# Nonlinear Dynamics Analysis of Actuation Strategies of Clustered Tensegrity V-Expander Structures

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**Abstract**. This work focuses on the dynamic analysis of cable-actuation processes of clustered tensegrity V-Expander modular structures. We present the study of energy-efficient cable actuation strategies for clustered tensegrity V-Expander towers subjected to shape changes in extension, flexure, shear, and torsion. First, based on the Lagrangian method and FEM approach, the equations governing the statics and dynamics of clustered tensegrities are given. After that, we analyze the nonlinear static and dynamic behavior during morphing processes realized with different actuation speeds. Then, the actuation efficiency of each particular choice of actuating cable is evaluated and discussed. The approaches developed here have general validity and can be used to design other types of cable-driven tensegrity structures.

## Introduction

V-Expanders are lightweight [1], deployable, and easy to assemble tensegrity modules [2]. The topology of a V-Expander tower assembled by two or more elementary cells is shown in Figure 1. A clustered string is a group of individual cables combined into one continuous string that runs over pulleys or through loops at the nodes [3]. We present the study of an energy-efficient cable-actuation strategy for clustered V-Expander tensegrity structures subject to different shape changes based on the nonlinear clustered tensegrity dynamics and statics. Based on the Lagrangian method and FEM approach, the equilibrium equations of statics and dynamics for clustered tensegrity structures are given. Then, the cable-actuation process is realized by choosing suitable sets of cables as active and passive elements among the whole set of cables. The length of the active cables decreases during actuation, while passive cables adjust their length accordingly following the motion of the structure. Five shape-change types are considered: stretching, shrinking, flexure, shear, and torsion, as shown in Figure 2. We analyze the nonlinear static and dynamic behaviors during the morphing process with different actuation speeds. The actuation efficiency of each particular choice of active and passive cables is also discussed. The approaches developed in this paper can also be used to design and analyze other types of deployable cable-driven tensegrity structures.

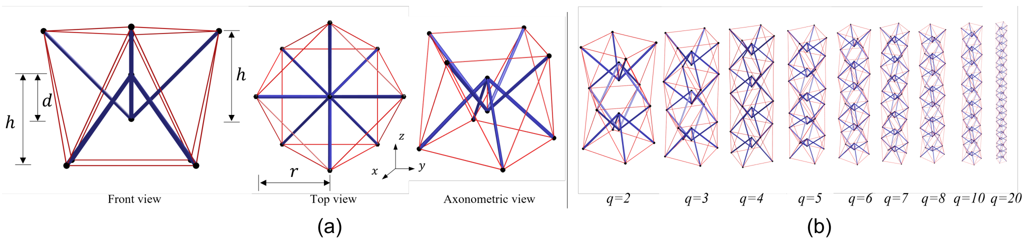


Figure 1: The V-Expander tensegrity: (a) the front, top, and axonometric views of one V-Expander cell, (b) the V-Expander column with different complexities. The thick blue lines are bars, and the thin red lines are cables.

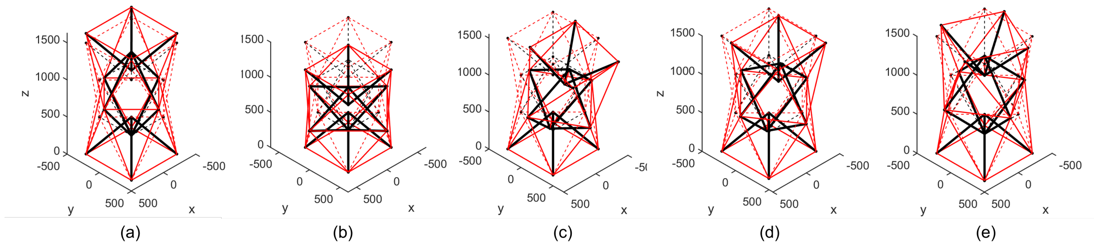


Figure 2: The energy-efficient cable-actuation strategy for the five shapes changes: (a) stretching, (b) shrinking, (c) flexure, (d) shear, (e) torsion. The solid and dotted lines represent the mode shapes and the initial configuration, respectively.

## References

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