CIV-E4090 Mechanics of Plate and Shell Structures Examination, April 17, 2020 / Niiranen

This examination consists of 3 problems rated by the standard scale 1...6.

Problem 1

(i) Briefly explain, preferably with the aid of some essential formulae, the meaning of the *plane stress assumption* in the context of elasticity theory and give an example class of structures for which this assumption provides a possibility to simplify the structural analysis.

(ii) Briefly explain, preferably with the aid of some essential formulae, what is meant by *principal moments* in the context of plate models.

(iii) Write down the formula giving the lowest *angular eigenfrequency* of simply supported rectangular *Kirchhoff plates* and briefly explain how adding the so-called Winkler's foundation under the plate affects the formula.

(iv) Briefly explain, preferably with the aid of some essential formulae, the key relationships between the *general shell*, *shallow shell*, *plate* and *membrane* models of thin structures.

Problem 2

Let us consider a rectangular balcony plate structure: the two short sides (length a) and one long side (length b) are clamped, whereas the other long side is free. Let us model the structure by using the *Kirchhoff plate model* with thickness t, Young's modulus E and a transversal body load f.

(i) Find (1) an analytical solution or a corresponding semi-analytical (hand calculation) approximation to the deflection of the problem and, accordingly, (2) the associated maximum bending moment and its location.

(ii) Explain briefly how would you modify or change (1) the problem setting and (2) the solution method you chose if you should solve the corresponding problem of free vibrations (for finding out, e.g., the fundamental natural frequency of the plate)?

Problem 3

(i) Explain (1) what is meant by *edge effects* in the context of shell models and (2) what is the relevance or role of edge effects in the structural design and engineering of shell structures.

(ii) Derive the physico-mathematical expression of the shear strain vector in terms of the kinematical (primary) variables in the context of the *general Reissner–Mindlin thin shell theory* by starting from the definition of the corresponding strain tensor components of the three-dimensional theory of elasticity.