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BREAKTHROUGH IN THE STRUCTURAL DESIGN CONCEPT OF A CNT MEGA-CABLE POTENTIALLY APPLIED IN A SPACE ELEVATOR SYSTEM

Abstract

The single most difficult task in building the Space Elevator is achieving the required tether strength-to-weight ratio, i.e. designing and developing a material that is both strong enough and light enough to support a 100,000 km long mega-cable on which elevator cars can move up and down.

In cooperation with the National Research Fund of Luxembourg the European Spaceward Association has held annually since 2007 International Workshops on Space Elevator and Carbon Nanotube (CNT) Tether Design with leading scientists and engineers discussing latest results of their research work. Consensus has been reached among participating experts that a space elevator can be built only if it will be based on the flaw tolerant design proposed by Pugno, abandoning earlier unrealistic proposals, which ignored the role of defects through intrinsic fracture of the nanotubes and assumed mega-cable strength larger than 100 GPa.

In 2009 Pugno completed the picture considering the complementary failure mode of the cable, that is nanotube sliding. For such a case, he has for the first time analytically calculated that single walled nanotubes with diameters larger than approximately 3nm will self-collapse in the bundle as a consequence of the van der Waals adhesion forces and that the self-collapse can enlarge the cable strength up to 30%. This corresponds to a maximum strength of about 48 GPa, comparable to the thermodynamic limit for intrinsic nanotube fracture.

At least a 10 GPa strong mega cable is practically needed in order to be able to tackle a first space elevator prototype. However the whole endeavour needs a concerted effort as Klettner depicts. There are already many researchers working on individual aspects of the space elevator system but they do not collaborate under a single coordinated framework and an appropriate funding. This provided a flaw tolerant mega cable may be already seen within the next 10 to 20 years. Implications for the design of the space elevator system are an increased taper ratio and a cable mass of two orders of magnitude larger. Even though the payload capacity of the first prototype will be accordingly lower a system of elevators using multiple cables and cars may allow highly profitable operations. Higher expense for the construction will be compensated by a significant decrease in the costs of CNT's due to mass production on a large industrial scale.

The paper presented by the authors will highlight these new findings in detail.