Wave Propagation at the Interface of an Orthotropic Micro polar Solid Half-and Liquid Half-Space

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DOI:graph.ijareas.38749.3982

Abstract: We investigate an orthotropic micro polar solid half-space in welding contact with an in viscid liquid half-space. Equations regulating an orthotropic solid half-space and a liquid half-space have appropriate plane vocal solutions found. In order to derive aorganization of 4 nonhomogeneous equations in fullness ratios for the occurrence quasi-longitudinal dislocation wave, these solutions meet the necessary boundary circumstances at the boundary. The numerical computation of the fullness ratios of different reproduced and diverted waves is done for a specific instance of the current model. Anisotropy's impact on these amplitude ratios is illustrated visually for a specific set of incidence angles.

Keywords: Elastic Solid, Wave Propagation

1 Introduction

The movements of a material's internal structures greatly influence how it reacts to external stimuli. This impact is excluded from classical elasticity, which only takes the paraphrase degrees of autonomy of the material fact of figure into account. The intrinsic microstructure rotations were incorporated into the linear micro polar theory of elasticity, which was created by Eringen. It offers a model that exhibits the high frequency visual branch of the upsurgeband and supports body and surface couplings. It can simulate industrial materials including liquid crystals, elastic solids with rigid granular inclusions, and composites containing stiff chopped fibers for use in engineering applications. Sharma (2007) used the LS and BiotPoro-elasticity philosophies to create a philosophyon behalf of a thermally leading, isotropic permeable material soaking with a solitaryunsolidified. The S upsurge is not affected by current properties, while the dualunhurriedWVirregularlydisplay diffusive behavior that be contingent on incidence, viscosity, and TE constants. Lewis (1990, 2004) tooThomsas (2007) examined a variety of warmness and mass transport problems using the finite division method.

With the help of various instances and aerobics, Nithiarasu (2016) showed the philosophies of the determinate element tacticon behalf ofhotness and mass show. The outcome of gyration on the replication of magneto-thermo EW underneath thermo elasticity deprived ofoomph dissipation stayed studied by Othman (2007).

The replication of smoothrollers at the stress-free external of an elastic material beneathpreliminary hydrostatic straindeprived of energy indulgence was studied by Othman and Song in 2007.

Abd (2016) looked into the echo of planar choralWVafter a semi-infinite adaptablesolid in the nonattendance of a charming field. Othman (2015) used regular mode investigation to reconnoiter the bearings of turning and initial tension with binarymalaises on a general thermo EM beneath three concepts, as fit as the EC ofturning and openingtrauma on physical extents.

In the background of a 3 stage lag perfect, Othman (2019) examined the EC of gravity, binaryfever variables, fibersupport, and stretch on aamount of thermo-physical limits. By the rotating consequence and Green-Naghdiphilosophy, Jahangir deliberates the likenessmarvels on updraftEM (2021a). Using the Abbas (2020) looked at how point lags affected thermo-mechanical relations in PM.

Shoran (2020) studied the broadcast of evenWV in a spinning thermo elastic diffusive medium by micro-concentrations besidesdualinfections in anfirstly strained circlingTEDM.

USRPTE solid

The coexistence of sponginess and TE is mutual in greatest industrial developments. The WVspread phenomenon is vital to the nondestructive appraisal (NDE) of compoundresources and assemblies. These elements are typically created in the crustal and tankpillars of the earth. US are a three-phase PM that typically consists of a hard frame, a fluid phase, besides a gas point. It is also referred to as an USRabsorbentadaptableaverage (US). The porous averagephilosophy and the declaration of TE were used by Zhou (2018) to suggest the subsequent constitutive relations of an USRPM.

$$Z_{ij} = \left[\bar{\gamma} u^{s}{}_{kk} + A_1 u^{1}{}_{kk} + A_2 u^{g}{}_{kk} + A_3 T\right]\delta_{ij} + \mu\left(u^{s}{}_{ij} + u^{5}{}_{j,i}\right), \quad (1)$$

$$-P_0 = D_1 u^s{}_{k,k} + D_2 u^1{}_{k,k} + D_3 u^g{}_{k,k} + D_4 T, \text{(2)}$$

$$-P_1 = D_5 u^s{}_{k,k} + D_6 u^1{}_{k,k} + D_7 u^g{}_{k,k} + D_8 T, \text{(3)}$$

Kroneckersign δ_{ij} is devoted to someplace, superscript cultures I, s, besides g, individually, stand on behalf offluid, rock-hard, and gas points. σ_{ij} Regulates the hard point's tautness,Displays $P_1 P_0$ the heavinessamid the pores aimed at air or fluid,theintermediatedisease is shownthrough T. The$\mu_i^s \mu_i^j \mu_i^i$ aresingly, control the essentials of fluid, dense, besides gas-particle translations.

The DE for thermo adaptable particle tendency in USRPTE middleis as trails:

$$Z_{ij,j} = pu_i^s + p^1 u_i^l + p^g u_i^g, \quad (4)$$

$$P_{0,i} = J^e u_i^s + V^e u_i^l + V^r u_i^1, \quad (5)$$

$$P_{1,i} = J_g u_i^s + V_g u_i^g + v_g u_i^g, \quad (6)$$

$$B_1\left(u_{ij}^s + t_q u_{ij}^s\right) + B_2\left(u_{ij}^l + t_q u_{ij}^l\right) + B_3\left(u_{ij}^g + t_q u_{ij}^g\right) + B_4\left(T + t_q T\right) = K\left[T_{jj} + t\phi T_{jj}\right], \text{(7)}$$

The WVcalculationson behalf ofUSRPTE television in distances of shiftcoursesul, us, and ug and infection T are providing as shadows.

$$\left(\mu + \bar{\lambda}\right)\nabla\left[\nabla . u^s\right] + \mu \nabla^2 u^s + A_1 \nabla\left[\nabla . u^l\right] + A_2 \nabla\left[\nabla . u^g\right] + A_3 \nabla T = pu^s + p^1 u^1 + p^g u^g, \text{(8)}$$

$$D_1 \nabla\left[\nabla . u^s\right] + D_2 \nabla\left[\nabla . u^;\right] + D_3 \nabla\left[\nabla . u^g\right] + D_4 \nabla T = p^t u^s + v^t u^l + v^t u^l, \quad (9)$$

$$D_5 \nabla\left[\nabla . u^s\right] + D_6 \nabla\left[\nabla . u^l\right] + D_7 \nabla\left[\nabla . u^g\right] + D_8 \nabla T = p^g u^s + v^g u^g + v^g u^g, \text{(10)}$$

$$B_1 \nabla\left[\ddot{u}^s + \tau_q \ddot{u}^s\right] + B_2 \nabla\left[\dot{u}^1 + \tau_q \ddot{u}^l\right] + B_3 \nabla\left[\ddot{u}^g + \tau_q \dot{u}^g\right] + B_4\left[\dot{T} + \tau_q \ddot{T}\right] = K\left[\nabla^2 T + \tau\theta \nabla^2 \dot{T}\right] \text{(11)}$$

Elastic Solid

The sectorialintentions of emblemon behalf of the constantES stance as [Kumar (2020)]

$$\left(\lambda_e + \mu_e\right)\nabla\nabla . u_e + \mu_e \nabla . \nabla u_e = p_e \ddot{u}_e, \text{(12)}$$

Somewhere λ_e besides μ_e are elasticunit of the elastic solid similarly, $\mathbf{u}_e p_e$ are the unchangeable elastic item'scrusadetrajectoryarena and framedepth.

WV propagation

Resultinginterruption theorem, displacementroutes are defined as surveys:

$$\nabla . \psi^i = 0, \text{(13)}$$

Wherever ϕ^{i} plus ψ^{i} stated the aptitudes of dilatational also shear surfs, separately. We banquetbinary sets of estimates when we superfluouscalculation (13) into estimates (8) – (11): one meant at compressional WVskills and the extra for slopingupsurgeabilities. Equal to the state of partially inundatedTPE mediaupstairs, injecting the face vectorobsessed byreckoning (12) harvests a customary of 2 equations: one meant at compressional increase potential (ϕ_e)then the additionalaimed atslopingWVpotential(ψ_e), definiteby:

$$\left(\nabla^2 + \omega^2 V_\beta^{-2}\right)\psi_e = 0, \text{(14)}$$

These stand well-known gainreckoningsexpected at compressional plustiltedWVwandering in an ES via phase timekeeping V_α *and* V_β, discretely.

Boundary conditions

These remain the foods for the limit at even z= 0.

$$(\tau_e)_{zx} = \sigma_{zx,}\ \dot{u}_x^s = \dot{u}_x^e, \text{ T=(15)}$$

Displacements

Languages of the wide-rangingmachineries of the k-phase disarticulation in the $x-$and $z-$information in an USR thermoplastic typicalissurein Kumar (2020):

$$u_x^s = \sum_{i=1}^{4}\frac{\partial\phi_i}{\partial\chi} + \frac{\partial\phi_5}{\partial z},\ u_z^s = \sum_{i=1}^{4}\frac{\partial\phi_i}{\partial z} - \frac{\partial\phi_5}{\partial x},\ u_x^l = \sum_{i=1}^{4}vi\frac{\partial\phi_i}{\partial x} + v5\frac{\partial\phi_5}{\partial z},$$

$$u_z^l = \sum_{i=1}^{4}vi\frac{\partial\phi_i}{\partial z} + v5\frac{\partial\phi_5}{\partial x}, \qquad (16)$$

$$u_x^g = \sum_{i=1}^{4}\mu i\frac{\partial\phi_i}{\partial x} + \mu 5\frac{\partial\phi_5}{\partial z},\ u_z^g = \sum_{i=1}^{4}\mu i\frac{\partial\phi_i}{\partial z} + \mu 5\frac{\partial\phi_5}{\partial x},$$

Where,

$$v_j = \frac{\bar{b}_0 - \bar{b}_1 V_j^2 + \bar{b}_2 V_j^4}{\bar{a}_0 - \overline{a_1 V_j^2} + \overline{a_2 V_j^4}},\ \mu_j = \frac{\bar{c}_0 - \bar{c}_1 V_j^2 + \bar{c}_2 V_j^4}{\bar{a}_0 - \overline{a_1 V_j^2} + \overline{a_2 V_j^4}},$$

$$v5 = \frac{p^1}{\overline{\overline{p^1}}},\ \mu_5 = -\frac{p^g}{\overline{\overline{p^g}}}$$

On the additional hand, the generalmachineries of shift in a standardizedadjustable solid HS inthe $x-$and $z-$instructions can be established as darks.

$$u_x^e = \frac{\partial \phi_e}{\partial x} - \frac{\partial \psi_e}{\partial z},$$

$$u_z^e = \frac{\partial \phi_e}{\partial z} - \frac{\partial \psi_e}{\partial x}, \qquad (17)$$

Reflection coefficients

The next equations characterize the abilities of the manyoccurrence and RW in the ES HS:

$$\phi_e = A_o^e e\left[\tau\omega\left\{\left(\frac{\sin\theta_0}{V\alpha}x + \frac{\cos\theta_0}{V\alpha}z\right) - t\right\}\right] + A_1^e e\tau\omega\left[\tau\omega\left\{\left(\frac{\sin\theta_1}{V\alpha}x - \frac{\cos\theta_1}{V\alpha}z\right) - t\right\}\right], (18)$$

$$\psi_e = B_o^e e\left[\tau\omega\left\{\left(\frac{\sin\theta_0}{V\beta}x + \frac{\cos\theta_0}{V\beta}z\right) - t\right\}\right] + B_1^e e\tau\omega\left[\tau\omega\left\{\left(\frac{\sin\theta_2}{V\beta}x - \frac{\cos\theta_2}{V\beta}z\right) - t\right\}\right], (19)$$

The bounties of the occasion*P* (or *SV*), echoed*P* and echoed*SVW* are described by the coefficients $A_o^e\left(B_o^e\right)$, A_1^e, B_1^e, separately.

Following Orchard (1982), the abilities of the diversedeflectedWVcitedupstairs in the incompletelysoakedPTE slid half- interplanetary dismiss be spoken equally:

$$\phi_j = A_j^s \exp(A_j.r).\exp\{i(P, r - \omega t)\}, (j = 1,2,3,4,5), \ (20)$$

Everywhere $A_j^s, (j = 1,2,3,4,5)$, suggests the set, P_1, P_2, P_3, $T_p$plus SV surges'bounties, similarly. The spread and attenuation courses of 5divertedWV are labeled as surveys:

$$P_j = k_R\hat{x} + d_{jR}\hat{z}, \ A_j = -k_I\hat{x} - d_{jI}\hat{z}, \ (21)$$

Everyplace, subscripts *I (R)* recognized the fantasy (real) portion of owncompound values and

$$d_j = p.v\left[\left(\frac{\omega}{V_j}\right)^2 - k^2\right]^{1/2}, (j = 1,2,3,4), \qquad (22)$$

*p.v.*agrees the majorworth of the multilayered value futureafter the right-angled root, $V_j$symbolizes the amount of the bentj^{th}WV. $k_R \geq 0$ promiseswaveproliferationlaterallyaffirmative x-direction. Future for γ_j (angle betwixt cutand movement vectors) besides (angle of diversion) in USR TPE usual, k is selected as roads

$$k = |P_j|\sin\theta_j - \tau|A_j|\sin(\theta_j - \gamma_j). \quad (23)$$

To please the enduranceprinciple at interface z=0, the WVquantity must be the identical on in cooperationedges of the boundary. But, the unvaryingES is not dissipative;then the WV number is real. Snell's regulationdesigned on behalf of the RARunruly is so as tracks in this instance:

$$k_R = \frac{\omega \sin\theta_0}{V_0} = \frac{\omega \sin\theta_1}{V\alpha} = \frac{\omega \sin\theta_2}{V\beta}. \quad (24)$$

And

$$k_j = 0 \quad (25)$$

By with the earlierlabeledcapacities into the bordersituations and put on Snell's law, we makeanarrangement of 7 IHG equations by7 unknowns on paper as a matrix.

$$\sum_{j=1}^{7} c_{tj} Z_j = h_l, (l = 1,\ldots,7). \quad (26)$$

The resemblance $(l = 1, 2)$ and set $(l = 3,\ldots..7)$ facts of WVabout the incidenceWV are representedthru Z_l in the system as specifiedupstairs of calculations:Latercalculations (22) moreover (24),

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$$\frac{k_R}{\omega} = \frac{\sin\theta_0}{V_0}, \frac{d_\alpha}{\omega} = \left(\frac{1}{V_\alpha^2} - \frac{\sin\theta^2}{V_0^2}\right)^{1/2},$$

$$\frac{d_\beta}{\omega} = \left(\frac{1}{V_\beta^2} - \frac{\sin\theta_0^2}{V_0^2}\right)^{1/2} and\, \frac{d_j}{\omega} = p.v.\left(\frac{1}{V_j^2} - \frac{\sin\theta_0^2}{V_0^2}\right)^{1/2}, (j = 1,2,3,4,5).$$

To get the falling-offailment in USRTPErock-hard, *p.v.* isscrutinizedthrough the curb*djI*≥ 0. In the organization, comparison (26), the quantities*bi* *(i*=1,2,.....7) remainpigeonholed as obscurities, The realvigorhandover per componentsuperficialzoneapiecemoduleperiod is specifiedthru<P^*>, which is the consecutivenormal of P^*finishedanold-fashioned. Thus, the usualget-up-and-goassets of WV in aflexiblerock-hard on aexternalbystandardend-to-end the z-direction are articulated by:

$$\langle P_e^* \rangle = \langle \tau_e \rangle_{xz} u_{ex} + \langle \tau_e \rangle_{zz} u_{ez}. \quad (27)$$

Intended atseconduninformedcomplexroles*g*before*f*, we guarantee $\langle \Re(f).\Re(g)\rangle = \frac{1}{2}\Re(f.\overline{g})$. This designcalculatesget-up-and-gostocks, which indicate the normaldegree of vigorshowafterRARbreakers in alignment to happeningbreakers.The livelinessstocks $E_l(l=1,2)$ on behalf ofreplicated*P* and simulated*SVW* are expressed as traces.

$$E_l = \frac{\langle P_{ei}^{*}\rangle}{P_{e0}^{*}}, \qquad (i=1.2), \qquad (28)$$

Where

$$\langle P_{e0}^{*}\rangle = p_e\omega^4\Re\left(\frac{\cos\theta_0}{V_0}\right),$$

$$\langle P_{e1}^{*}\rangle = p_e\omega^4|Z_1|^2\Re\left(\sqrt{\frac{1}{\sqrt{2}_\alpha} - \frac{\sin\theta_0^2}{V_0^2}}\right),$$

$$\langle P_{e2}^{*}\rangle = p_e\omega^4|Z_2|^2\Re\left(\sqrt{\frac{1}{\sqrt{2}_\beta} - \frac{\sin\theta_0^2}{V_0^2}}\right).$$

Major, respectively, the get-up-and-gostrengths of the occasionWV, the imitatedPW, and the echoedSVW

The subsequentreckoningsexplain the vitalityparts of RW on behalf of partially inundatedPTE solids:

$$\langle P_{ij}^{*}\rangle = \Re\left[\sigma_{xz}^{(i)}\right]\Re\left[\left(u_x^s\right)^{(j)}\right] + \Re\left[\sigma_{zz}^{(i)}\right]\Re\left[\left(u_z^s\right)^{(j)}\right] + \Re\left[-P_l^{(i)}\right]\Re\left[\left(u_z^l\right)^{(j)}\right]$$
$$+\Re\left[-P_g^{(i)}\right]\Re\left[\left(u_z^g\right)^{(j)}\right] \qquad (29)$$

The subsequentplan is rummage-sale to fix how abundantdynamism is circulatedbetween the 5whitecaps as they livelinesssecret the moderatelywetPTE factual:

$$E_{lm} = -\frac{\langle P_{lm}^{*}\rangle}{\langle P_{e0}^{*}\rangle}, (l,m=1,\ldots.,5), \qquad (30)$$

The RW's energy ratios to the incident WV are represented by the diagonal elements in equation (30). The remaining elements depict the intense interactions among the RW. The relationships among the total interaction energy (E_I) and bulk energy (E_T) measured at the welding contact amongIHG ES and USRPMis as follows:

$$E_1 = \sum_{i=1}^{5}\left(\sum_{j=1}^{5} E_{ij} - E_{ii}\right), \quad (31)$$

$$E_T = E_1 + E_2 + E_1 + \sum_{i=1}^{5} E_{ii} = 1. \quad (32)$$

The fulllivelinesspercentagewouldlikeunion in harmonyper equation (32), which demonstrates the law of get-up-and-gosafeguarding.

2. Results

The huge figure of strictures included in the investigativeperfectadvanced in the previous segment makes it practically difficult to realize the outcome of bothparameters on WVcomportment at the edge of the binary media.

The suggestion of a numerical study to ascertain the impact of important model parameters is therefore helpful. To demonstrate the hypothetical conclusions established in this exertion, we donemathematical simulations using MATLAB, which were subsequently followed by graphical presentations. T1 Table 1 presents the study's medium parameters. As can be shown from Table 1, this endeavor is being rummaged-sale by a thermally primaryUSRleakycompact (Zhou 2019).

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p_e=2460 kg/m^3,

$\mu_e = 5GPa, \lambda_e = 12GPa$

F1 The hustles and decreases of IHGP_3,P_2, P_1, $T_p$plusSVW endured reachable in Table.1 of Kumar (2014). In Table. 1, we resolve be reviewing the impact of updraftevolutionnumber β_T throughteventcourse (θ_0) on the isolating of occurrencesparkleamiddifferentRARWV. Table. 1 photographs that evolution in β_T clues to anintensification in the goportion of abstracted*P1W* and a falling in the lifepart of detouredP_2 P_3Won behalf of $\theta_0 \in (0,90^{\circ})$.But, around are metamorphoses in the warmth of RW and detoured*SVW* to β_T variants. Where, on behalf of the reflected *SVW* and setP_3,P_2, $T_p$breakers, we essential the maximumdifferencesthroughreverence to anadjustment in β_T and expected at the echoed*P_1*, propensity and diverted*P_1*, *SV,*breakers the distinctions are honestlyaddednegligible.

Created on Table. 1, it can similarlyrealize that the carriage of emulated (detoured) compressional (clip) undertaking is not absoluterefluctuationsin β_T. In inference, this designtinimagine that the updraftenlargementpersistentshow business a vital idol in segmentingepisodedynamismmiddiverseWV at the renovatedline of dualmass radio.

Table 1: Thermo physical parameters of unsaturated PTE medium

Parameter	V	Parameter	V
$\lambda(kPa)$	9 x 10^6	$\mu(kPa)$	4 x 10^6
K_s(kPa)	3.5 x 10^7	P_g(kPa)	101.3
P^g(kg/m^3)	1.3	k(m^2)	1 x 10^{-11}
$\tau_\theta(S)$	1.5 x 10^{-7}	$\tau_q(s)$	20 x 10^{-7}
$\beta_{wp}\left(P_a^{-1}\right)$	4.58 x 10^{-10}	$x\left(Pa^{-1}\right)$	0.0001
$\beta_{st}\left(K^{-1}\right)$	7.80 x 10^{-6}	$B_{wT}\left(K^{-1}\right)$	2.10 x 10^{-4}
$\beta_\psi\left(K^{-1}\right)$	2.09 x 10^{-3}	$B_T\left(K^{-1}\right)$	1.0 x 10^{-4}
$C_s(J/kg/K)$	1000	$c_T(J/kg/K)$	4180
$T_o(K)$	300	$T(K)$	293.2
n	0.4	M	0.5
S^l	1.0	S^l	0.05
d^{sat}	2	S^{res}	0.6

3. Conclusions

Increasingly doyens and professors are cramming the effects of malaise and warmness on various aspects of geotechnical industrial. In order to comprehend the connecter impact amongadaptabletwist and infection change, we need therefore looked at the RARfeatures at the boundary of ES and USR PTE rock-hardunderneath the current problematic of non-isothermal locations. Numerous academics and practitioners in a range of business and fundamental knowledge fields, including seismic industrial, astronomy, precise seismology, besides life skills, run into issues that necessitate an understanding of EW. Exploration geophysics routinely makes use of data that has been reflected or refracted to calculate liquid fullness, permeability, absorbency, and other substantial properties.Hence, with these considerations in mind, we put forward this challenge. We needexplored the EC of runnycapacity, porousness, penetrability, factors of updraft expansion, and WVincidence on the RARWV in this issue. The distribution of occasionoomphamong refracted and RW was tentatively and quantitatively added. It is crucial to accurately measure WVlivelinesspanel at the boundary of dual different radio in command to fully appreciateWVbroadcast in USRmixed rocks (i.e., unique is an ES then the additional is an USR PTE hard).This educationadvises that we sensibly consider the properties of penetrability, absorbency, water overload level, WVincidence, and ray track on the faces of various WV' proliferation.

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