DYNAMIC STABILITY AND RESPONSE OF A BIO-INSPIRED TENSEGRITY STRUCTURAL COMPONENT UNDER EARTHQUAKE LOADING

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Keywords: Tensegrity, Biomimicry, Stability, Dynamic Analyses, Optimisation

Evolution has been the nature's solution to the survival issues of living creatures in direct response to their living environment in which physical forces are dominant. The investigation of bio-forms and how these forms are structurally stable and equilibrated, reveal the fact that life utilises tensegrity systems for its physical and mechanical incarnation. According to the literature, a tensegrity system is a tensionally integrated medium which comprises of a continuous set of tensile elements (or cables) supported by a discontinuous set of compressive elements (or struts). A tensegrity structure is stabilised by the sets of self-stresses borne in its elements. Ever since the tensegrity structures' concept was proposed and patented, major research attempts have performed on static stability, form-finding and structural behaviour of this type of structures. Recently in some limited works, the dynamic characteristics and analyses of tensegrity structures have been discussed. These studies state some proposed analytical formulations for general dynamic characteristics and response of tensegrity structures of which form-finding process is done beforehand and the static self-stress set is determined and accepted as the design self-stress set during the dynamic analyses.

In the present work the tissue structure has been opted representing the proposed tensegrity structural biomimicry. A tissue context has a hierarchical formation in which cells' cytoskeletons are its space-filler building blocks. Cytoskeleton is a structural unit composed of filamentous biopolymers that mechanically stabilises the cell and actively generates self-stresses resisted by external adhesive tethers to the extracellular matrix or fascia. The fascia is a purely tensile network whose duty is binding the structural blocks, filaments and other hierarchical formations in the tissue and integrating its structural behaviour. Thus, cytoskeletons and fascia form a synergetic tensegrity system.

This paper aims to investigate the dynamic stability and response of the proposed fascia-cytoskeleton tensegrity system under earthquake loading considering the self-stress set and connectivity as dynamic variables while assuming the system to be a linear dynamical entity. In this regard, optimisation techniques are applied in the tensegrity dynamic analyses to trace its stability and equilibrium at discrete time steps as well as controlling the element deformations and nodal displacements in the allowable or specified ranges. The results include optimum connectivity and self-stress set for the tensegrity system which perform the best when the structure is under the design earthquake excitations. The final outcome of the optimised dynamic stability analyses is a tissue-mimiced tensegrity structural component with minimum required elements and the initial dynamic design self-stress set which satisfies the equilibrium, stability, constitutive laws and limit constraints during the time span in which the design earthquake is exerted on the structure. This component can control and minimise the desired structural objectives such as nodal displacements (or accelerations/velocities) and element deformations. In order to further clarify the dynamic design method here, numerical examples are considered, analysed and depicted schematically.