On the existence and properties of solitary waves traveling in tensegrity-like lattices

Julia de Castro Motta[*], Ada Amendola[*] and Fernando Fraternali[*]

[*]*Department of Civil Engineering, University of Salerno, Fisciano (SA), 84084, Italy*

Abstract. Mass-spring chains equipped with tensegrity prisms that feature a locking-type response support the propagation of compression solitary waves under impulsive loading. We carry on an analytical study, analysing the existence and properties of solitary pulses travelling on tensegrity-like lattices, which exhibits an interaction potential similar to that of tensegrity prisms, but easier to handle analytically. Previous literature results were compared to the ones found in this study, revealing a good qualitative matching between the responses of tensegrity and tensegrity-like mass-spring chains. We show that the solitary pulses traveling in such systems tend to assume a peakon-like profile as the wave speed reaches a limit value v_{lim}, which produces the locking of the chain.

Introduction

It is known that 1D mass-spring chains equipped with tensegrity prisms that feature a locking-type response under compression loading (Fig.1(a)) support the propagation of compression solitary waves under impulsive loading [1-3]. This work presents an analytic study on the existence and properties of solitary waves on tensegrity-like lattices. These lattices are formed by a mass-spring chain, in which the nonlinear springs exhibit a tensegrity-like response. The interaction potential of the tensegrity-like lattices is similar to that of tensegrity prisms chains with locking-type response, but more manageable from the analytic point of view. Using Weierstrass theory of one-dimensional Lagrangian systems, it is possible to implicit derive the shape of the pulses traveling through tensegrity-like lattices.

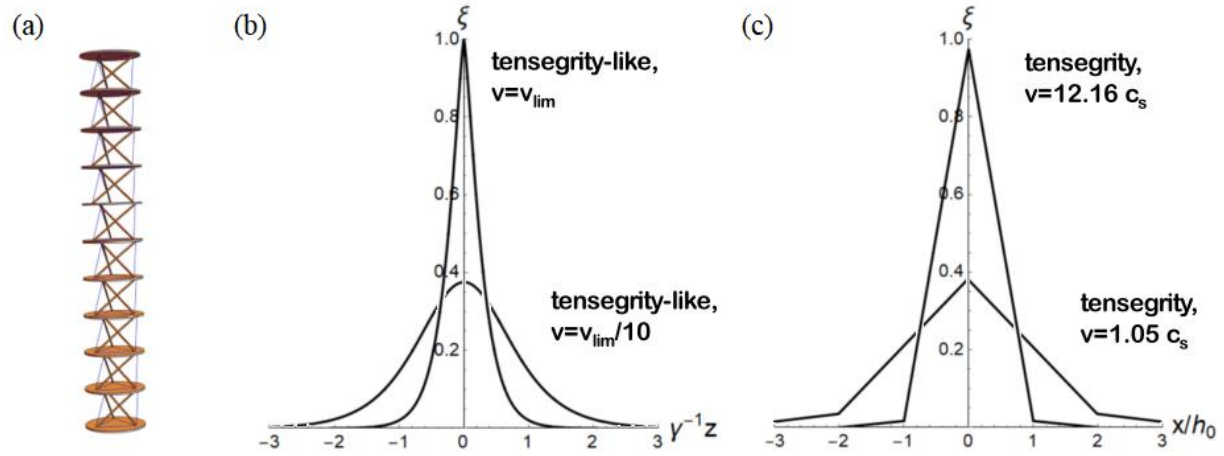

Figure 1: (a) Tensegrity mass-spring chain. (b) Wave profiles for different wave speeds: analytical results of the tensegrity-like lattices. (c) Wave profiles for different wave speeds: obtained numerically for tensegrity chains in [1].

Results and discussion

We show that the solitary pulses traveling in such systems exist. Moreover, we show that their shapes depend on the wave speed and tend to assume a peakon-like profile as the wave speed reaches a limit value v_{lim}, which produces the locking of the chain (Fig.1(b)). A comparative analysis with previous literature results was carried on (Fig.1(c)) revealing a good qualitative matching between the responses of tensegrity and tensegrity-like mass-spring chains, as both exhibit the localization behaviour as the wave speed is increased. This behavior can be applied on the design of mechanical metamaterials with wave-focusing capabilities, as well as new actuators/sensors for damage detection by the generation of stress waves. Furthermore, the stability of the solitary wave solutions obtained in this work can be investigated.

References

[1] F. Fraternali, L. Senatore, C. Daraio, (2012) Solitary waves on tensegrity lattices. *J. Mech. Phys. Solids* **60** 1137-1144.

[2] F. Fraternali, G. Carpentieri, A. Amendola, R.E. Skelton, V.F. Nesterenko, (2014) Multi- scale tunability of solitary wave dynamics in tensegrity metamaterials. *Appl. Phys. Lett.* **105** 201903.

[3] A. Micheletti, G. Ruscica, F. Fraternali, (2019) On the compact wave dynamics of tensegrity beams in multiple dimensions. *Nonlinear Dyn.* **98** 2737-2753.