2022「中技社科技獎學金」

2022 CTCI Foundation Science and Technology Scholarship

境外生生活助學金

Living Grant for International Graduate Students

Application of Seismic Surveys in Geotechnical Engineering

Multichannel Analysis of Surface Waves (MASW) and Horizontal to Vertical Spectral Ratio (HVSR)

Maria Desti Natalin[1] and Jiunn-Shyang Chiou[2]

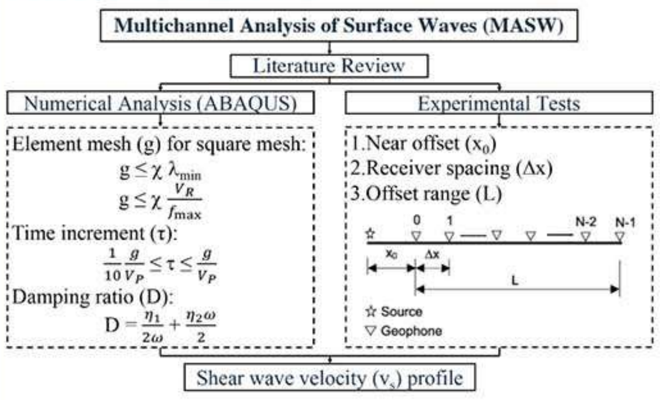
1. Ph.D. Student, Department of Civil Engineering, National Taiwan University, Taipei, Taiwan, R.O.C. Email: mariadesti25@gmail.com
2. Associate Professor, Department of Civil Engineering, National Taiwan University, Taipei, Taiwan, R.O.C. Email: jschiou@ntu.edu.tw

ABSTRACT

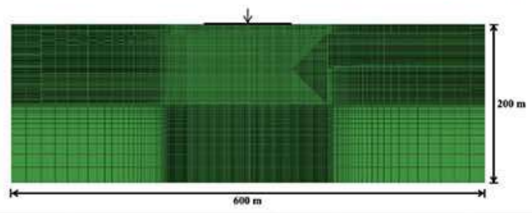
Seismic surveys are conducted to obtain information regarding the soil characteristics in a non-destructive manner using seismic wave propagation, e.g., Multichannel Analysis of Surface Waves (MASW) and Horizontal to Vertical Spectral Ratio (HVSR). MASW is a well-known non-invasive wave test used to construct shear wave velocity (v_s) profile. In the present study, the finite element program ABAQUS is used to simulate full-wave propagation of the MASW tests, and then the results are compared with the field measurements data at NTU Sport Field. Results confirm two important issues, specifically the near-field and soil nonlinearity effects. Near-field effect can also be overcome by setting an appropriate near-offset distance (x_0); however, the far-field effect may occur if the near-offset distance (x_0) is too large. Therefore, the selection of near-offset distance (x_0) must be considered carefully in the future. Meanwhile, the HVSR is commonly conducted to determine the predominant period of the soil profile. Pseudo-response Spectral Acceleration (PSA) and Fourier Amplitude Spectra (FAS) can be used for the calculation of predominant period (T_p). The calculations of the predominant period (T_p) from HVSR tests at NCREE show consistent value. Furthermore, the PSA and FSA are comparable to determine predominant period (T_p). In addition, the v_{s30} of soil profile can be predicted by using the predominant period and peak amplitude of H/V ratio.

MULTICHANNEL ANALYSIS OF SURFACE WAVES (MASW)

METHODOLOGY



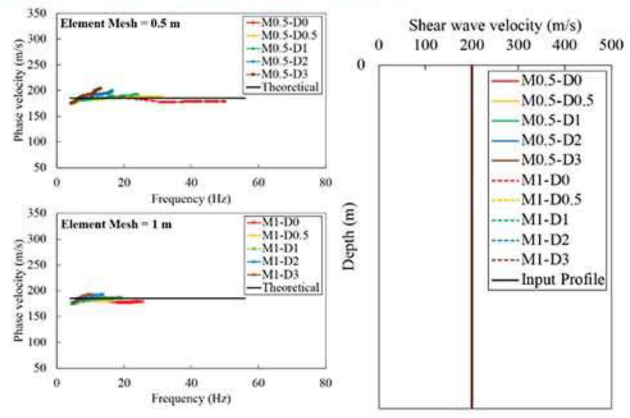
NUMERICAL MODEL (ABAQUS)



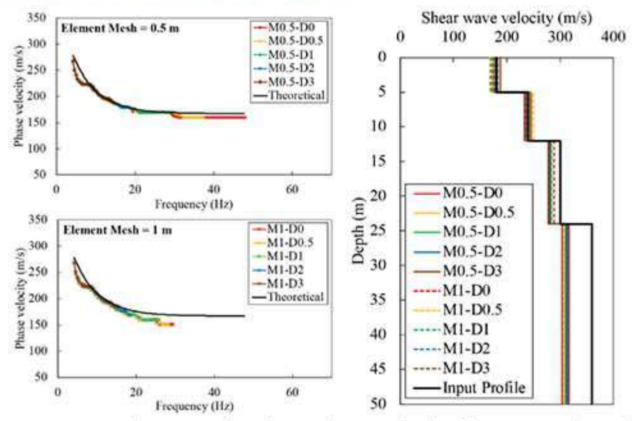
Thickness (m)	Velocity (m/s) Case I	Velocity (m/s) Case II	Poisson's Ratio	Density (kg/m³)
5	200	180	0.3	1800
7		240		
12		300		
Half-space		360		

NUMERICAL ANALYSIS: VALIDATION RESULTS

Homogeneous soil layer (Case I)



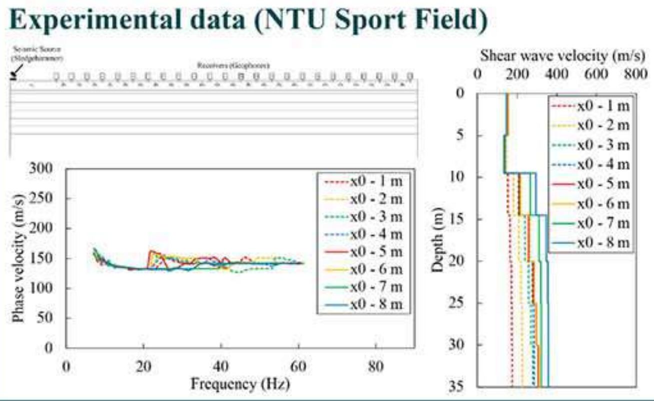
Multiple soil layer (Case II)



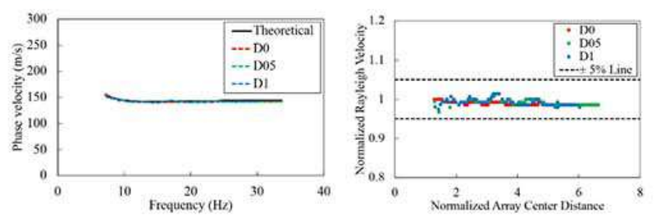
Element mesh (M) influences the identified maximum frequency, whereas the damping ratio influences the phase velocity at a higher frequency. Underestimation of phase velocity due to the near-field effect can be observed at a lower frequency which leads to underestimation of shear wave velocity (v_s) at a deeper soil depth.

EXPERIMENTAL TESTS

Experimental data (NTU Sport Field)



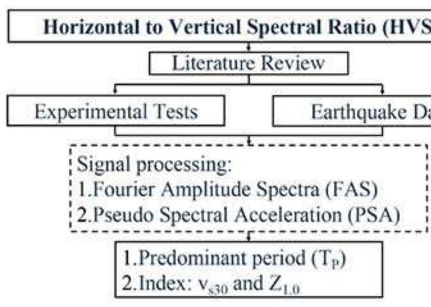
Numerical analysis results



From the numerical analysis, it can be concluded that a near-offset distance (x_0) of 5 m is appropriate for MASW testing at the NTU Sport Field.

HORIZONTAL TO VERTICAL SPECTRAL RATIO (HVSR)

METHODOLOGY



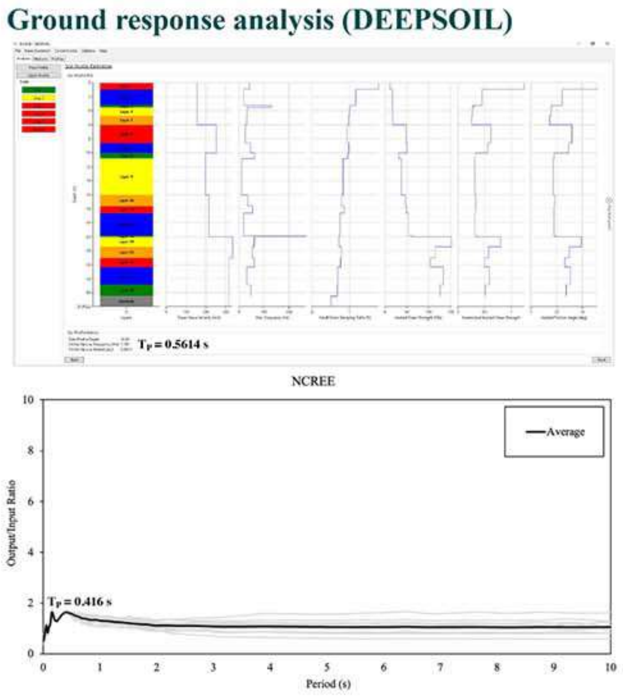
HVSR tests are commonly used to estimate the dynamic characteristics of surface layers by measuring the microtremor of the surface solely. In our future study, the v_{s30} will be calculated by using the equations below (for shallow soil regions: including Japan, China, and Taiwan):

$$\log(v_{s30}) = 2.76 + 0.22\ \log(f_p) - 0.49 \log(A_{peak})$$

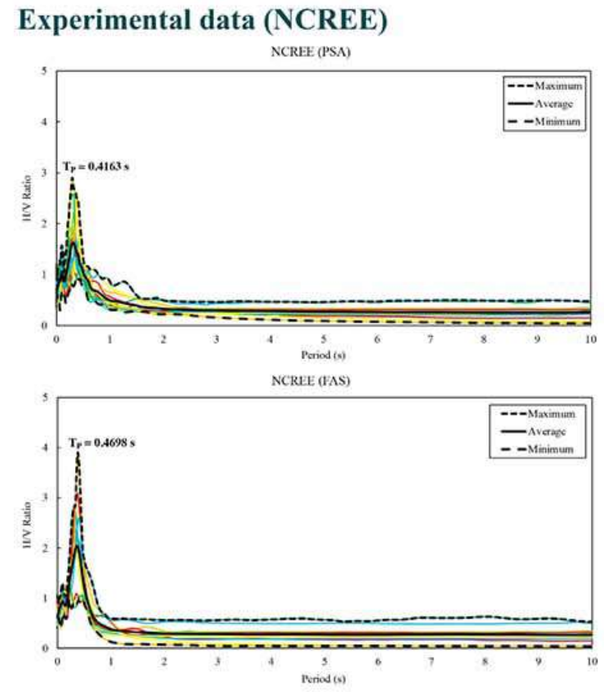
where: f_p, A_{peak} = natural frequency and peak amplitude from HVSR

EXPERIMENTAL TESTS

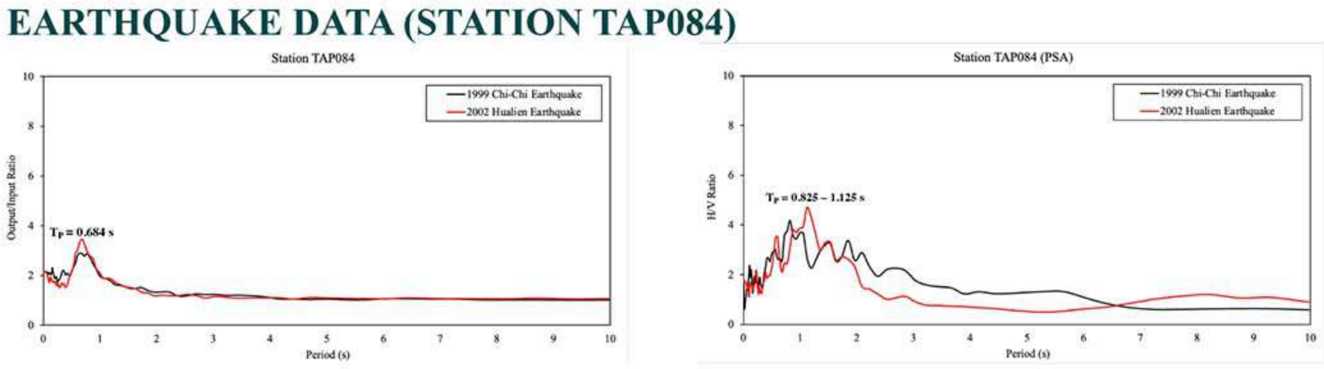
Ground response analysis (DEEPSOIL)



Experimental data (NCREE)



EARTHQUAKE DATA (STATION TAP084)



CONCLUSIONS

- This study confirms two important issues for the MASW tests, specifically the near-field and soil nonlinearity effects. Numerical analysis is recommended to overcome the near-field effect in further study; meanwhile, the detailed damping ratio profile must be carefully determined to overcome the soil nonlinearity effect at the ground surface. Near-field effect can also be overcome by setting an appropriate near-offset distance (x_0); however, the far-field effect may occur if the near-offset distance (x_0) is too large. Therefore, the selection of near-offset distance (x_0) must be considered carefully in the future.
- The calculation of predominant period (T_p) from HVSR testing show consistent value. Meanwhile, the approximation calculation of T_p using soil thickness (H) and shear wave velocity (v_s) is larger than the actual value. In addition, the PSA and FSA methods are comparable to determine predominant period (T_p). However, the predominant period (T_p) increases due to the nonlinear behaviour of the soil during large excitation (e.g., earthquake).

臺大土木工程學系
Department of Civil Engineering
National Taiwan University

AUTHOR INFORMATION

Name : Maria Desti Natalin
Advisor : Prof. Chiou Jiunn Shyang
Current GPA : 3.79 / 4.30
Research Experiences:

- ❑ Bearing resistance of compacted stabilized soils with polymer and cement (2018 - 2019)
- ❑ Numerical analysis of seismic responses of geosynthetic reinforces soil (GRS) retaining walls subjected to horizontal and vertical seismic loadings (2019 - 2021)
- ❑ Seismic performance of bridge with spread footings (ongoing)