

EQUILIBRIUM CONDITIONS OF A CLASS I TENSEGRITY STRUCTURE

Robert E. Skelton¹, Darrell Williamson², JeongHeon Han³

ABSTRACT

Static models of tensegrity structures are reduced to linear algebra problems, after first characterizing the problem in a vector space where direction cosines are not needed. That is, we describe the components of all member vectors as opposed to the usual practice of characterizing the statics problem in terms of the magnitude of tension vectors. While our approach enlarges (by a factor of 3) the vector space required to describe the problem, the computational space is not increased. The advantage of enlarging the vector space makes the mathematical structure of the problem amenable to linear algebra treatment. Using the linear algebraic techniques, many variables are eliminated from the final existence equations. This paper characterizes the existence conditions for all tensegrity equilibria.

Key Words: tensegrity, structure, statics, equilibrium conditions, linear algebra.

INTRODUCTION

The Tensegrity structures introduced by Kenneth Snelson pose a wonderful blend of geometry and mechanics. In addition, they have engineering appeal in problems requiring large changes in structural shape. We define "class I" tensegrity as a stable connection of bars and strings with only one bar connected to any given node. Nodes connecting more than one bar or other constraints form "class II" tensegrity. Thus, class I structures are unconstrained, whereas, class II may have boundary constraints or bar to bar connections. Most existing *smart structure* methods are limited to small displacements. Since class I tensegrity structures [8] have no bar-to-bar connections, the control of tendons allows very large shape changes. Therefore, an efficient set of analytical tools could be the enabler to a hoist of new engineering concepts for deployable and shape controllable structures.

This paper characterizes the static equilibria of class I tensegrity structures. Furthermore, we use vectors to describe each element(bars and tendons), eliminating the need to use direction cosines and the subsequent transcendental functions that follow their use.

It is well known in a variety of mathematical problems that enlarging the domain in which the problem is posed can often simplify the mathematical treatment. For example, nonlinear Riccati equations are known to be solvable by linear algebra in a space that is twice the size of the original problem statement. Many nonlinear problems admit solutions by linear techniques by enlarging the domain of the problem. The purpose of this paper is to show that by enlarging the vector space in

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