrated design of buildings. Building energy and indoor climate systems. Microclimate around buildings. Advanced methods for analysis of the interplay between building design, building use, outdoor climate and HVAC-systems (BSim). Design methods for passive energy technologies as passive cooling, natural ventilation, passive solar systems and daylight
- *Architectural Lighting Design Considerations (1 ECTS) 8th semester*
  An introduction to architectural lighting design that will assist in the aesthetic design of internal lighting and the production of a photometric model of a portion of the design for your main project that allows an accurate estimation of the properties of light. This model is intended to provide a quantitative understanding of internal and external lighting levels through visualization, as distinct from photo-realistic renderings prepared for their qualitative and aesthetic properties

Conclusion:

The present paper gives a short summary of the architectural engineering competences related to the specialization in *Architectural Design.* The summary presents the themes and the contents for main projects the related technical courses. However, the architectural engineering competences are developed through the main project. Since results of main projects not have been presented the level of the competence are invisible. The presentation of the paper will consider this issue.

Literature:

[1] Integrated Design Process in Problem-Based Learning : Integrated Design Process in PBL / Knudstrup, Mary-Ann. I: The Aalborg PBL Model : Progress, Diversity and Challenges. Aalborg : Aalborg University Press, 2004. s. 221-234