A 4 dof discrete beam model based on bi-arcs for predicting connections forces in elastic gridshells

Lionel DU PELOUX[a], Cyril DOUTHE[a,*], Olivier BAVEREL[a], Jean-François CARON[a]

[a] Laboratoire Navier, UMR 8205, ENPC, IFSTTAR, CNRS, 6-8 Av. Blaise Pascal, F-77455 MLV Cedex 2.
* cyril.douthe@ifsttar.fr

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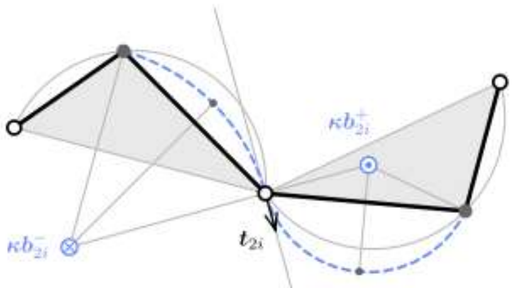
Abstract

The construction process of elastic gridshells implies large displacements of the constituting members which are initial straight and deformed into a three dimensional shape. This shape is the result of material elastic properties, section characteristics and loading conditions represented by the supports and the various links with the members in the "perpendicular" direction. Non axisymmetric sections induce coupling between bending and torsion, while connection forces induce discontinuities in internal forces or moments. In most practical realizations, one tends to reduce the influence of these two issues by constructional means: like for instance, in the historical example of the Mannheim gridshell which is made of two layers of square wooden laths, connected with a single screw providing the least possible rotational restraints. The proper sizing of the connection requires however that connection forces be predicted accurately and therefore an appropriated model.

The richest models, in the following of Crisfield co-rotational formulation [1], provide the necessary information but lack the simplicity and intuitivity of discrete models initiated by Barnes *et al* for axisymmetric members [2]. We thus propose here to built on Tayeb *et al* approach [3] and develop a novel 4 dofs discrete beam model that can be easily implemented in a Dynamic Relaxation Scheme. This model uses a list of positions in space to represent the neutral axis of the beam. Curvature and tangent vectors are first evaluated using three points circumcircles, then curvature discontinuities are introduced through local bi-arcs. Afterwards standard discrete differential geometry is used to build and propagate Bishop' frame by double reflection. The position of the actual material frame is finally retrieved from the fourth angular degree of freedom which accounts from the local twist between material and Bishop frames. The beam being elastic, the internal forces are directly deduced from the centerline deformation and Kirchoff' rod model…



$$\boldsymbol{\kappa b}_{2i}^{-} = \frac{2}{l_{2i-1}} \boldsymbol{u}_{2i-1} \times \boldsymbol{t}_{2i}$$

$$\boldsymbol{\kappa b}_{2i}^{+} = \frac{2}{l_{2i}} \boldsymbol{t}_{2i} \times \boldsymbol{u}_{2i}$$

A few applications will illustrate the potential of the proposed model for the design of connections as well as for the prediction of the global shape of elastic gridshells.

References

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