MEC-E2007 - Ship Structures and Construction

2nd Midterm exam

Time: 24.5.2018 at 13-15

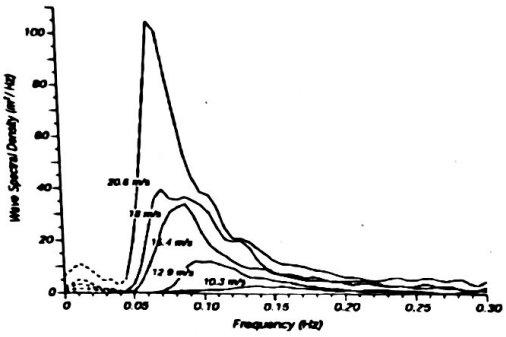
Place: Lecture room 216, K1 building (Otakaari 4)

Answers either in Finnish or in English. When you select the language, remember the correct terminology in that language. Remember clear handwriting and short answers.

1. Vibrations of Ship Structures

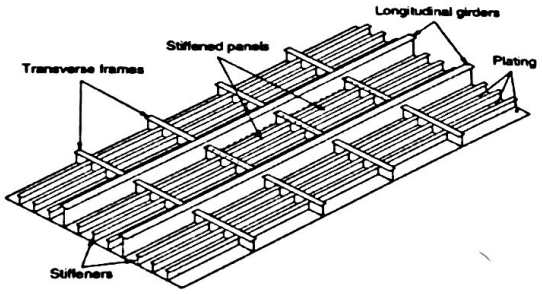
a) What is the difference between springing and whipping? Utilize the text and figures in the answer. Describe the ship characteristics that affect the occurrence of these events. **3p.**

b) Determine the lowest allowed eigen frequency with 10% safety margin for the concept design of your project ship. The structure experiences the enclosed wave spectra and the machinery and propeller induced vibrations: main engine 510RPM and propellers 120RPM (5 blades). **3p.**

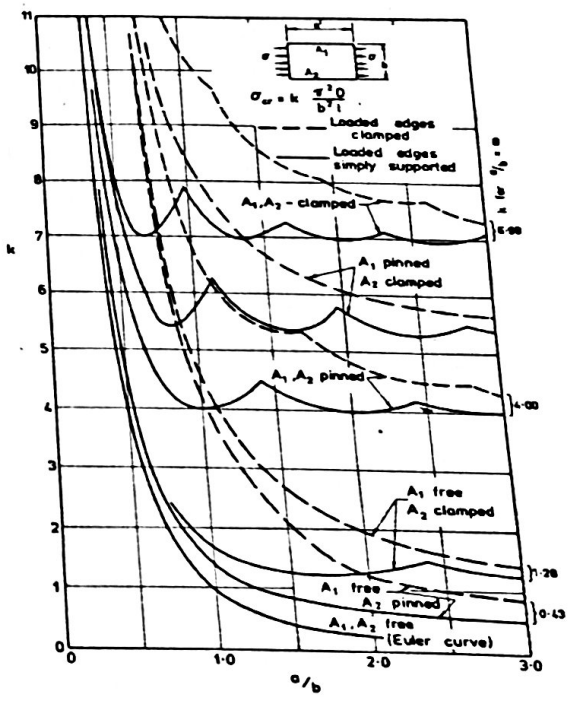


2. Buckling Assessment of Ship Structures

a) Describe the main affecting factors on the buckling analysis of stiffened plate structures. Discuss the difference in buckling behavior between plate, stiffener and stiffened plate. **3p.**



b) Calculate the buckling strength of the plate fields. The material is steel with E=206GPa and v=0.3, σ_y=355. The plate has thickness t=6mm. The stiffened plate has longitudinals T120x5/50x4, s=600mm and web-frames and girders T450x6/120x8, $S_{webframe}$=2800mm. The buckling coefficient can be select form the enclosed figure, but selection should be justified. **3p**



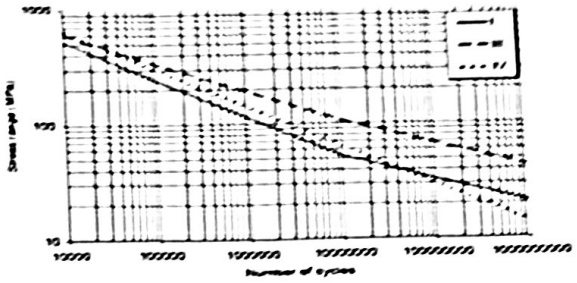
3. Fatigue and Fracture of Ship Structures

a) Describe the elements contributing to fatigue in ships. Discuss also how we can control the brittle and ductile fracture of ship structures. **3p**

b) Ship travels from Helsinki to Germany. For simplicity, it is assumed to have 3 equal length wave conditions and the resulting the following stress states at the main deck:

- T_z = 0.1s, $\Delta\sigma$ = 300MPa, 15 hours,
- T_z = 5s, $\Delta\sigma$ = 100MPa, 15 hours and
- T_z = 30s, $\Delta\sigma$ = 60MPa, 15 hours.

Calculate the fatigue damage for the given period using Miner's sum. The SN-curve for the deck detail (Category I) is enclosed. **3p.**



4. Reliability and Optimization

a) Discuss the roles of scantling, geometry and topology optimization in ship structural design. What are the main objectives and constrains for the optimization? **3p**

b) Discuss the objectives and importance of reliability analysis on ship structural design. **3p**

Equations

Rectangular section

$$\sigma = \frac{M}{W} = \frac{M}{Z} \qquad I = I_1 + I_s = \frac{bh^3}{12} + d^2A$$

$$D = \frac{n_1}{N_1} + \frac{n_2}{N_1} + \ldots + \frac{n_i}{N_i} \qquad NS^m = C \qquad \mathrm{FAT} = \left(\frac{\mathrm{C}}{2\cdot 10^6}\right)^{\frac{1}{\mathrm{m}}} \qquad \eta = \sum_{i=1}^{n} \frac{n_i}{N_i} \le \eta_L$$

$$\sigma_{hs} = K_s \cdot \sigma_{nom} \qquad \eta = \frac{\mathrm{N}}{\mathrm{C}} \mathrm{S}_{\mathrm{C}}^{\mathrm{m}} (\ln \mathrm{N})^{-\frac{\mathrm{m}}{\mathrm{k}}} \Gamma(1 + \frac{\mathrm{m}}{\mathrm{k}})$$

$$\sigma_e = \frac{\pi^2 kE}{12(1-\nu^2)}\left(\frac{t}{s}\right)^2$$

$$\sigma_{el} = \pi^2 \frac{EI}{L_e^2 A} \qquad \sigma_p = \sigma_y\left(1 - \frac{\sigma_y}{4\sigma_e}\right)$$

$$\sigma_{cr} = \begin{cases} \sigma_e & \frac{\sigma_e}{\sigma_y} < \frac{1}{2} \\ \sigma_p & \frac{\sigma_e}{\sigma_y} \ge \frac{1}{2} \end{cases}$$