DYNAMICS OF SHAPE MEMORY ALLOY TRUSS STRUCTURES

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ABSTRACT

A truss is a fundamental type of engineering structure commonly used in construction, especially in bridges, roofs, and towers. It consists of straight members connected at joints to form a framework, usually in the shape of interconnected triangles. When the structural members lie in a single plane we speak about plane trusses which can be considered as two-dimensional structural systems. However, when the arrangement of elements is not limited to one plane, we have spatial trusses that should be analyzed as three-dimensional structural systems. The triangular arrangement of members is used most often because it provides stability and ensures that forces applied to the structure are distributed efficiently. The triangle is the most stable geometric shape, and arrangement of the members of a truss in the form of triangles helps maintain the structure's stability and rigidity. A truss maximizes stiffness and strength while minimizing material usage. Since its members are primarily subjected to axial forces (tension and compression), thanks to pinned joints (called nodes) and loads are applied at the nodes, it uses less material compared to other structural forms to carry significant loads. Thus, trusses are widely used in bridge construction, as their design allows for large spans without excessive material weight, and for roofs in large-span buildings, such as auditoriums or warehouses, as they enable open spaces without interior columns. By using less material while maintaining stiffness and strength, trusses provide an economical solution for spanning large distances.

In this talk we will provide a dynamic analysis of trusses that are made of pseudoelastic shape memory alloy (SMA). Shape memory alloys are a class of materials which possess a unique ability to return to their initial shape even after large deformations (strains up to 8%) when unloaded and/or heated. Our approach is based on the concepts of thermodynamics [1] and we make use of the finite element method [3], which allows us to account for damping properties of the SMA truss [2]. The problem we study can be formulated in mathematical terms as the system of differential equations

$$\mathbf{M}\,\ddot{\mathbf{u}} + \mathbf{K}\,\mathbf{u} + \mathbf{F}^{\mathrm{SMA}}(\mathbf{u},\mathbf{c}) = \mathbf{F}(t) \tag{1}$$

where $\mathbf{M}$ is the mass matrix, $\mathbf{K}$ is the stiffness matrix of the structure, $\mathbf{F}^{\mathrm{SMA}}(\mathbf{u},\mathbf{c})$ is a vector of forces depending on hysteresis loops and the unknown displacement vector $\mathbf{u}$ and a set of internal variables (volume fractions in the martensitic phase transformation) $\mathbf{c}$, and $\mathbf{F}(t)$ is a vector of forcing functions.

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