Manufacturing & Prototyping

Use of Nanofibers to Strengthen Hydrogels of Silica, Other Oxides, and Aerogels

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Research has shown that including up to 5 percent w/w carbon nanofibers in a silica backbone of polymer cross-linked aerogels improves its strength, tripling compressive modulus and increasing tensile stress-at-break five-fold with no increase in density or decrease in porosity. In addition, the initial silica hydrogels, which are produced as a first step in manufacturing the aerogels, can be quite fragile and difficult to handle before cross-linking. The addition of the carbon nanofiber also improves the strength of the initial hydrogels before cross-linking, improving the manufacturing process. This can also be extended to other oxide aerogels, such as alumina or aluminosilicates, and other nanofiber types, such as silicon carbide.

This work was done by Mary Ann B. Meador, Lynn A. Capadona, Frances Hurwitz, and Stephanie L. Vivod of Glenn Research Center and Max Lake of Applied Sciences, Inc. Further information is contained in a TSP (see page 1).

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Two Concepts for Deployable Trusses

Thermal-actuation and misalignment-tolerant double-pivot designs are proposed.

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Two concepts that could be applied separately or together have been suggested to enhance the utility of deployable truss structures. The concepts were intended originally for application to a truss structure to be folded for compact stowage during transport and subsequently deployed in outer space. The concepts may also be applicable, with some limitations, to deployable truss structures designed to be used on Earth.

The first concept involves a combination of features that would help to maximize reliability of a structure while minimizing its overall mass, the complexity of its deployment system, and the expenditure of energy for deployment. The deployment system would be integrated into the truss: some of the truss members would contain folding/unfolding-detent mechanisms similar to those in umbrellas; other truss members would contain shape-memory-alloy (SMA) coil actuators (see Figure 1). Upon exposure to sunlight, the SMA actuators would be heated above their transition temperature, causing them to extend to their deployment lengths. The extension of the actuators would cause the structure to unfold and, upon completion of unfolding, the umbrellalike mechanisms would lock the unfolded truss in the fully deployed configuration. The use of solar heating to drive deployment would eliminate the need to carry a deployment power source. The actuation scheme would offer high reliability in that the truss geometry would be such that deployment could be completed even if all actuators were not functioning. Of course, in designing for operation in normal Earth gravitation, it would be necessary to ensure that the SMA actuators could apply forces large enough to overcome the deployment-resisting forces attributable to the weights of the members.

The second concept is that of an improved design for the joints in folding members. Before describing this design,

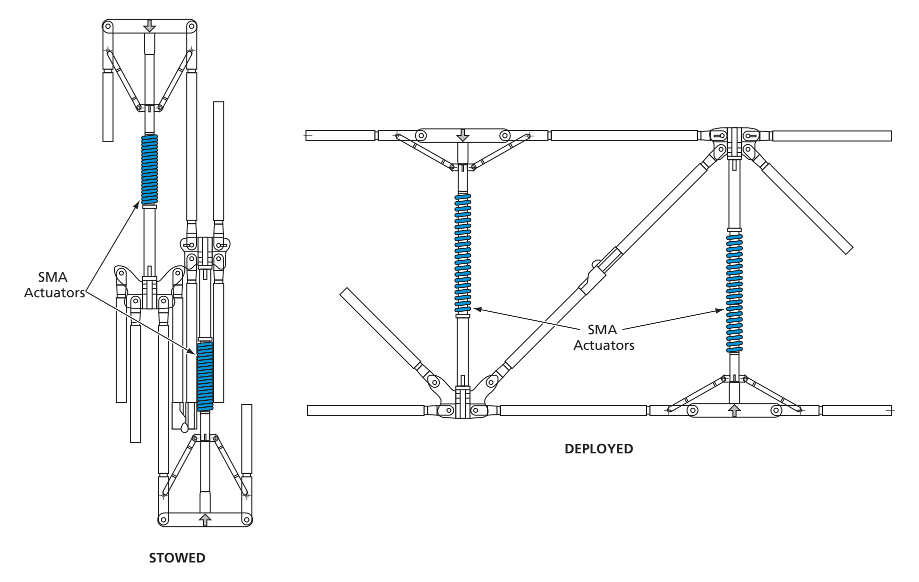

Figure 1. **SMA Coil Actuators** would apply forces to displace jointed members to unfold a truss structure from compact stowage to a fully deployed condition.

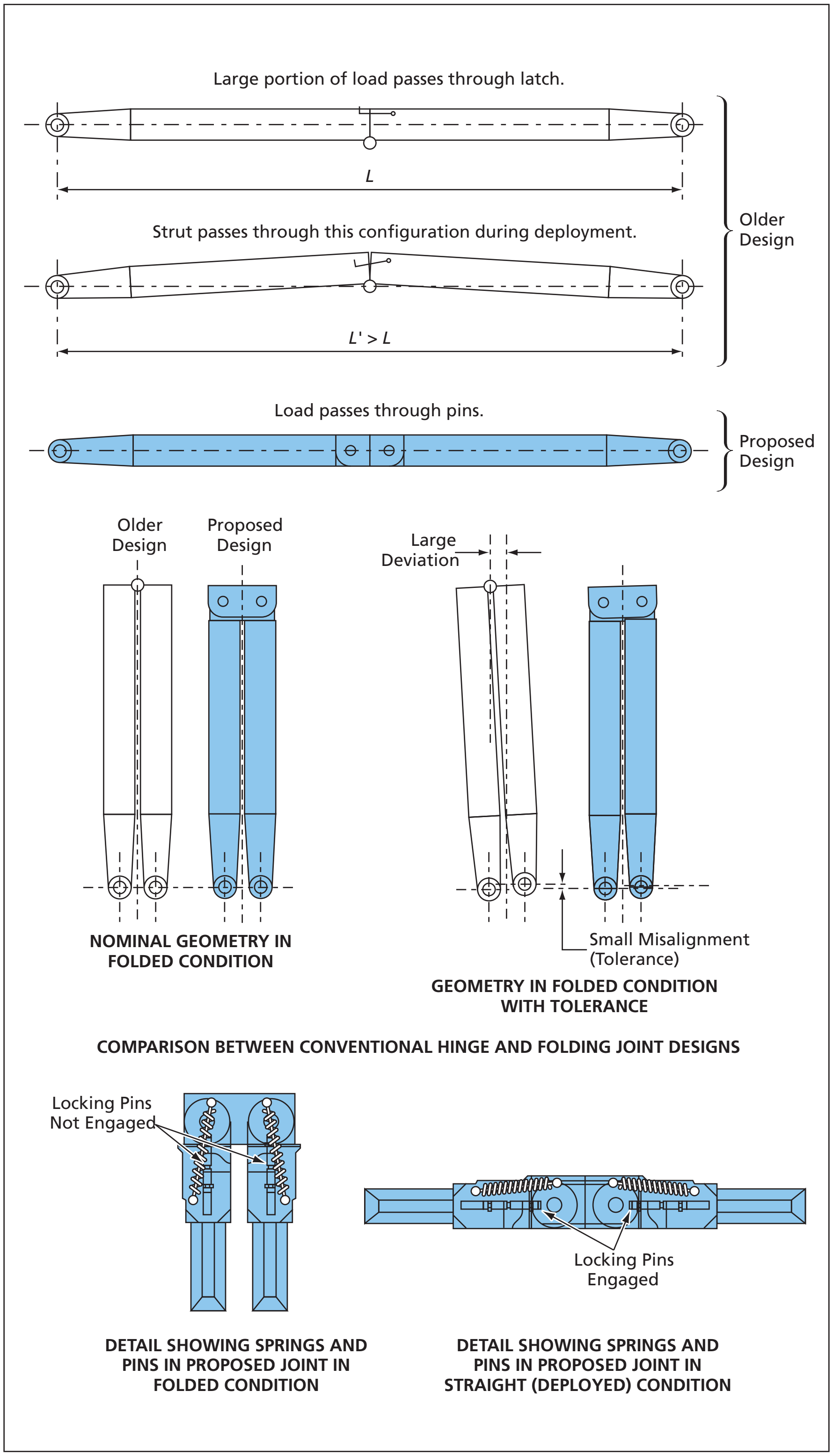

Figure 2. A **Proposed Double-Pivot Joint Design** would offer advantages over an older single-off-center-pivot design.

it is necessary to describe pertinent aspects of a prior design concept that this design concept is intended to supplant. In a typical folding truss structure of prior design, a joint in a folding member includes a pivot located away from the centerline on one side and a latch located away from the centerline on the opposite side (see Figure 2). This entails three disadvantages:

- Much of the load is borne by the latch. If the latch is spring-loaded, then the spring must be designed so that it poses only minimal resistance to unfolding and yet applies a substantial latching preload. At best, it is difficult to satisfy this combination of requirements, and the joint is vulnerable to dislocation during loading.
- The use of only one pivot necessitates adherence to tight tolerances in order to accommodate folding.
- Pivoting about an off-center point necessitates passage of the member through an “over-the-center” condition that may be undesirable.

The present second design concept calls for two pivots, located a short distance apart and nominally located on the centerline when the member is unfolded. In comparison with the single-off-center-pivot arrangement, the two-pivot arrangement could accommodate large misalignment in the folded condition. The joint would include two springs in an “over-the-center” configuration in which they would not apply deployment force while the member remained completely folded but would apply straightening force and torque during the final stages of deployment. Spring-loaded axial latching pins would snap into place at completion of deployment. Thereafter, the two pivots would bear the main axial load, while the latching pins would stabilize the joint against buckling.

This work was done by John W. Renfro of The Boeing Company for Johnson Space Center.. For further information, contact the JSC Innovation Partnerships Office at (281) 483-3809.

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center, (281) 483-1003. Refer to MSC-23848-1/4142-1.