Discrete elastica for shape design of gridshells

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Abstract

We present an approach to designing a gridshell structure, which is constructed connecting beams under bending deformation by hinge joints. The gridshell is modeled as an assembly of piecewise linear curves called 'discrete elastica', which is a discretized form of elastica defined as the shape of buckled beam-column with large deflections. Shape parameters such as span, height at the support, height at the internal joint, and the external moments are assigned to generate various shapes of discrete elastica, which are found by minimizing the total potential energy. It is shown in the numerical examples that a gridshell surface designed using discrete elastica has small interaction forces between the curved beams at joints. Large deformation analysis is carried out for verification of the shape generated using discrete elastica. An optimization approach is presented to further reduce the interaction forces between beams by assigning specified number of 'hinge+slot joints' to allow relative translational displacement at a hinge. Finally, the static structural characteristics of optimal gridshells are investigated.

References

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