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Energy Content and Spectral Energy Representation of Wave Propagation in a Granular Chain

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Abstract : A mechanical wave is propagation of vibration with transfer of energy and momentum. Studying the energy as well as spectral energy characteristics of a propagating wave through disordered granular media can assist in understanding the overall properties of wave propagation through inhomogeneous materials like soil. The study of these properties is aimed at modeling wave propagation for oil, mineral or gas exploration (seismic prospecting) or non-destructive testing for the study of internal structure of solids. The study of Energy content (Kinetic, Potential and Total Energy) of a pulse propagating through an idealized one-dimensional discrete particle system like a mass disordered granular chain can assist in understanding the energy attenuation due to disorder as a function of propagation distance. The spectral analysis of the energy signal can assist in understanding dispersion as well as attenuation due to scattering in different frequencies (scattering attenuation). The selection of one-dimensional granular chain also helps in studying only the P-wave attributes of the wave and removing the influence of shear or rotational waves. Granular chains with different mass distributions have been studied, by randomly selecting masses from normal, binary and uniform distributions and the standard deviation of the distribution is considered as the disorder parameter, higher standard deviation means higher disorder and lower standard deviation means lower disorder. For obtaining macroscopic/continuum properties, ensemble averaging has been used. Interpreting information from a Total Energy signal turned out to be much easier in comparison to displacement, velocity or acceleration signals of the wave, hence, indicating a better analysis method for wave propagation through granular materials. Increasing disorder leads to faster attenuation of the signal and decreases the Energy of higher frequency signals transmitted, but at the same time the energy of spatially localized high frequencies also increases. An ordered granular chain exhibits ballistic propagation of energy whereas, a disordered granular chain exhibits diffusive like propagation, which eventually becomes localized at long periods of time.

Keywords : discrete elements, energy attenuation, mass disorder, granular chain, spectral energy, wave propagation
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