Enhanced limit state analysis using computational homogenization and machine learning

Summary

The Equivalent Single Layer (ESL) approach, whereby the stiffened panel is replaced with a single plate, is an efficient means to model and perform non-linear analyses of large or composite structures [1]. The basis for the approach is the unit cell simulations, which describe the underlying structural behavior and need to be run beforehand to enable homogenization. This is also the biggest bottleneck of the methodology. Therefore, the objective of this work is developing a surrogate model that could replace the unit cell analysis using data-driven and machine learning methods. As the ESL model would be used for buckling response, vibration response, accidental and ultimate limit state analysis, the developed surrogate model could potentially cover all these loading scenarios but can also be limited to only one of those scenarios.

Research field:	Environmental, marine and coastal technology
Supervisor:	Mihkel Kõrgesaar
Availability:	This position is available.
Offered by:	School of Engineering Kuressaare College
Application deadline:	Applications are accepted between January 01, 2025 00:00 and January 24, 2025 23:59 (Europe/Zurich)

Description

Tasks (preliminary, not exhaustive):

- Use existing routines already developed for buckling to run unit cell analysis and generate a database of stiffness matrices for different structural configurations.
- Identify candidate machine learning (ML) models compatible with stiffness data and build an ML surrogate.
- Embed the surrogate model in the FE package Abaqus using subroutines.
- Explore applicability for alternative loading conditions (vibration, collision, fracture, etc.).
- Embed the machine learning model into Abaqus user subroutines.
- Demonstrate the applicability of the approach.

Relevant literature:

[1] Putranto, T., Kõrgesaar, M., & Tabri, K. (2022). Application of Equivalent Single Layer Approach for Ultimate Strength Analyses of Ship Hull Girder. *Journal of Marine Science and Engineering*, 10(10), 1530. https://doi.org/10.3390/JMSE10101530

[2] Putranto, T., Kõrgesaar, M., & Jelovica, J. (2022). Ultimate strength assessment of stiffened panels using Equivalent Single Layer approach under combined in-plane compression and shear. *Thin-Walled Structures*, 180, 109943. https://doi.org/10.1016/J.TWS.2022.109943

[3] Putranto, T., Kõrgesaar, M., Jelovica, J., Tabri, K., & Naar, H. (2021). Ultimate strength assessment of stiffened panel under uni-axial compression with non-linear equivalent single layer approach. *Marine Structures*, 78, 103004.

Supervision:

- **Main supervision:** Mihkel Kõrgesaar
- **Co-supervisors:** Jasmin Jelovica (UBC), Teguh Putranto (IST)

Requirements:

The performed work combines computational and experimental research. The applicant should have a good understanding of solid mechanics and ship structures. Since the position presumes the development of data-driven models, prior experience in machine learning methods and/or statistical analysis is considered a plus, but not strictly required. Experience in coding and programming (e.g., Python) is considered beneficial. The candidate should prove their capabilities in writing technical reports and scientific papers in high-quality journals. Good skills in English, both written and oral, are required. Experience in collaborative research/publication with existing TalTech staff is also a plus.

The applicant for the position must have a Master's degree and must fulfill the requirements for doctoral students at the Tallinn University of Technology (https://taltech.ee/en/phd-admission). During the assessment, emphasis will be placed on your potential for research, motivation, and personal suitability for the position.

Employment & Funding:
The position is at the Tallinn University of Technology and includes some work as a teaching assistant in our courses. The expected duration of doctoral studies is four years, but following standard practice, the contract is initially made for 4 months. The extension is subject to the progress of studies and research. The base salary is according to the salary system of Tallinn University of Technology but is flexible depending on the candidate's capabilities.

How to apply to this position:
Follow the instructions in https://taltech.ee/en/phd-admission and for hybrid meeting email mihkel.korgesaar@taltech.ee.

1. Motivation letter (maximum one A4 page, important: provide clear, but honest, evidence of your skills related to the job description and requirements above).
2. CV and other proof of scientific activity (publications, conference papers, etc.).
3. A copy of the master's degree certificate and an official transcript of records, and their translations, if the originals are not in English.
4. An English abstract or summary of the MSc thesis.
5. Introducing two referees who can be contacted directly.
6. Proof of proficiency in English.

Further information:

- Application open until a suitable candidate is found.
- **Job location:** Kuressaare, Estonia

To get more information or to apply online, visit https://taltech.glowbase.com/positions/890 or scan the the code on the left with your smartphone.