Bachelor Themes SFE – branch D
Thematic area: Building Mechanics

Topic 1: Statics

1) Forces acting at a point and upon a body, equilibrium, moments of forces, couples, equivalence and resultants of force systems in plane and in space, reduction to a point.
2) Degrees of freedom of rigid bodies in plane and space, basic types of constraints (external and internal) reactions in constraints.
3) Cinematically and statically determinate and indeterminate bodies and their systems in plane and space, ill conditioned supports.
4) Reactions in statically determinate objects – points, plates in plane, bodies in space, planar systems of plates, checking the results by equilibrium conditions.
5) Principle of virtual displacements for the solution of the reactions in statically determinate structures.
6) Solution of statically determinate planar trusses, methods of joints and sections, assessment of tension/compression and null force in members.
7) Statically equivalent force (magnitude and ray) for continuous line loads, in particular uniform and linearly varying ones.
8) Basic bearing elements of building structures, load transmission to these elements.
9) Internal forces in cross-sections of plane and space beams, the rules for drawing their diagrams.
10) Equilibrium of a differential length of beam, differential equations connecting the internal forces and loads in a straight planar and space beams.
11) Internal forces by the reduction of all forces acting upon a part of a beam or structure with respect to the beam axis (for planar and space, straight and broken beam axes), free body diagrams.
12) Internal forces diagrams in straight and broken axes beams and their systems, joints equilibrium.
13) Cross-section moments of inertia axial, deviatoric, polar, coordinate system transformations, translations/rotation.
14) Gravity center and moments of inertia of cross-sections composed of simple geometric shapes or rolled steel sections.
15) Principal and central axes and moments, radius of gyration and inertia ellipse.
16) Effects of force and thermal loads and support settlements on the internal forces and reactions in statically determinate and indeterminate structures, implications for design.
17) Comparison of the force and displacement (slope deflection) methods for planar frames, basic equations and primary unknowns.
18) Elementary deformation modes of a beam, geometric and constitutive equations on the cross-section level including the thermal loads.
19) Continuous beams analysis by the slope deflection method, force and thermal loads
20) Planar frames analysis by the slope deflection method, degrees of freedom, difference between the slope deflection and general displacement methods.
21) Symmetric and antisymmetric load states in symmetric planar frames.

22) Deflection in planar frames using the virtual work principle, actual state, virtual state and unit force virtual state.
23) Deflections in straight beams by the integration of geometric equations of a cross-section or by the virtual work principle, force and thermal loads, support settlements.
24) Comparison of the work of the moment, shear and normal forces in planar frames in terms of their contributions to the deflection.
25) Force method, redundant, primary structure, compatibility equations.
26) Force method for statically indeterminate planar frames.
27) Force method for statically indeterminate planar trusses.
28) Influence lines of reactions and internal forces, allocation of force loads for extreme values and evaluation of the extremes by the integration of the influence line.
29) Matrix formulation of the displacement method, degrees of freedom, beams end forces, stiffness matrix and load vector of a beam and of the whole structure, principal steps of the solution.
30) Beam on an elastic subground, Winkler and Pasternak constants, foundation settlement, planar gridwork beams

Topic 2: Elasticity and Strength

31) Stress-strain diagrams and material characteristics for linear elastic material, elastic perfectly-plastic, elastic plastic material with linear hardening.
32) Definition of stress (in mechanics), stress components on elementary cube in case of general three-dimensional stress state.
33) Difference between absolute and relative elongation, definition of strain, strain components on elementary cube.
34) Cauchy's differential equations of equilibrium in case of general three-dimensional stress state.
35) Strain-displacement (geometric) equations in case of general three-dimensional stress state.
36) General Hooke's law, its simplified version in case of one-dimensional stress state, influence of thermal changes.
37) Young's modulus of elasticity, Poisson's ratio, shear modulus of elasticity, their physical meaning and approaches for their experimental determination.
38) Relationship between internal forces and stresses in the cross-section (internal forces as stress resultants).
39) Differential equations and boundary conditions for beam loaded in tension.
40) Beams subjected to bending, Bernoulli-Navier bending hypotheses.
41) Normal strain and stress distributions in the cross-section in case of simple bending, curvature-moment relationship, bending stiffness of the cross-section.
42) Differential equation of deflection curve in case of simple bending, static and kinematic boundary conditions.
43) Normal strain and stress distribution in the cross-section loaded by combination of bending and tension or compression, neutral axis.
44) Analysis of normal stress in the cross-section loaded by general combination of internal forces, possible simplification in case of special choice of the cross-section coordinate system, determination of neutral axis location.

45) Compression center (eccentric compression), core of the cross-section.
46) Shear in bending, relation between shear flow and shear stress, distribution of shear stress.
47) Warping of the cross-section, shear stress in the solid and thin-walled cross-sections caused by the pure torsion, twist rate and its relation to the torque (cross-sections without warping).
48) Polar moment of inertia, torsional constant (solid, open and closed thin-walled cross-sections), shear stress in the open and closed thin-walled cross-sections in case of pure torsion.
49) Thin-walled cross-section, shear center, principal sectional area, sectional moment of inertia, torsional stiffness.
50) Free torsion and restrained warping, stress caused by the torque, warping moment (bimoment).
51) Governing equation for twist of the thin-walled cross-section, boundary conditions.
52) Buckling of perfect beam columns, effective length, buckling load, slenderness ratio.
53) Linear buckling analysis of planar structures, buckling load factor, eigenmodes, geometric stiffness matrix, second-order analysis.
54) Elastic perfectly-plastic material model, bending strain and stress, elastic and plastic limit moments.
55) Plastic hinge, plastic limit state analysis of beams, load intensity for the plastic limit state.
56) Planar structures – slab vs. wall, internal forces and stresses, fundamental equations, methods of discretization, finite difference method.
57) Planar structures – slab, differential equation, boundary conditions, internal forces and stresses.
58) Planar structures – wall, differential equation, Airy stress function, boundary conditions, internal forces and stresses.

Guarantee: K132

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