Reflection phenomena and nonlocal effect on phase velocity of plane wave in an initially stressed triclinic half space at stress free boundary interface

Deepak kumar [1a]

[1] Guru Ghasidas Vishwavidyalaya Bilaspur, Chhattisgarh-495009, India

[@] Corresponding author: deepakkumarggu@gmail.com

Abstract: The study investigates how the nonlocal parameter influences the phase velocity and reflection phenomena of different waves (qP, qSV, qSH) at the stress-free boundary of a stressed triclinic medium. Results show that reflection coefficients depend on incidence angle and elastic constants. Nonlocality parameters indirectly affect reflection coefficients via phase velocities. Numerical computation and graphs are presented using Vosges sandstone as the triclinic medium.

Keywords. Reflection coefficients; initial stress; triclinic half-space; quasi-longitudinal (qP), quasi-transverse (qSV and qSH); energy ratios.

1. INTRODUCTION

The study of elastic wave propagation and reflection phenomena from such discontinuous boundary surfaces in elastic materials has been an ongoing area of interest for researchers. Various researchers, such as Crampin and Taylor [1], Norris [2], and others, have contributed to this field. In the early 2000s, the classical linear anisotropic elastic theory was extended to include different boundary interfaces and initial stresses by Chattopadhyay and Rogerson [3], Chattopadhyay et al. [4], Recent studies by Chatterjee et al. [5] have explored reflections in highly anisotropic media for three-dimensional plane waves under initial stresses. A significant factor influencing wave propagation in triclinic materials is the role of nonlocal effects. Nonlocal phenomena occur when a material's response at a particular point depends not only on local conditions but also on its surroundings. The theory of nonlocal elasticity originated from the work of A. C. Eringen [6] and was further investigated by Edelen and Laws [7]. It highlights the importance of a nonlocal parameter that is absent in classical local field theories. Eringen and Edelen [8] significantly contributed to the development of this theory by presenting their own version of nonlocal elasticity and deriving the corresponding constitutive equations. Researchers have shown a keen interest in studying wave propagation in nonlocal elastic solids because the results can be used to predict nonlocal parameters and mechanical properties of anisotropic materials. In various scientific fields, the study of the reflection of plane waves at a stress-free boundary in anisotropic media holds significant importance due to its practical applications in areas such as geophysics, engineering, and others. Researchers have explored several problems concerning wave reflection from stress-free boundaries. Notable contributions in the realm of nonlocal theories have been made by researchers like Eringen, Chakraborty, and Gopalakrishnan, among others, as documented in papers [9, 10]. In recent study, Chakraborty [11] investigated the propagation of waves in anisotropic media using non-local elasticity.

In this study, we examined nonlocal parameter impact on phase velocity & reflection phenomena of qP, qSV, and qSH waves at stress-free boundary of stressed triclinic lower half-space. Derived closed form of phase velocity, obtained reflection coefficients. Found reflection coefficients dependent on incidence angle & elastic constants. Verified energy balance during reflection. Numerical calculations & graph presented in presence of initial stress & nonlocal parameters revealed valuable insights.

2. Mathematical formulation and geometry of the problem

we considered an initially stressed triclinic half-space. A two-dimensional incident qP wave strikes the interface of the free boundary, resulting in the generation of three waves: qP, qSV, and qSH-waves. We adopted a rectangular coordinate system (x, y, z) wherein the z-axis points downward vertically within the half-space (as illustrated in Fig. 1).

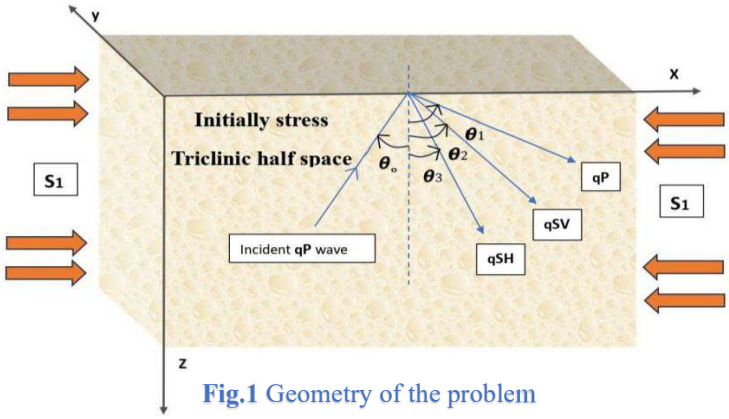

Fig.1 Geometry of the problem

3. Discussion and Conclusions

It concluded that:

- The coefficients of equations giving the amplitude ratios are not involving nonlocality parameters explicitly, but it is occurring through the speeds of various existing waves in the media.
- The reflection coefficients of qP, qSV, and qSH waves depend on the angle of incidence and the elastic constants of the triclinic medium
- To ensure the accuracy of the results we verified energy conservation, the energy balance at the interface is rigorously examined. This step confirms that the incident energy is equal to the sum of energies carried by the reflected waves.
- The nonlocality parameters indirectly affect the reflection coefficients through the phase velocities of the waves in the lower half-space.

Numerical computations and graphs are presented for various scenarios, considering the presence of initial stress values and nonlocal parameters values. For computing process, we used elastic constants from Vosges sandstone as a triclinic medium.

4. References

1. Crampin, S., & Taylor, D. B. (1971). The propagation of surface waves in anisotropic media. Geophysical Journal International, 25(1-3), 71-87.
2. Norris, A. N. (1983). Propagation of plane waves in a pre-stressed elastic medium. The Journal of the Acoustical Society of America, 74(5), 1642-1643.
3. Chattopadhyay, A., & Rogerson, G. A. (2001). Wave reflection in slightly compressible, finitely deformed elastic media. Archive of Applied Mechanics, 71, 307-316.
4. Chattopadhyay, A., Venkateswarlu, R. L. K., & Saha, S. (2002). Reflection of quasi-P and quasi-SV waves at the free and rigid boundaries of a fibre-reinforced medium. Sadhana, 27, 613-630.
5. Chatterjee, M., Dhua, S., Sahu, S. A., & Chattopadhyay, A. (2014). Reflection in a highly anisotropic medium for three-dimensional plane waves under initial stresses. International Journal of Engineering Science, 85, 136-149.
6. Eringen, A. C., & Edelen, D. (1972). On nonlocal elasticity. International journal of engineering science, 10(3), 233-248.
7. Edelen, D. G. B., Green, A. E., & Laws, N. (1971). Nonlocal continuum mechanics. Archive for Rational Mechanics and Analysis, 43, 36-44.
8. Eringen, A. C. (1972). Nonlocal polar elastic continua. International journal of engineering science, 10(1), 1-16.
9. Eringen, A. C. (1977). Screw dislocation in non-local elasticity. Journal of Physics D: Applied Physics, 10(5),671.
10. Chakraborty, A., & Gopalakrishnan, S. (2005). A spectrally formulated plate element for wave propagation analysis in anisotropic material. Computer Methods in Applied Mechanics and Engineering, 194(42-44), 4425-4446.
11. Chakraborty, A. (2007). Wave propagation in anisotropic media with non-local elasticity. International journal of solids and structures, 44(17), 5723-5741.