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AN EXTENSION OF ALGEBRAIC EQUATIONS OF ELASTIC TRUSSES WITH SELF-EQUILIBRATED SYSTEM OF FORCES

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Linear elastic analysis of truss structures can be done within the finite element method formalism [2] as well as without the approximation of the displacement field, by algebraic equations [1]. The present paper is an extension of the considerations presented in [1] to the algebraic equations for geometric stiffness matrix. The matrix allow to include the influence of self-equilibrated systems of forces on the response of truss structure. It is a crucial aspect for the qualitative and quantitative analyses of tensegrity-like trusses [3].

Let us to consider a plane pin-joint structure composed of e straight and prismatic bars of the lengths l_k, cross sections A_k and Young modulus E_k. The bars are connected in nodes in which the number of s nodal displacements q_j and nodal forces Q_i are defined [1]. Axial forces N_k can be expressed by the extensions of bars Δ_k in the form $N_k = E_k A_k \Delta_k / l_k$. The extensions Δ_k are a combination of nodal displacements $\Delta_k = \sum_{j=1}^{s} B_{kj} q_j$, $j = 1, 2, ..., s$. Additionally the self-equilibrated system of axial forces S_k which satisfy the homogeneous sat of equilibrium equations $\sum_{k=1}^{e} B_{jk} S_k = 0$ is considered. If one consider equations of equilibrium in the actual configuration then moment of forces $M_k = S_k l_k \psi_k$ is acting on each bar. Angles of bar rotations ψ_k can be expressed as a combination of nodal displacements $\psi_k = \frac{1}{l_k} \sum_{j=1}^{s} C_{kj} q_j$. The above formalism leads to the linear system of algebraic equations $\sum_{j=1}^{s} (k_{ij} + k_{ij}^G) q_j = Q_i$, in which the stiffness matrix k_{ij} and geometric stiffness matrix k_{ij}^G can be experssed in algebraic form $k_{ij} = \sum_{k=1}^{e} B_{ki} \frac{E_k A_k}{l_k} B_{kj}$, $k_{ij}^G = \sum_{k=1}^{e} C_{ki} \frac{S_k}{l_k} C_{kj}$. The above considerations can be extended for 3D truss structures.

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