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Computational methods for the zero-stress state and the pre-stress state of tensile cable-net structures

Key words:

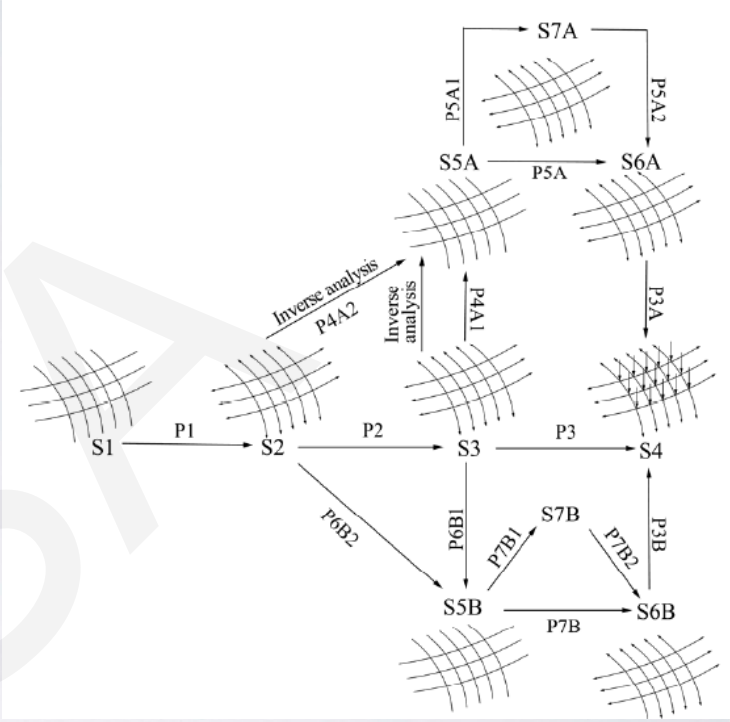
Tensile cable-net structure, Zero-stress state, Pre-stress state, Pre-stress release analysis, Pre-tensioning development analysis, Form finding, Inverse Problem





Extended design process and mechanical description of cable-net structures

This paper proposes an extended design concept and mechanical description for cable-net structures, including 10 states and 15 procedures which are defined according to their physical nature and analytical capabilities.



Extended design concept of cable-net structures

The following sections will focus on the procedures P4A2, P5A and the states S5A and S6A.



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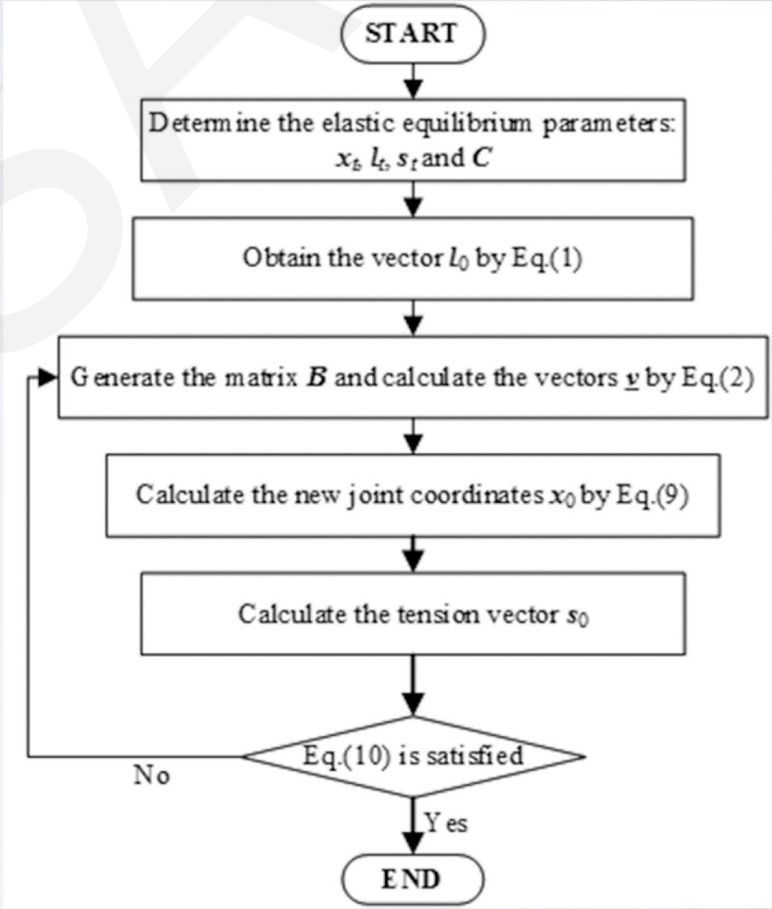
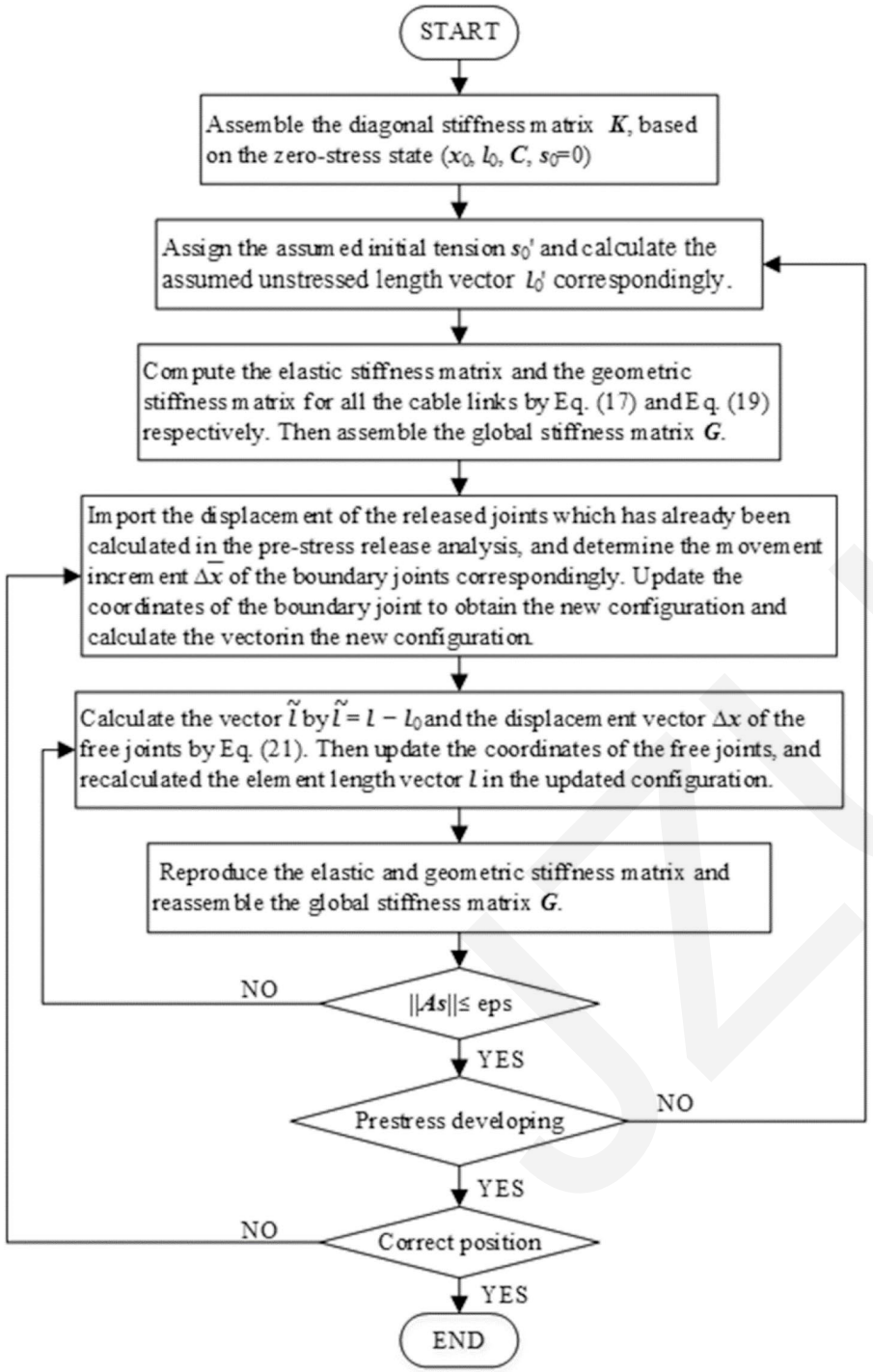
Computational Methods for the S5A Zero stress State

In the pre-stress release analysis, an iterative computational method is developed for the inverse evaluation from the equilibrium state to the zero-stress state, which adopts the least norm least square approach to the compatibility equation because of the indeterminate property of a cable-net structure.



Flow chart of the computation of the pre-stress release analysis





Computational Methods for the S6A Pre-stress State

An iterative computational method is developed for the positive problem from the zero-stress state to the actual pre-stress state by moving the boundary joints, in which the explicit governing equations are formulated based on the particular energy function and a feasible self-stress mode is adopted to avoid the singularity of the initial stiffness matrix.





Main Conclusions

- An extended design concept is proposed and the corresponding flow chart is simulated, suggesting a highly detailed description of the stress state and simulation procedure.
- This study found that the configuration of the zero-stress state obtained herein compares well with those obtained by the dynamic relaxation method, which validates the efficiency and accuracy of our computational method.
- It also found that the “actual” pre-stress and configuration predicted by our computational methods are consistent with the prescribed pre-stress state, suggesting that the combination of the pre-stress release and pre-tensioning development analyses could successfully eliminate the shape and pre-stress discrepancies.
- These computational methods are formulated as modular procedures in order to be a standard design process.