Structural Optimization - BMEEOTMDT83

I. Tantárgyleírás

1. Alapadatok

1.1 Tantárgy neve

Structural Optimization

1.2 Azonosító (tantárgykód)

BMEEOTMDT83

1.3 Tantárgy jellege

Kontaktórás tanegység

1.4 Óraszámok

Típus	Óraszám / (nap)
Előadás (elmélet)	2

1.5 Tanulmányi teljesítményértékelés (minőségi értékelés) típusa

Vizsga

1.6 Kreditszám

3

1.7 Tárgyfelelős

név	Dr. Lógó János
beosztás	Egyetemi tanár
email	logo.janos@emk.bme.hu

1.8 Tantárgyat gondozó oktatási szervezeti egység

Tartószerkezetek Mechanikája Tanszék

1.9 A tantárgy weblapja

https://epito.bme.hu/BMEEOTMDT83
https://edu.epito.bme.hu/course/view.php?id=2559

1.10 Az oktatás nyelve

magyar és angol

1.11 Tantárgy típusa

Ph.D.

1.12 Előkövetelmények

1.13 Tantárgyleírás érvényessége

2022. szeptember 1.

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2. Célkitűzések és tanulási eredmények

2.1 Célkitűzések

The purpose of the subject is, that the students acquire the basic concepts and methods of structural optimization. In the frame of this they will get to know the mathematical background. Namely: optimality conditions and duality with coverage of the nature, interpretation, and value of the classical Fritz John (FJ) and the Karush-Kuhn-Tucker (KKT) optimality conditions; the interrelationships between various proposed constraint qualifications; and Lagrangian duality and saddle point optimality conditions
Algorithms and their convergence, with a presentation of algorithms for solving both unconstrained and constrained linear and nonlinear programming problems.
Optimality criteria methods. Minimum weight design. Fundamental theories in topology optimization. Stress-constrained topology optimization. Governing equations. The "singularity problem" in stress-constrained optimization. Handling of constraints via local and global approaches. Mixed finite elements for the optimal design of structures. The displacement-based FEM. Analysis and design of no-tension structures, by formulating optimization problems. A constrained force density method (FDM).
Energy-based method, based on topology optimization, for the finite element analysis of no-tension solids (walls and vaults).
Overview of the currently used methods in SHM: Damage-sensitive sensor placement for sparsity constrained optimization; Modelling of damage in circular flange bolted connections.
Numerical Methods in Probabilistic Topology Optimization.

2.2 Tanulási eredmények

A tantárgy sikeres teljesítése utána a hallgató

A. Tudás

1. knows the fundamental mathematical theories of operational calculus,
2. knows the fundamental theories of structural design of elastic bar structures with the displacement method in matrix algebraic formulation,
3. knows the fundamental theories of structural design of elasto-plastic bar structures with the displacement method in matrix algebraic formulation,
4. knows the knows the fundamental theories of structural design of elastic membrane structures in matrix algebraic formulation,
5. knows the derivations of the optimality conditions of different structural models and their mathematical formulations,
6. knows the main steps of the finite element based optimization ,
7. knows the main steps of the finite element based topology optimization,
8. knows the main steps of the finite element based stress-constrained topology optimization
9. knows the main steps of the finite element based probabilistic topology optimization,

B. Képesség

1. is able to derive the general formulas describing a structural optimization problem by the use of elasto-plastic materials,
2. is able to derive optimality condition in topology design
3. is able to solve a linear programming problem by the use of simplex method,

4. derives the static theorem of the constant stress of plasticity, and uses it accordingly,
5. derive the static theorem of plastic limit state analysis, and applies it to beam structures,
6. speaks out the kinematic theorem of plastic limit state analysis, and applies it to beam structures,
7. derives the fundamental formulations of topology design of membrane structures
8. derives the fundamental formulation of topology design of membrane structures by the use of stress constraints
9. shows the shakedown analysis with its static theorem and applies it for the shakedown analysis of a beam structure,

C. Attitűd

1. co-operates with the teachers in improving his/her knowledge,
2. expands his/her knowledge by constant learning,
3. endeavors to discover and routinely use the tools necessary to the problem solving of optimization problems,
4. aspires to prepare a well-organized documentation in writings, and pursues the precise self-expression in oral communication
5. is open to the use of IT devices

D. Önállóság és felelősség

1. is able to individually think over the extremum problems of structural mechanics and to solve them using the given resources,
2. is open to valid criticism,
3. applies a systematic approach in his/her reasoning

2.3 Oktatási módszertan

Lectures with theoretical knowledge and computational examples, written and oral communication, use of IT devices and techniques, optional practice problems solved individually.

2.4 Részletes tárgyprogram

Week	**Topics of lectures and/or exercise classes**
1.	Optimization of structures: basics. Governing equations. Problem formulation.
2.	Solution of the minimization problem. Applications.
3.	Stress-constrained topology optimization. Governing equations.
4.	The “singularity problem” in stress-constrained optimization. Handling of constraints via local and global approaches.
5.	Problem formulations. Applications.
6.	Mixed finite elements for the optimal design of

	structures. The displacement-based FEM.
7.	The use of “truly-mixed” fem is investigated to address specific applications.
8.	Analysis and design of no-tension structures, by formulating optimization problems. A constrained force density method (FDM).
9.	Energy-based method, based on topology optimization, for the finite element analysis of no-tension solids (walls and vaults).
10.	Introduction to Structural Health Monitoring
11.	Overview of the currently used methods in SHM: Damage-sensitive sensor placement for sparsity constrained optimization; Modelling of damage in circular flange bolted connections.
12.	Overview of the currently used methods in SHM: Detectability of loosened bolts in lap connections. Substructural methods for damage localization in skeletal structures.
13.	Reviewing Numerical Methods in Probabilistic Topology Optimization
14.	Summary

A félév közbeni munkaszüneti napok miatt a program csak tájékoztató jellegű, a pontos időpontokat a tárgy honlapján elérhető "Részletes féléves ütemterv" tartalmazza.

2.5 Tanulástámogató anyagok

a) Suggested readings:

- Mokhtar S. Bazaraa, Hanif D. Sherali, C. M. Shetty: Nonlinear Programming: Theory and Algorithms, 3rd Edition, Wiley, ISBN: 978-0-471-48600-8
- Prekopa A: Stochastic Programming, ISBN-13: 978-0792334828
- Kirsch, U. : Structural Optimization. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-84845-2_1

b) Online materials:

- on the website of the subject https://edu.epito.bme.hu/course/view.php?id=2559

c) Lecture notes:

- on the website of the subject https://edu.epito.bme.hu/course/view.php?id=2559

2.6 Egyéb tudnivalók

The exam is a ppt. presentation . Topic is a virtual optimization work based on the own research activity.

2.7 Konzultációs lehetőségek

The instructors are available for consultation during their office hours, as advertised on the department website. Special appointments can be requested via e-mail

Jelen TAD az alábbi félévre érvényes:

2024/2025 semester II

II. Tárgykövetelmények

3. A tanulmányi teljesítmény ellenőrzése és értékelése

3.1 Általános szabályok

The exam is a ppt. presentation . Topic is a virtual optimization work based on the own research activity.

3.2 Teljesítményértékelési módszerek

Evaluation form	Abbreviation	Assessed learning outcomes
ppt presentation	ppt	A.1-A.9; B.1-B.9; C.1-C.5; D.1-D.3

A szorgalmi időszakban tartott értékelések pontos idejét, a házi feladatok ki- és beadási határidejét a "Részletes féléves ütemterv" tartalmazza, mely elérhető a tárgy honlapján.

3.3 Teljesítményértékelések részaránya a minősítésben

Abbreviation	Score
ppt. presentation	100%
Sum	**100%**

3.4 Az aláírás megszerzésének feltétele, az aláírás érvényessége

Attending the classes

3.5 Érdemjegy megállapítása

Grade	Points (P)
excellent (5)	80%≤P
good (4)	70%≤P<80%
satisfactory (3)	60%≤P<70%
passed (2)	50%≤P<60%
failed (1)P	<50%

3.6 Javítás és pótlás

general rules of study are apply

3.7 A tantárgy elvégzéséhez szükséges tanulmányi munka

Activity	Hours/semester
contact lessons	14×2=28
preparation for lessons during the semester	14×2=28
preparing to exam	34
Sum	**90**

3.8 A tárgykövetelmények érvényessége

2022. szeptember 1.

Jelen TAD az alábbi félévre érvényes: