

Active tensegrity structures with sliding cables - static and dynamic behaviour

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Tensegrities are spatial, reticulated and lightweight structures that are increasingly investigated as structural solutions for active and deployable structures. Tensegrity systems are composed only of axially loaded elements and this provides opportunities for actuation and deployment through changing element lengths. In cable-based actuation strategies, the deficiency of having to control too many cable elements can be overcome by connecting several cables together and using only one motor to control them (Sultan and Skelton 2003). This suggests that groups of individual active cable elements could be combined into continuous active cables. A continuous cable can slide over multiple nodes through frictionless pulleys. This strategy has the advantage that fewer actuators are necessary for control. However, using continuous cables significantly changes the mechanics of classical tensegrity structures. Specifically, the number of self-stress states can decrease and possible mechanisms may increase (Motro and Raducanu 2003). This leads to significant challenges for structural analysis, control and actuation (Moored and Bart-Smith 2009).

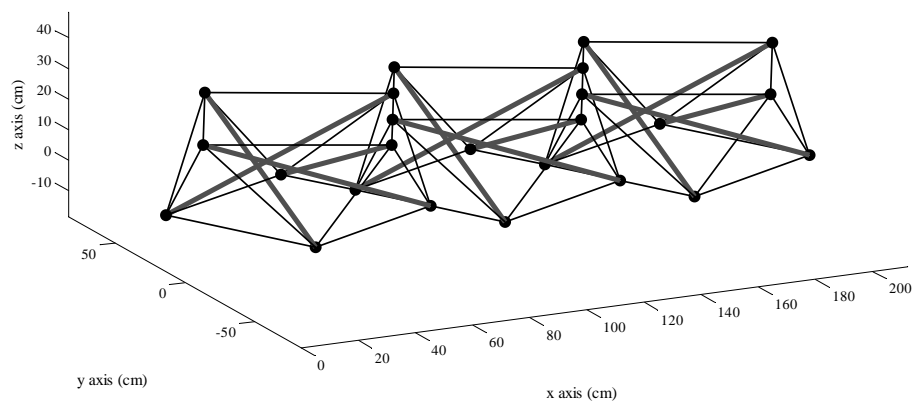


Figure 1. A perspective view of the tensegrity beam

The dynamic relaxation method (DR) is particularly efficient for form-finding and analysis of tension structures. This method is extended to accommodate tensegrity structures that have continuous sliding cables. The applicability of the modified DR for this type of structure is demonstrated. Furthermore, DR is employed to investigate the static behaviour of tensegrity structures with and without sliding cables. The performance of the modified DR algorithm is demonstrated using the topology of a clustered tensegrity structure studied by Moored and Bart-Smith (Moored and Bart-Smith 2009). The structure is a tensegrity beam composed of an assembly of three prismatic modules commonly known as quadruplex modules (Figure 1). Results obtained from numerical simulations show that the values predicted by the DR method are in a good agreement with those generated by the transient stiffness method.

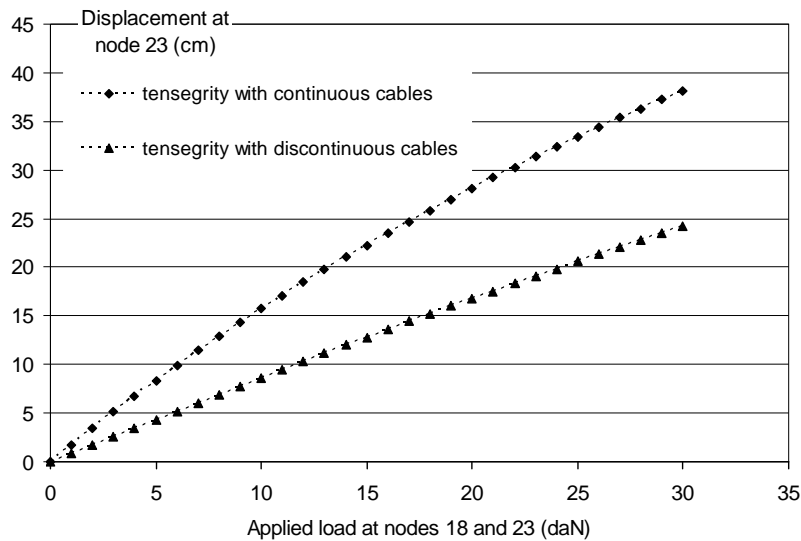


Figure 2. Load-displacement curves of the tensegrity beam with and without sliding cables

The effects of introducing sliding cables into tensegrity structures are also investigated. Load-displacement curves of the tensegrity beam before and after grouping cable members into continuous cables are compared in Fig.2. This comparison reveals that predicted nodal displacements are larger for the tensegrity beam with continuous sliding cables. Results indicate that the beam with sliding cables is approximately 55% more flexible than an equivalent configuration having discontinuous cables. This suggests that the nonlinear behaviour induced by large displacements is more pronounced in tensegrity structures with continuous cables. Furthermore, an eigenfrequency analysis showed that employing sliding cables influences the natural frequencies of the tensegrity structures. DR is also employed to investigate actuated bending deformation of the tensegrity beam.

This study shows that using sliding cables is a scalable solution that can be employed for active structures that incorporate active elements, thereby reducing the number of actuators needed for active control and deployment.

References

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