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# DEVELOPMENT OF THEORETICAL DISPERSION CURVES AND COMPARISON WITH MULTICHANNEL ANALYSIS OF SURFACE WAVES (MASW)

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ABSTRACT

Multichannel Analysis of Surface Wave (MASW) technique, which is based on measurement of Raleigh waves, has been used to determine soil dynamic properties and shear wave velocities. In MASW shear wave velocity profiles are obtained based on Raleigh wave dispersion curves. In this paper an attempt has been made to develop the theoretical dispersion curve based on wave propagation in soils. The theoretical dispersion curves are developed based on Newtonian mechanics for layer medium and has been programmed using MATLAB. Soil is assumed to be homogenous and isotropic in each layer. These layers are assumed to be lying over a semi-infinite, homogenous, isotropic layer. Soil is assumed to be elastic and thus the strain produced by these elastic waves (Raleigh Waves) is also within elastic limits. This model gives the dispersion curve for Raleigh waves for any layered medium, given the parameters of each layer. The parameters include the shear modulus, Poison's ratio, density, and thickness of each layer. Shear Modulus, Poison's ratio, density, and thickness of different layers are measured by conducting geotechnical investigations and at the same location MASW tests (1D and 2D) survey have been carried out. Developed dispersion curves of layered medium using MATLAB matches well with field test results obtained from MASW. The theoretical development for the obtaining dispersion curves and details of field tests and comparison of results are presented in the paper.

Keywords: Dispersion curve, Raleigh Wave, MASW.

## INTRODUCTION

Raleigh Waves (Raleighs and Lard, 1885) propagate on earth surface with their energy concentrated at depths proportional to their wavelengths. Higher wavelengths penetrate deeper than lower ones. Thus, if soil properties vary with depth, different wavelengths travel with different velocities resulting in dispersion (Krammer, 1996). Dispersion of Raleigh Waves in multi layered media is the key fact implemented in Multi Channel Analysis of Surface Waves (MASW) (Park et al, 1998, 1999, 2001). A geophysical method (Park et. al, 1999; Xia et. al, 1999; Miller et. al, 1999) characterized by collection of ground roll arrival data at multiple receiver stations which further is processed (Ivanov et. al, 2001) to obtain the experimental dispersion curve. On inversion (Xia et al 2000; Valentina et al 2002), near surface dynamic soil parameters are obtained. MASW being non-destructive, time saving and handy is gaining momentum in its applications an microzonation and site response studies. Propagation of Raleigh Waves in multi layered media is studied and programmed in MATLAB to obtain theoretical dispersion curve given Shear Modulus, Poison's Ratio, Density and Thickness of each layer. SPT data at the selected study area is used to obtain the theoretical dispersion curves which are then compared with experimental curves from MASW.

## THEORETICAL MODEL FOR DISPERSION CURVE

Any wave propagating in a 3D elastic isotropic and homogenous solid is governed by the differential equations, (Richart et al., 1970)

$$\rho\frac{\partial^2 u}{\partial t^2}=(\lambda+\mu)\frac{\partial\bar{\varepsilon}}{\partial x}+\mu\nabla^2 u\,;\ \rho\frac{\partial^2 v}{\partial t^2}=(\lambda+\mu)\frac{\partial\bar{\varepsilon}}{\partial y}+\mu\nabla^2 v\,;\ \rho\frac{\partial^2 w}{\partial t^2}=(\lambda+\mu)\frac{\partial\bar{\varepsilon}}{\partial z}+\mu\nabla^2 w$$

Where $u, v, w$ are the displacements along x, y, and z axes, $\bar{\varepsilon}$ being the dilatational strain, $\lambda, \mu$ are lamb's coefficients. X, Y axes are along ground surface and Z axis positive down, where X axis is the direction of propagation of wave. $v$=0 for Raleigh Waves as per their definition (Raleigh and Lord, 1885) and we have only two governing equations. (Richart et al., 1970**)**

$$\rho\frac{\partial^2 u}{\partial t^2}=(\lambda+\mu)\frac{\partial\bar{\varepsilon}}{\partial x}+\mu\nabla^2 u$$

$$\rho\frac{\partial^2 w}{\partial t^2}=(\lambda+\mu)\frac{\partial\bar{\varepsilon}}{\partial z}+\mu\nabla^2 w$$

Assuming displacement potentials $\phi, \varphi$ such that,

$$u=\frac{\partial\phi}{\partial x}+\frac{\partial\varphi}{\partial z} \quad \text{and} \quad w=\frac{\partial\phi}{\partial z}-\frac{\partial\varphi}{\partial x}$$

$\phi, \varphi$ for semi infinite homogenous isotropic medium can be obtained as (Richart et al., 1970**)**

$$\phi=\left(A_1 e^{-qz}+B_1 e^{qz}\right)e^{i(wt-kx)}$$

$$\varphi=\left(A_2 e^{-sz}+B_2 e^{sz}\right)e^{i(wt-kx)} \quad \text{where, } q^2=k^2-\left(\frac{\omega^2}{V_p^{\,2}}\right) \text{ and } s^2=k^2-\left(\frac{\omega^2}{V_s^{\,2}}\right)$$

$k, \omega$ are wave number and frequency of Raleigh Wave respectively

$$\text{Body Wave Velocity}=V_p=\sqrt{\frac{\lambda+2\mu}{\rho}} \qquad \text{(Richart et al., 1970)}$$

$$\text{Shear Wave Velocity}=V_s=\sqrt{\frac{\mu}{\rho}}$$

Consider N-1 elastic, homogenous and isotropic layers lying over a semi infinite homogenous elastic isotropic medium and neglect the effect of water table. $G_m$,$\rho_m$,$\nu_m$, $d_m$ be the parameters of m$^{th}$ layer where G,ρ,ν,d are Shear modulus, Density, Poisson's ratio and thickness of corresponding layer. Assuming Z=0 at the ground surface, the potential functions for the m$^{th}$ layer has to be modified as:

$$\phi_m=\left(A_m e^{-q(z-Z_{m-1})}+B_m e^{q(z-Z_{m-1})}\right)e^{i(wt-kx)}$$

$$\varphi_m=\left(C_m e^{-s(z-Z_{m-1})}+D_m e^{s(z-Z_{m-1})}\right)e^{i(wt-kx)}$$

Where, $Z_{m-1}$ is the depth upto (m-1)$^{th}$ layer

So, now the problem is to find the co-efficient $A_m$ , $B_m$, $C_m$, $D_m$ for every layer and the semi-infinite medium at the bottom. Once these coefficients are obtained, potentials and displacements can be obtained. In total, for (N-1) layers and the semi infinite medium, we have 4N unknowns with 4 unknowns per each layer.

The equations we have at our hand are:

1) Stresses ( $\sigma_{zz}$, $\sigma_{zx}$) at the bottom of upper layer should be equal to the stresses at the top of the lower layer. (N-1 equations)
2) The displacements (u, w) at the bottom of upper layer should be equal to the displacements at the top of the lower layer. (N-1 equations)
3) The displacements at infinite depth should be equal to zero.
4) The stresses at surface should be equal to zero.

Thus, there are a total of 2(N-1)+ 2(N-1)+2+2 = 4N, equations. We have 4N unknowns and 4N equations. But, the solution is impossible because all these 4N equations are not independent. This can be explained physically too. Suppose say that these equations are independent, then there exists a unique solution. This implies what ever may be the energy imparted we have the same potentials and displacements. But, it is not true. Potentials change with the amount of energy imparted. So, since we have not considered the effect of source, the solution should be redundant. Taking ground displacements at the surface as known, we can express the rest in the terms of the ground displacements on the surface. Say $u_0, w_0$ are the displacements along x-axis and z-axis respectively at the ground surface and $\sigma_0, \tau_0$ be the normal stress and shear stress respectively at ground surface. Similarly $u_m, w_m, \sigma_m, \tau_m$ are the displacements and stresses in the m[th] layer.

$$\phi_m = \left(A_m e^{-q(z-Z_{m-1})} + B_m e^{q(z-Z_{m-1})}\right) e^{i(wt-kx)}$$
$$\varphi_m = \left(C_m e^{-s(z-Z_{m-1})} + D_m e^{s(z-Z_{m-1})}\right) e^{i(wt-kx)}$$

Say,

$$\phi_m{}^+ = B_m e^{q(z-Z_{m-1})}; \phi_m{}^- = A_m e^{-q(z-Z_{m-1})}; \varphi_m{}^+ = D_m e^{s(z-Z_{m-1})}; \varphi_m{}^- = C_m e^{-s(z-Z_{m-1})}$$

**Thus we have,** $\phi_m = \left(\phi_m{}^+ + \phi_m{}^-\right)e^{i(wt-kx)}$ **and** $\varphi_m = \left(\varphi_m{}^+ + \varphi_m{}^-\right)e^{i(wt-kx)}$

Finding the functions for displacement and stresses in each layer:

$$u_m = \frac{\partial \phi_m}{\partial x} + \frac{\partial \varphi_m}{\partial z} = \left[\phi_m{}^+ \varphi_m{}^+ \phi_m{}^- \varphi_m{}^-\right]^T \left[-ik \quad s_m \quad -ik \quad -s_m\right] e^{i(wt-kx)}$$
$$w_m = \frac{\partial \phi_m}{\partial z} - \frac{\partial \varphi_m}{\partial x} = \left[\phi_m{}^+ \varphi_m{}^+ \phi_m{}^- \varphi_m{}^-\right]^T \left[q_m \quad ik \quad -q_m \quad ik\right] e^{i(wt-kx)}$$
$$\sigma_m = \lambda \bar{\varepsilon} + 2\mu \varepsilon_{zz} = \left[\phi_m{}^+ \varphi_m{}^+ \phi_m{}^- \varphi_m{}^-\right]^T \left[\mu a_m \quad 2i\mu s_m k \quad \mu a_m \quad -2i\mu s_m k\right] e^{i(wt-kx)}$$
$$\sigma_{xz} = \mu \varepsilon_{xz} \qquad = \left[\phi_m{}^+ \varphi_m{}^+ \phi_m{}^- \varphi_m{}^-\right]^T \left[-2i\mu k q_m \quad \mu a_m \quad 2i\mu k q_m \quad \mu a_m\right] e^{i(wt-kx)}$$

where $\quad a_m = \left(2k^2 - \frac{\omega^2}{\left(V_s{}^m\right)^2}\right)$

Defining the vectors,

$$S_m(z) = \left[u_m(z) \quad w_m(z) \quad \sigma_m(z) \quad \tau_m(z)\right]^T \text{ and}$$
$$\theta_m(z) = \left[\phi_m{}^+(z) \quad \varphi_m{}^+(z) \quad \phi_m{}^-(z) \quad \varphi_m{}^-(z)\right]^T$$

From above equations, we have,

$$S_m(z) = \begin{bmatrix} -ik & s_m & -ik & -s_m \\ q_m & ik & -q_m & ik \\ \mu a_m & 2i\mu k s_m & \mu a_m & -2i\mu k s_m \\ -2i\mu k q_m & \mu a_m & 2i\mu k q_m & \mu a_m \end{bmatrix} \theta_m(z) e^{i(wt-kx)}$$

$= T_m \theta_m(z) e^{i(wt-kx)}$ , Notating $T_m$ to be Transformation Matrix.

$$S_0 = \begin{bmatrix} u_0 \\ w_0 \\ \sigma_0 \\ \tau_0 \end{bmatrix} \text{ and } \theta_m(Z_m) = \begin{bmatrix} e^{q_m d_m} & 0 & 0 & 0 \\ 0 & e^{s_m d_m} & 0 & 0 \\ 0 & 0 & e^{-q_m d_m} & 0 \\ 0 & 0 & 0 & e^{-s_m d_m} \end{bmatrix} \theta_m(Z_{m-1}) = E_m \theta_m(Z_{m-1})$$

Now, to satisfy the boundary conditions at every interface,

$S_{m+1}(Z_m) = S_m(Z_m)$
$= T_m \theta_m(Z_m)$
$= T_m E_m \theta_m(Z_{m-1})$
$= T_m E_m T_m^{-1} S_m(Z_{m-1})$

Say, $G_m = T_m E_m T_m^{-1}$

$S_{m+1}(Z_m) = G_m S_m(Z_{m-1})$

Thus, $S_2(Z_1) = G_1 S_1(Z_0)$

$S_3(Z_2) = G_2 S_2(Z_1) = G_2 G_1 S_1(Z_0)$

Similarly,

$S_N(Z_{N-1}) = G_{N-1} G_{N-2} \ldots\ldots\ldots G_1 S_1(Z_0)$

$\theta_N(Z_{N-1}) = T_N^{-1} G_{N-1} G_{N-2} \ldots\ldots\ldots G_1 S_1(Z_0)$

$$\theta_N(Z_{N-1}) = \begin{bmatrix} \phi_m^+(Z_{N-1}) \\ \varphi_m^+(Z_{N-1}) \\ \phi_m^-(Z_{N-1}) \\ \varphi_m^-(Z_{N-1}) \end{bmatrix} = \begin{bmatrix} B_N e^{q(Z_{N-1}-Z_{N-1})} \\ D_N e^{s(Z_{N-1}-Z_{N-1})} \\ A_N e^{-q(Z_{N-1}-Z_{N-1})} \\ C_N e^{-s(Z_{N-1}-Z_{N-1})} \end{bmatrix} = \begin{bmatrix} B_N \\ D_N \\ A_N \\ C_N \end{bmatrix}$$

But, for underlying semi infinite layer $B_N$ ,$D_N$ are zero, since the displacements at infinite depth should be zero.

Say,

$\theta_N(Z_{N-1}) = T_N^{-1} G_{N-1} G_{N-2} \ldots\ldots\ldots G_1 S_1(Z_0) = R\, S_1(Z_0) = R\, S_0$

R is a 4*4 matrix. In a simple manner, we can write R as a 2*2 matrix with each element a 2*2 matrix.

$$R = \begin{bmatrix} R_{11} & R_{12} \\ R_{21} & R_{22} \end{bmatrix} \text{then, } R_{11}\begin{bmatrix} u_0 \\ w_0 \end{bmatrix} + R_{12}\begin{bmatrix} \sigma_0 \\ \tau_0 \end{bmatrix} = \begin{bmatrix} B_N \\ D_N \end{bmatrix} = 0;$$

$$\Rightarrow \begin{bmatrix} u_0 \\ w_0 \end{bmatrix} = -R_{11}^{-1} R_{12}\begin{bmatrix} \sigma_0 \\ \tau_0 \end{bmatrix} = -\frac{\overline{\overline{R}}_{11}}{|R_{11}|} R_{12}\begin{bmatrix} \sigma_0 \\ \tau_0 \end{bmatrix}$$

So far we have applied all the boundary conditions except that stresses at surface are zero. Now applying that condition,

$$\begin{bmatrix} u_0 \\ w_0 \end{bmatrix} = -R_{11}^{-1} R_{12}\begin{bmatrix} \sigma_0 \\ \tau_0 \end{bmatrix} = -\frac{\overline{\overline{R}}_{11}}{|R_{11}|} R_{12}\begin{bmatrix} \sigma_0 \\ \tau_0 \end{bmatrix} = -\frac{\overline{\overline{R}}_{11}}{|R_{11}|} R_{12}\begin{bmatrix} 0 \\ 0 \end{bmatrix} = \frac{0}{|R_{11}|}$$

But, the displacements at surface are non-zero. The values taken depend upon the energy imparted. For displacements to take values as per the energy imparted, $|R_{11}| = 0,$ so that $\frac{0}{0}$ is indeterminate and displacements can have variable values. But, $R_{11}$ is a function of k and ω. For this secular function, solution exists only for particular pairs of k and ω for which the secular function is zero. It is impossible to find the roots of the secular function there are two unknowns. So, the best method is to fix the value of one variable and find the value of other. Fixing frequency, K values for which the secular function is zero can be found. There exist infinite solutions for this problem. But, all the Raleigh waves propagating in the layered medium can have velocities ranging between the highest and lowest Raleigh velocities, calculated considering each medium as homogenous semi-infinite medium. K values are searched in this range of velocities. The highest K value gives the velocity corresponding to First mode and the next gives the next lower mode. Finding the Raleigh wave velocity in different modes over a frequency range, theoretical dispersion curve can be drawn for different modes. The program developed would require to be fed with the number of layers, G,ρ,ν,d for each layer, frequency range of consideration, increment in frequency and increment in wave number, which would generate the Dispersion Curve in fundamental mode. The accuracy and speed of the program can be controlled by the two inputs of Poisson's ration and depth of each layer. The flow chart is as shown in Figure 1.

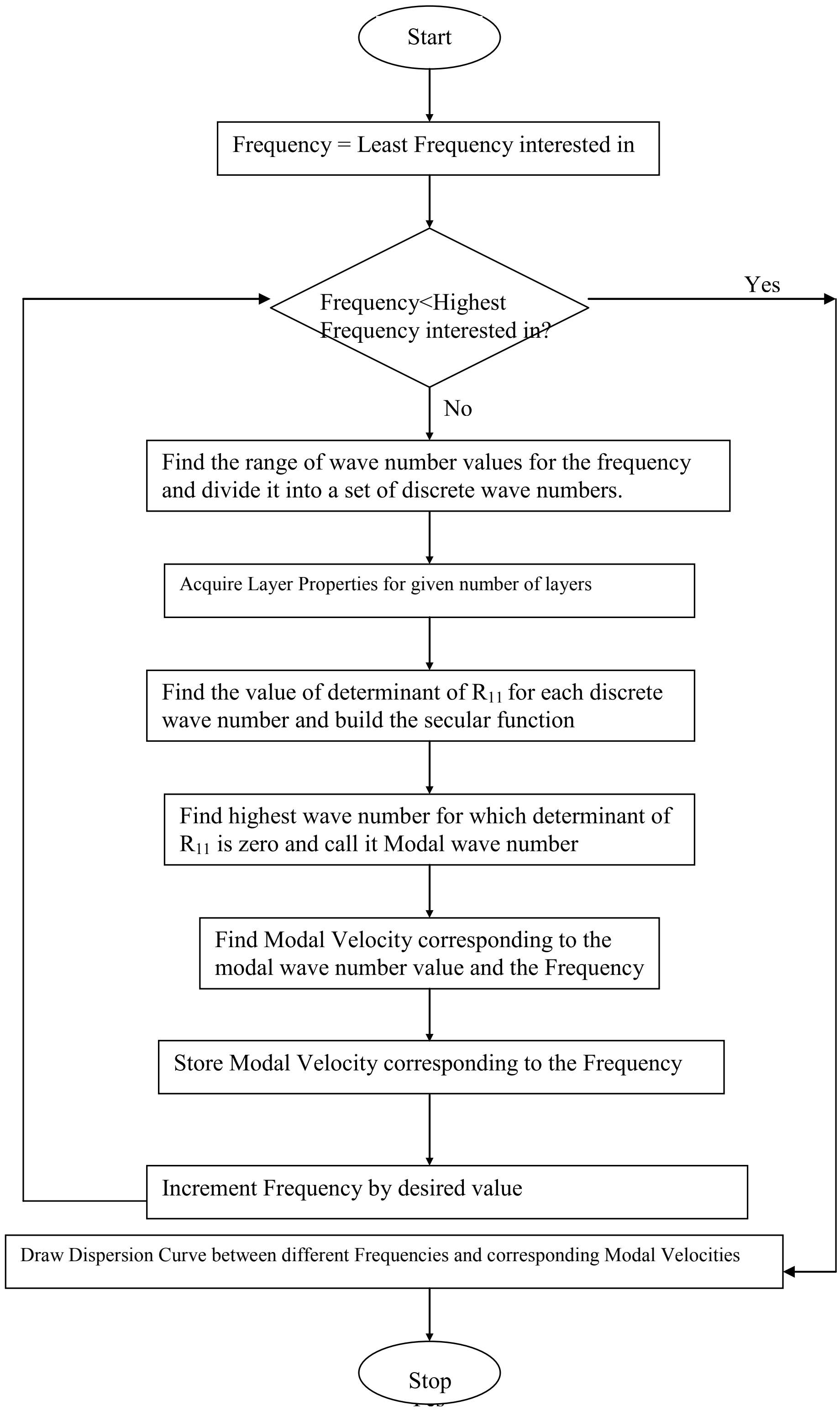


**Figure 1. Flow chart of MATLAB Program**

## STANDARD PENETRATION TEST

The input parameters for program have been obtained from the drilled standard penetration test (SPT) bore holes. The SPT and MASW test site is located on southern part of Bangalore city near to the International Airport, having the dimension of 37mx52.7m. The topography of the site is a flat terrain with two side roads on the northern side and western side of the site. Bore holes are drilled using Rotary hydraulic drilling of 150mm diameter up to the rock depth. SPT testing results shows the general soil profile which consists of a variable thickness of soil overburden. The thickness of the overburden varies from 3.5m to 16.5m from ground level at different borehole locations The disintegrated weathered rock exists below Figure 1: Site Map with Marked Testing Locations the silty sand layer having a refusal strata with N>100. Below the disintegrated weathered rock, weathered / hard rock exists. The rock formation is classified as granitic gneiss without faults and fissures. Water table in this area during the investigation is at about 1.4m below the ground level in all the boreholes. Typical bore log is shown in Figure 2. The N values measured in the field using standard penetration test procedure have been corrected for various corrections, such as:(i) Overburden Pressure ($C_N$), (ii) Hammer energy ($C_E$), (iii) Bore hole diameter ($C_B$), (iv) presence or absence of liner ($C_S$), (v) Rod length ($C_R$) and (vi) fines content ($C_{fines}$) (Seed et al.; 1983, Skempton; 1986, Schmertmann; 1978). Field "N" is corrected using the following equation and Corrected "N" value i.e., (N60) is obtained:

$$N_{60} = N \times (C_N \times C_E \times C_B \times C_S \times C_R \times C_{fines}) \quad (1)$$

**BORE LOG**

Location Institute of Arospace Medicine
BH No 3

Date of commencement 16.11.2005
Date of completion 18.11.2003
Ground Water Table 1.5m

| Depth Below GL(m) | Soil Description | Thickness of Strata (m) | Legend | Details of Sampling | | SPT N Value |
|---|---|---|---|---|---|---|
| | | | | Type | Depth (m) | |
| 0.0 | Filled Up Soil | | | SPT | 1.5 | 1/1//0 N=2 |
| 1.0 | | | | | | |
| | | | | UDS | 2.5 | |
| 2.3 | | 2.3 | | | | |
| | Reddish /Grayish Clayey sand | | | SPT | 3.0 | 10/9//10 N=19 |
| 3.0 | | 0.7 | | | | |
| | | | | UDS | 4.5 | |
| 4.5 | Greyish silty sand/ Sandy silt with mica | | | SPT | 5.0 | 12/14/2025 N=39 |
| 6.0 | | | | | | |
| | | | | SPT | 6 | 30/48/53 N=101 |
| 8.0 | | | | | | |
| | | | | SPT | 7.5 | 75R for 3cm Penetration |
| 9.0 | | 6 | | | | |
| | Weathered Rock 9m to 10.5m | | | SPT | 9 | 75R for no Penetration |
| 10.0 | | | | | | |
| 10.5 | CR=76%,ROD=43% | 1.5 | | | | |

Bore hole Terminated at 10.5m

Note
SPT Standard Penetration Test
UDS Undisturbed Sample
R Rebound

**Figure 2: Typical Borelog at the selected site.**

Corrected N values are used to calculate the shear wav velocity using the equation 2, then shear modulus are evaluated. Other data of density, layer thickness are obtained from borelog and Poisons ration assumed as 0.35. Typical N correction and Vs calculation is shown in Table 1. These values are given as input for MATLAB program and theoretical dispersion curve has been generated. Typical dispersion curve (DC) generated my MATLAB given in Figure 3.

$$Vs = 80 N_{60}^{(1/3)} \text{ (JRA, 1980)} \qquad (2)$$

**Table 1: Typical SPT ($V_s$) Calculation**

Institute of Aerospace Medicine — Water Table = 1.5 m/18-11-2005
Bore hole No-BH3

| Depth | Field "N" Value | Density | T.S | E.S | $C_N$ | Correction Factors For | | | | $C.N_1$ | F.C | C.F.C | $N_{60}$ | Vs |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| m | | kN/cu.m | kN/sq.m | kN/sq.m | | Hammer Effect | Bore hole Dia | Rod Length | Sample Method | | % | | | (m/sec) |
| 1.50 | 2 | 20.10 | 30.15 | 30.15 | 1.47 | 1 | 1.05 | 0.75 | 1 | 2.31 | 31 | 1.796 | 4 | 128 |
| 3.00 | 19 | 20.10 | 60.30 | 45.59 | 1.33 | 1 | 1.05 | 0.8 | 1 | 21.20 | 41 | 1.261 | 27 | 239 |
| 5.00 | 39 | 20.10 | 100.50 | 80.88 | 1.10 | 1 | 1.05 | 0.85 | 1 | 38.12 | 35 | 1.186 | 45 | 285 |
| 6.00 | 101 | 20.10 | 120.60 | 110.79 | 0.95 | 1 | 1.05 | 0.85 | 1 | 85.93 | 28 | 1.128 | 97 | 368 |
| 7.50 | 100 | 20.10 | 150.75 | 136.04 | 0.86 | 1 | 1.05 | 0.95 | 1 | 85.71 | 22 | 1.101 | 94 | 364 |
| 9.00 | 100 | 20.10 | 180.90 | 166.19 | 0.77 | 1 | 1.05 | 0.95 | 1 | 76.68 | 22 | 1.102 | 85 | 351 |

T.S - Total Stress
E.S - Effective Stress
$C_N$ – Correction for overburden correction
F.C – Fines content
C.F.C – Correction for Fines content
$N_{60}$ – Corrected 'N' Value
Vs – Shear Wave Velocity
$C_{N1}$- Corrected "N" value before applying fine content corrections

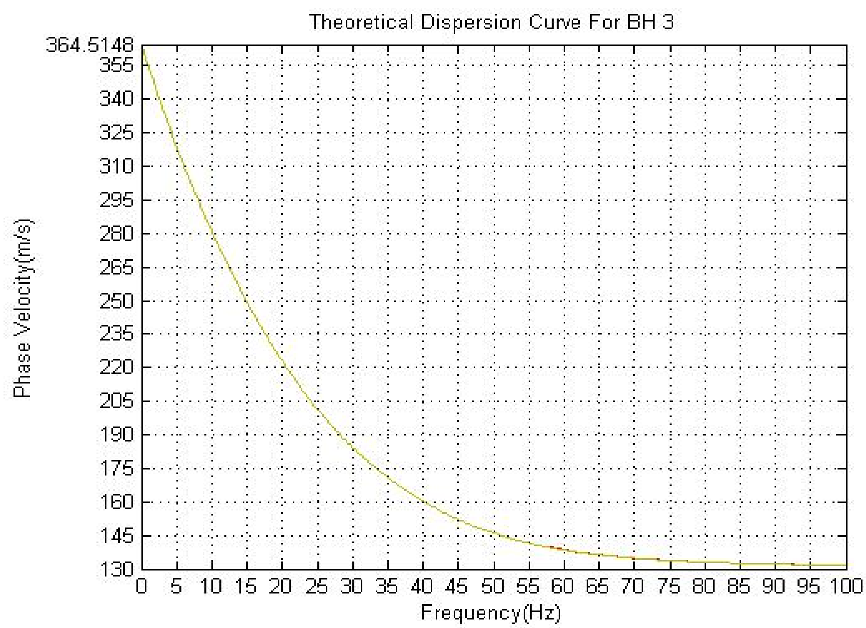


**Figure 3. Typical Dispersion curve generated using MATLAB**

## GEOPHYSICAL INVESTIGATIONS USING MASW

The DC generated using G, ρ,ν,d by MATALB program is compared with the Dispersion curve obtained from MASW at borehole locations. MASW generates a shear-wave velocity (Vs) profile (i.e., Vs versus depth) by analyzing Raleigh-type surface waves on a multichannel record. MASW has been effectively used for identification of broadband width and highest signal-to-noise ratio (S/N) of surface waves. MASW system used for this investigation consists of 24 channels Geode seismograph with 24 geophones of 4.5 Hz capacity. The seismic waves are created by impulsive source of 10 pound (sledge hammer) with 1'x1' size hammer plate with ten shots, these wave are captured by geophones/receivers. The captured Rayleigh wave is further analyzed using SurfSeis software. SurfSeis is designed to generate Vs data (either in 1-D or 2-D format) using a simple three-step procedure: i) preparation of a Multichannel record (some times called a shot gather or a field file), ii) dispersion-curve analysis, and iii) inversion. The 1D MASW test has been carried out corresponding to 5 borehole locations (BH-1 to BH-5) with 25 recording points. The spread length locations are shown in Figure 1 as survey line 1-1 to 5-5. The optimum field parameters recommended by Park et al. (1999) (source to first and last receiver, receiver spacing and spread length of survey line) are selected in such a way that required depth of information can be obtained. All the testing has been carried out with geophone interval of 1m and source to first and last receiver is varied from 5m, 10m and 15m. Typical recorded surface wave arrivals using source to first receiver distance as 5m with recording length of 1000 milli second (ms) is shown in Figure 4 for the survey line 5-5.

The generation of a dispersion curve is a critical step in all MASW methods. A dispersion curve is generally displayed as a function of phase velocity versus frequency. Phase velocity can be calculated from the linear slope of each component on the swept-frequency record. The lowest analyzable frequency in this dispersion curve is around 4 Hz and highest frequency of 35Hz has been considered. Typical dispersion curve is shown in Figure 5 for the location 5-5, each dispersion curve obtained for corresponding locations has the high signal to noise ratio 80 and above. A Vs profile has been calculated using an iterative inversion process that requires the dispersion curve developed earlier as input. A least-squares approach allows automation of the process (Xia et al., 1999) as inbuilt in SurfSeis. Vs have been updated after completion of each iteration with parameters such as Poisson's ratio, density, and thickness of the model remaining unchanged. An initial earth model is specified to begin the iterative inversion process. The earth model consists of velocity (P-wave and S-wave velocity), density, and thickness parameters.

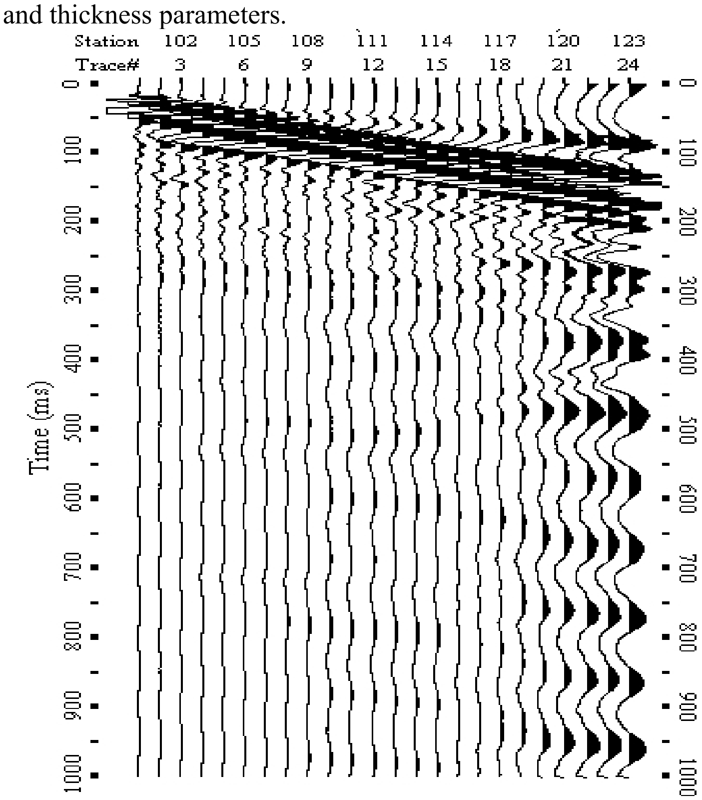


**Figure 4: Typical Seismic waves Recorded in Location 5-5**

## COMPARISON

The program developed from our study is validated with the field MASW test results for conducting MASW testing at same location of SPT test data used for program. The shape of dispersion curve obtained from model matches well with the shape of the experimental dispersion curve obtained from MASW. The dispersion analysis is repeated number of times and finally the dispersion curve obtained from MASW matched with generated dispersion curve. From our study, generated theoretical program can be effectively used to cross check or validate the MASW results (dispersion curve shapes) with little borelog information.

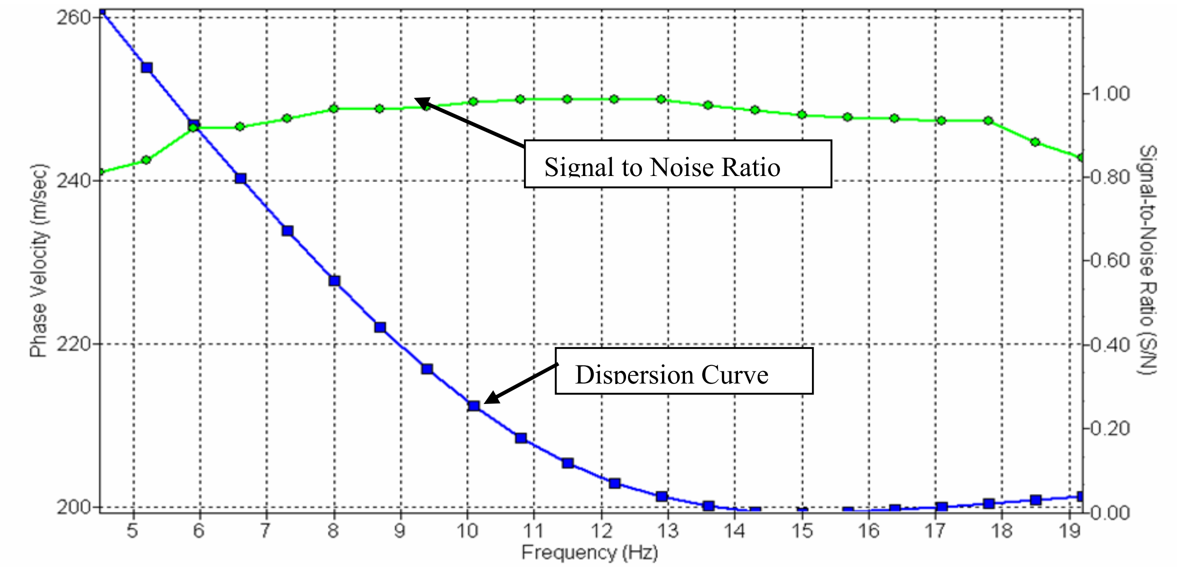


**Figure 5. Typical Dispersion curve obtained from MASW**

## CONCLUSIONS

A theoretical MATLAB program has been generated to develop the dispersion curve based on borelog information. The developed model is validated with experimental dispersion curve obtained from MASW. The dispersion Curves are almost similar and the dispersion curve obtained from MASW doesn't vary much compared with the theoretically expected dispersion curve. The developed program can be used effectively to validate the MASW dispersion cures.

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