Adaptive Structures of Resilient Cyclic Knots

Dmitri KOZLOV

Research Institute of Theory and History of Architecture and Urban Planning
9 Dushinskaya St., Moscow 111024, Russia
kozlov.dmitri@gmail.com

Abstract

Adaptive structures of the living nature are usually based on the principle of reversible deformation known as "*effect of resilience*". Thanks to this effect the elastic energy accumulated in the materials of natural structures can deform them without causing any damage to them. By analogy, man-made adaptive structures of resilient type have definite advantages over non-resilient ones including increased load-bearing capacity, reduced weight, and extended term of their service life.

The nature creates its resilient adaptive structures mainly of elastic filaments (fibers, tendons) combined into regular woven structures, which can be prestressed to keep elastic energy. Similarly, bionic adaptive structures may be made of elastic one-dimensionally extended components such as resilient rods, prestressed by means of their bending. The most obvious and natural way of prestressing a long resilient rod is to bend it into a ring by joining together its two free ends. The regular circular form of the ring is a result of the uniform distribution of its inner elastic energy.

If a long resilient rod is tied into a knot it will take a cyclic form, because the elastic energy of the bent and closed rod tends to take its minimum value and distributes evenly along it exactly as in the case of the simple ring. The elastic energy makes loops of knot smooth and causes them to take equal sizes. Interweaving of the loops additionally bends them making their crossings contacting and forcing the knot to coincide with the plane.

Under the action of external forces an excess of elastic energy arises in the knot, forcing it to leave the plane and take a spatial form corresponding to the minimum of its energy by means of changing the curvature of the surface defined by contacting crossings of the knot. As a result, the elastic closed cyclic knot functions as an adaptive spatial structure.

The resilient adaptive structures of this type may find their field of application in the building under extreme environmental conditions such as strong winds, great snow loads, high or low temperature, active seismicity, flood zones, etc. They have great demand in remote areas of the polar regions and deserts, in the sea and under water, in the outer space and on other planets.