

Study plan for the research subject

## **LIGHTWEIGHT STRUCTURES (SWE: LÄTTKONSTRUKTIONER)**

Within the school of Engineering Sciences, KTH

This study plan for the research subject Lightweight Structures complements the common guidelines and regulations given in the university's study handbook for research studies and in the KTH handbook II.

### **SUBJECT DESCRIPTION AND GOALS FOR THE EDUCATION**

Lightweight structures as a subject aims to develop and widen the use of lightweight structures and lightweight materials in order to achieve increased performance for a wide range of structural applications. Performance is conceptualised as a general quantity aiming at both functionality and use in terms of e.g. reduced fuel consumption, environmental impact and life cycle cost. Lightweight structures is a generic but also application near research area based on material science, structural mechanics, processing and design. The scientific aim is to develop understanding for specific phenomena occurring in these areas, or in the interface between them. New unconventional materials and their use in applications with low weight requirements are specifically studied. Such materials are today especially polymer based fibre composites, wood and cellular materials, i.e. materials that have in common being anisotropic and inhomogeneous.

The subject also contains analysis and modelling of loads, structural response, sea keeping properties, operability, working environment and system monitoring of ships, with a focus on the design of lightweight ship structures.

The aim of the education is in-depth studies within one, or several, of the divisions research areas through a balanced training in both analytical/numerical method and experimental work. The research education shall also provide the ability to plan, structure and solve complex scientific and engineering problems and to individually present results both orally and in writing.

#### **1.1 Scientific area**

Within the subject Lightweight structures, research is primarily conducted in the area of composite- and sandwich structures, wood and wood fibre composites, metal fatigue and modelling of structural response of marine vehicles. The applications covered are mainly within aerospace, automotive, ships and rail vehicles, but also of wind power and infra structure. The research encompasses mechanical properties, manufacturing processes and its modelling, material science (mainly composites and cellular materials), analysis, design, testing and optimisation of lightweight load carrying structures.

The marine related research is focused on the interaction between structure and fluid, especially towards simulation of planning craft in high seas. The consequence of this fluid-structure interaction is studied also in terms of sea keeping properties and structural loads.

## **2 CURRENT RESEARCH**

The current research in Lightweight structures encompasses mainly the following areas:

- Material modelling, especially for inhomogeneous and anisotropic materials, e.g. cellular materials
- Modelling and testing of wood on the micro-scale and hygromechanical behaviour of wood and wood fibre composites
- Damage mechanics and fracture criteria for composite and cellular materials covering also analysis, testing and fatigue
- Modelling of composites and sandwich structures manufacturing processes
- Design optimisation of composite and sandwich structures
- Fatigue and damage tolerance
- Fluid-structure interaction for ship hull structures
- Time domain simulation of planning craft at sea
- Operational conditions on ships

The research is focused towards a number of different applications, mainly aerospace, ground- and rail vehicles, ships and applications using wood as structural material. The common denominator for all the research work is the combination of theoretical analysis, numerical calculations and experiments.

### **3 THE SYLLABUS**

The research education consists of one course part and one dissertation part with credit point requisites given below.

The course part shall to its main part consist of technical/scientific course credits. The courses are chosen together with the advisor(s) based on the specific knowledge needs for the considered research work.

The research work is conducted under the supervision of one main advisor and possible also together with an assistant advisor. The student must have written an individual study plan with 6 month of admission to research studies and this plan must then be updated at least once per year. The individual study plan is created jointly by the student and the main advisor and must be in accordance with the here given study plan for the research subject Lightweight Structures.

The student is anticipated to conduct his/her research work with the aim to write technical reports (papers) that will constitute foundation of the thesis. These reports should be aimed for publication in international peer-review journals within relevant areas. One or several reports can also be published in international conference proceeding at which the student is anticipated to orally present his/her work.

### **4 MANDATORY AND RECOMMENDED COURSES**

#### **Course requirements**

- For licentiate exam the course requirements are at least 25 credit points (37.5 ECTS), which together with a dissertation corresponding to maximum 55 credit points (82.5 ECTS) makes the sum of total credit point 80 (120 ECTS)
- For the Ph.D. exam the course requirements are at least 40 credit points (60 ECTS). The dissertation corresponds to maximum 120 credit points (180 ECTS), which makes the sum of total credit point 160 (240 ECTS)

- According to the KTH rules (KTH handbok II: flik 21.3) up to 20 credit points (30 ECTS) may be assimilated for a student with a Civ.Ing. degree (or similar). Within Lightweight structures, assimilation of credit points from studies on undergraduate level may only be done for credits not included in previous degrees and under the condition that the courses are relevant for the current research education. The supervisor decided ultimately in these matters.
- The individual study plan may contain a maximum of 10 credits (15 ECTS) of course work on undergraduate level (assimilate course credits included). The rest of the course credits should be for Ph.D.-level courses. In exceptional cases, e.g. within multi-disciplinary research projects the student may have up to 20 course credits (30 ECTS) from undergraduate level courses.
- Course credits from language courses cannot be used. However, courses in e.g. technical English including report writing may be used, but only to a maximum of 4 credits (6 ECTS).
- Seminar series type courses without any major individual activity may not be used.
- Literature studies and construction assignment tasks may be given course credits, but to a maximum of 10 credits (15 ECTS).
- Courses in theory of science and research methodology can be included (see below for maximum credits). Parts of this is assumed to be included naturally in other theoretical courses and in the research work.

If the student is teaching as part of his/her departmental assignments, he/she must take a course in pedagogy. Normally only 5 credit points may be used in the individual study plan for courses on research methodology, pedagogy, etc.

### **Conditionally optional and recommended courses**

The course part of the research studies consists of conditionally and recommend courses that are specified in the list below. The total course part for each student is agreed between the student and his/her supervisor based on the expected needs of specific and general knowledge for the research work.

#### *Conditionally optional courses*

For the licentiate exam at least one of the following subjects must be included and for the Ph.D. exam at least two must be included.

- Mechanics of Cellular Solids, 4-8p (6-12 ECTS)
- Fatigue and Fracture of Composite Materials, 4-8p (6-12 ECTS)
- FEM in Structural Analysis, 4-8p (6-12 ECTS)
- Advanced Composites Manufacturing, 4-8p (6-12 ECTS)
- Experimental Characterisation of Composite Materials, 4-8p (6-12 ECTS)
- Analysis and Design of Sandwich Structures, 4-8p (6-12 ECTS)
- Analysis and Design of Composite Materials and Structures, 4-8p (6-12 ECTS)
- Wood and Cellulose Materials Engineering, 4-8p (6-12 ECTS)
- Biobased Composites, 4-8p (6-12 ECTS)
- Numerical Optimization with Applications in Structural Mechanics, 4-8p (6-12 ECTS)
- Fluid Mechanics, 4-8p (6-12 ECTS)<sup>1</sup>
- High Speed Craft, 4-8p (6-12 ECTS)

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<sup>1</sup> Relevant Fluid Mechanics course(s) given by e.g. the Department of Mechanics, KTH

Courses with corresponding contents at other universities may be used as well. All other courses are chosen in agreement with the supervisor.

## 5 THESIS

The thesis is a mandatory part of the research education. The thesis can consist of an introduction followed by a number of appended papers or a monograph. In Lightweight structures the thesis is commonly of the former type. The thesis is always written in English.

### *Licentiate thesis*

A thesis for the licentiate exam shall contain new scientific knowledge or a new application of state-of-the-art knowledge. The latter implies a new application and development of such via analytical or empirical research work. The thesis shall also contain an overview of previous research in the chosen research area (literature study).

Regardless of the thesis being an introduction with appended papers or a monograph, its content should be of such quality and quantity that it can be judged to correspond to two papers published in the open literature or presented at international conferences.

Within Lightweight structures, a licentiate thesis normally has the following contents (variations are common and accepted):

One published/accepted paper, one paper in draft form, plus potentially one conference paper. Together with these papers there should be an introduction to the thesis consisting of approximately 15-25 pages covering the basics of the subject, the methodology used and references. The introduction must also contain the following headings and contents

- Abstract
- Dissertation page
- Division of work between authors

Monographs are accepted if special circumstances apply. If this is accepted is up to the division faculty. Monographs must satisfy the same requirements as other type of dissertations in terms of published papers on which the monograph is based.

The licentiate thesis shall be presented at a public seminar at which an external assessor will discuss and question the student on the contents of the thesis (thesis defence).

### *Ph.D. dissertations*

A thesis for the Ph.D exam shall contain new scientific knowledge or a new application of state-of-the-art knowledge. The latter implies a new application and development of such via analytical or empirical research work. The thesis shall also contain an overview of previous research in the chosen research area (literature study).

Regardless of the thesis being an introduction with appended papers or a monograph, its content should be of such quality and quantity that it can be judged to correspond to at least four papers published in the open literature (international peer-review journals). With papers in this case are meant original scientific contributions including at least one new academic problem with clear news value. Published and accepted papers are deemed equal, as well as conference papers that has gone through peer-review (which is not the normal procedure in most conferences). If non-published or conference papers are appended to the thesis the number of papers should normally exceed four. If non-published papers in draft form are appended to the thesis it is up to the supervisor to judge whether these satisfy the requirements.

Within Lightweight structures, a Ph.D thesis normally has the following contents: (variations are common and accepted):

- Four published/accepted papers, plus potentially one conference paper, or
- Three published/accepted papers, one paper in draft form and one conference paper, or
- Two published/accepted papers, one conference paper and two papers in draft form

Together with these papers there should be an introduction to the thesis consisting of approximately 20-30 pages covering the basics of the subject, the methodology used and references. The introduction must also contain the following headings and contents

- Abstract
- Dissertation page
- Division of work between authors

Monographs are accepted if special circumstances apply. If this is accepted is up to the division faculty. Monographs must satisfy the same requirements as other type of dissertations in terms of published papers on which the monograph is based.

The thesis is defended in a public defence act (see KTH Handbok II, flik 27.1)

## **6 PREREQUISITES AND SELECTION**

### **6.1 Basic and special requirements and prerequisites**

To be accepted as Ph.D. student in Lightweight structures the student must have the prerequisites corresponding to a Civ.Ing. degree (M.Sc.) from programmes M, T, F or BD at KTH. Student from European technical universities with similar education are treated on a similar basis. The student must have thorough basic skills in mechanics, mathematics, strength of materials and material science. The student's background and skills are assessed by the future supervisor. Ability to work practically/experimentally is an explicit condition as well as good communication skills in English.

### **6.2 Foundations for selection**

Students applying to research education (Ph.D. programme) in Lightweight structures are selected based on the knowledge and skills sought after for the particular research project. Students that show great interest and special abilities for the subject in question are prioritised. Other important characteristics are personal skills e.g. communication skills, creativity, etc. The supervisor makes this assessment of the candidate.

## **7 EXAMS AND TESTS IN THE EDUCATION**

### **Licentiate and doctors exam**

**A licentiate thesis can be a final degree. Even if a Ph.D. exam is the final aim the student will normally first seek to pass the licentiate exam. The total time for this is nominally two years, where the course credits requirements are at least 25 points (37.5 ECTS). The licentiate thesis is presented and defended at a public seminar.**

The Ph.D. exam (doctors exam) includes a course part with minimum 40 credit points (60 ECTS) and a Ph.D. thesis. The nominal total study time is 4 years. The student will then defend his/her thesis in a public oral defence seminar (disputation). The thesis is assessed by an examination committee which is appointed by the school.

### **7.1 Tests included in the education**

Ph.D. courses has written and/or oral tests and exams.