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# Influence of a-priori information on the estimation of fundamental frequency of soil using MASW testing

*Aniket Desai, Ravi S. Jakka*

*Department of Earthquake Engineering, IIT Roorkee, Uttarakhand, India*

## Introduction

The fundamental frequency of soil ($f_0$) is an important parameter to understand the soil behaviour during earthquakes. Therefore, its estimation is critical in studies related to geotechnical earthquake engineering. One method for its estimation is the use of multichannel analysis of surface waves (MASW) method and subsequent site response analysis (SRA). However, the shear wave velocity ($V_s$) profile of soil estimated by the MASW method contains inherent non-uniqueness. This causes ambiguities in the estimation of $f_0$. In this study, an evaluation has been made about the quantity of reduction in the uncertainties in $f_0$ estimation using a-priori information along with MASW testing. The a-priori information has been considered in the form of number and thickness of soil layers and soil type. A field MASW test and borehole drilling were carried out at a test site and subsequent analyses were carried out. The results of $f_0$ estimation without and with a-priori information were compared.

## Procedure

The MASW test was carried out at the lawn of the Department of Earthquake Engineering, IIT Roorkee. The test setup was a 24-channel system with the natural frequency of geophones being 4.5 Hz. At the same site, a borehole was drilled and the information about soil layering and soil type was obtained. The dispersion image and the picked dispersion curve from the field MASW testing are shown in Fig. 1. The borelog information has been shown in Fig. 2.

The inversion of the dispersion curve was carried out for two cases: (1) Without using the borehole information and (2) With the use of borehole information. The results of inversion, i.e., the $V_s$ profiles are shown in Fig. 3.

Then, using these $V_s$ profiles, site response analysis was carried out for the same two cases: Without and with borehole information. Without a-priori information, there was no idea about the number soil type. So, they had to be assumed or randomizations had to be applied. With a-priori information from Fig. 2, this information became available, which made SRA quite simple. The motion recorded during Uttarkashi earthquake (Dated: 19/10/1991; Mw=6.8) at Purola station (rock site) was used as the input motion or the SRA. The SRA results have been presented in Fig. 4 in terms of Fourier amplification spectra.

In the final step, the $f_0$ of soil was obtained from all the above analyses for both the cases. A box plot has been made to demonstrate the distribution of $f_0$ values in both the cases (Fig. 5).

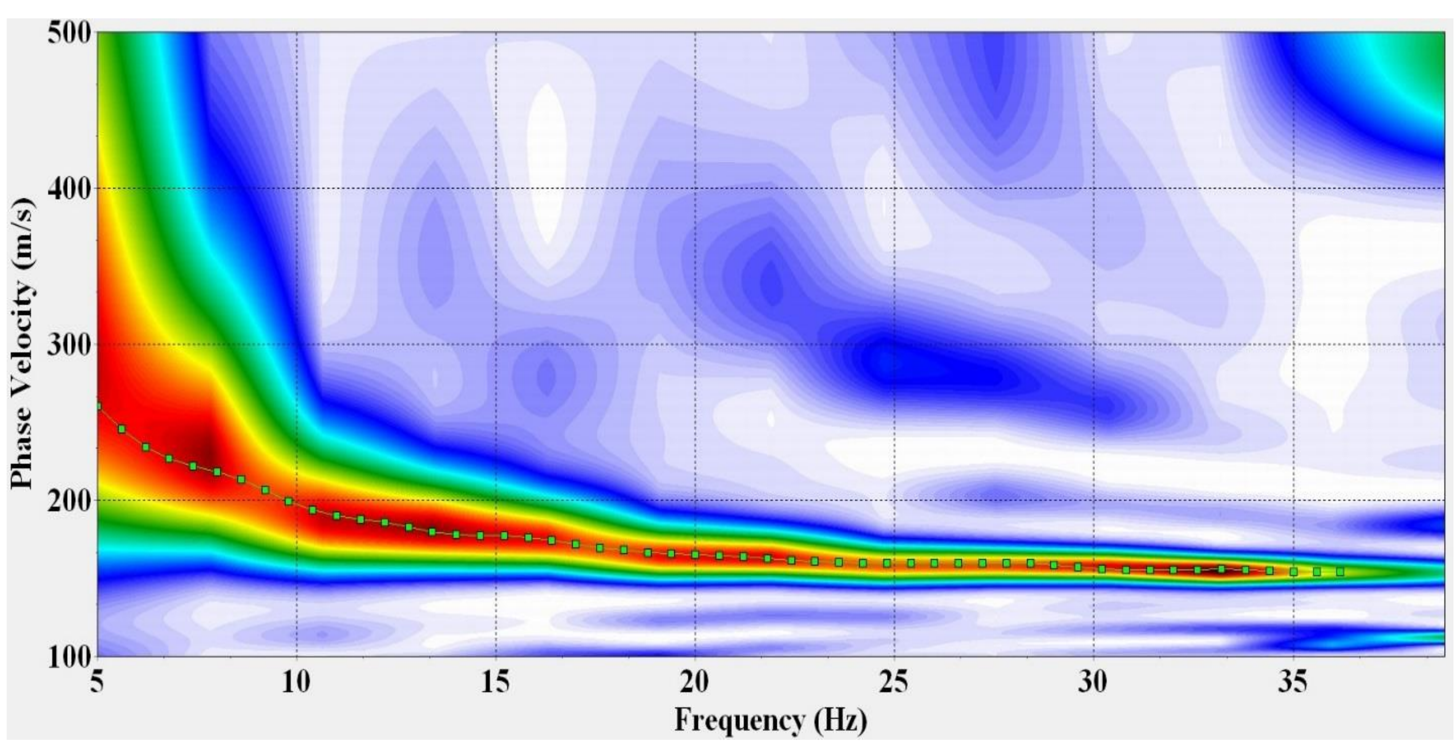


**Fig. 1 Dispersion image from the MASW test at the study location**

| Depth(m) | Soil type |
|---|---|
| 4.5 | SM (Silty sand) |
| 6.5 | CL (Clay with low compressibility) (PI=14) |
| 8 | CL (Clay with low compressibility) (PI=23) |
| 12 | SM (Silty sand) |
| 15 | CL (Clay with low compressibility) (PI=10) |
| 24 | SM (Silty sand) |

**Fig. 2 Borelog data of the study location**

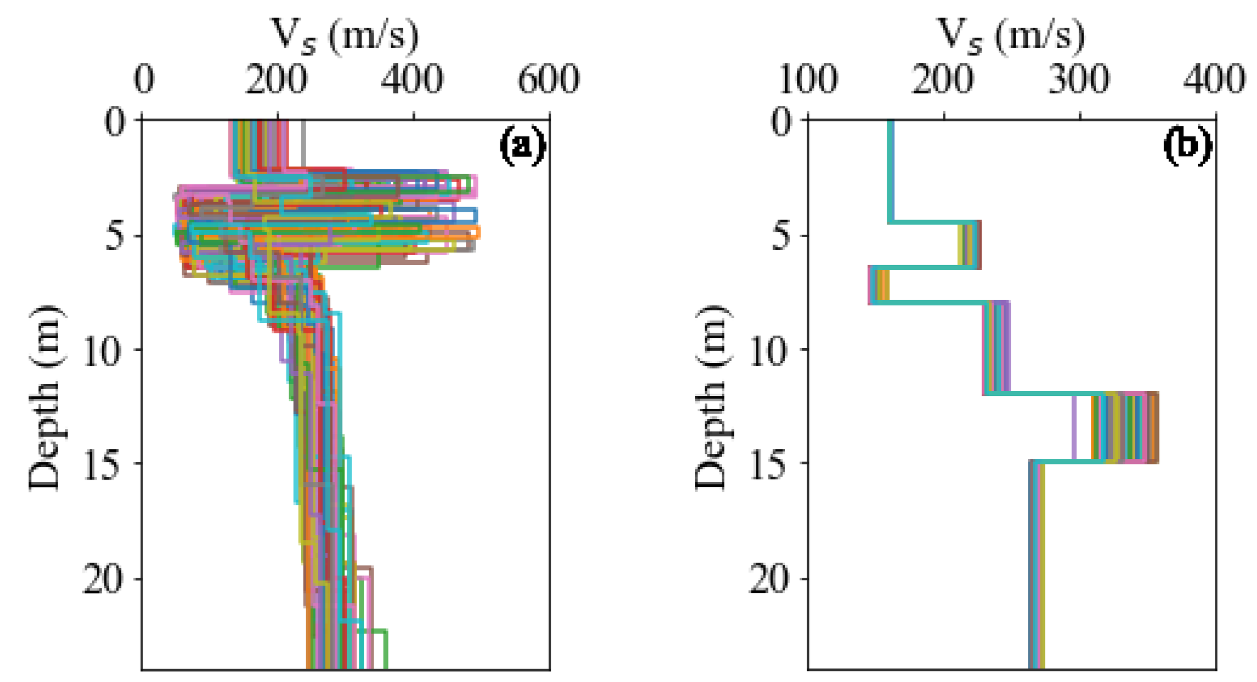


**Fig. 3 100 $V_s$ profiles with the lowest misfit after inversion considering (a) No a-priori information; (b) With a-priori information**

## Observations

From Fig. 3, it is evident that with a-priori information, the variability in the $V_s$ profiles after inversion decreases notably.

In Fig. 4, it can be seen that the range of amplification values is becoming smaller with a-priori information. Also, the band of peak frequency also becomes narrow. This indicates the uncertainty reduction due to a-priori information.

In the box plots in Fig. 5, a huge reduction in the bounds of the $f_0$ values can be seen with the use of a-priori information. Without a-priori information, the mean and standard deviation of $f_0$ were 4.03 Hz and 5.17. With a-priori information, they were 1.44 and 1.12.

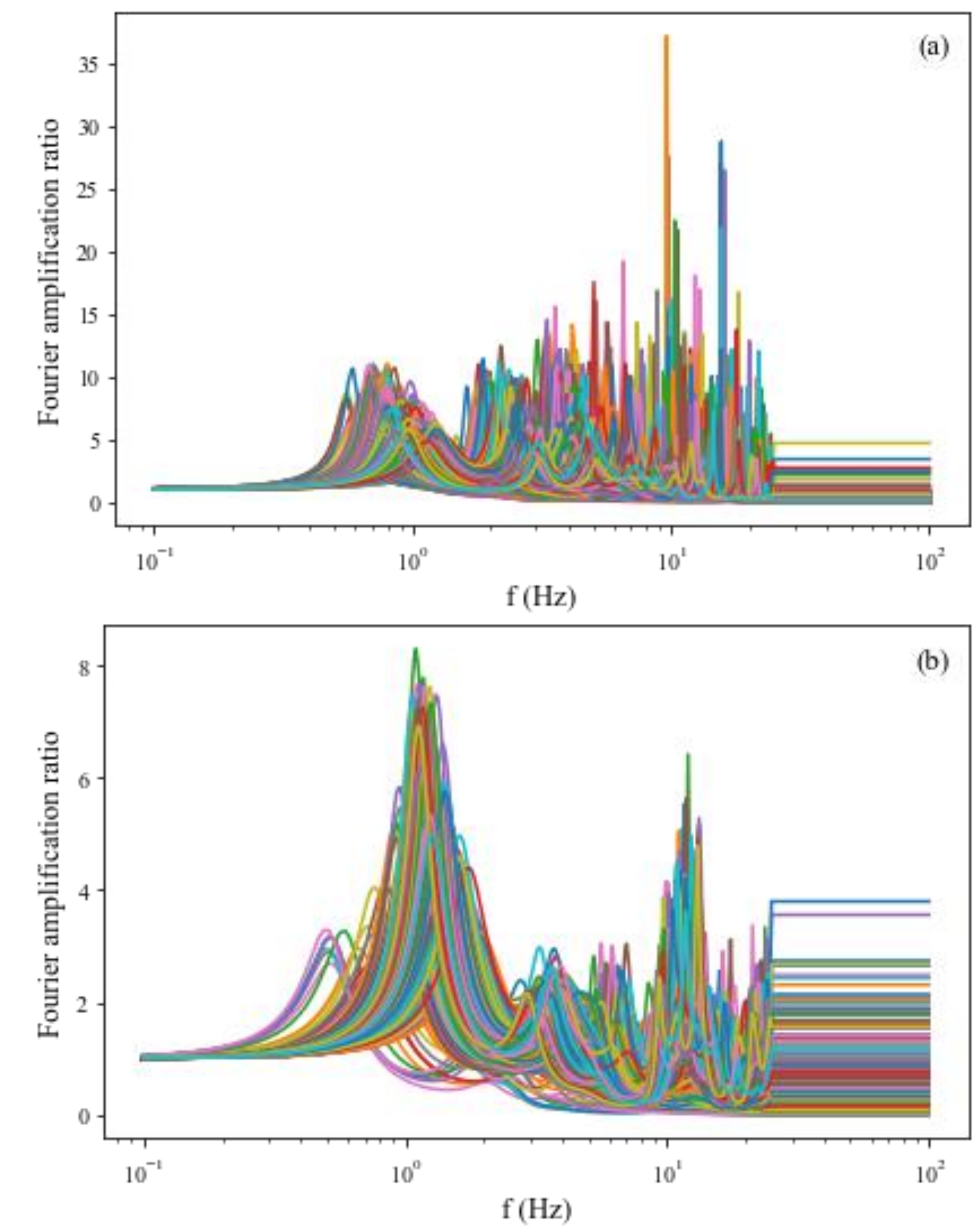


**Fig. 4 Site response analysis results in terms of Fourier amplification ratio considering (a) No a-priori information; (b) With a-priori information**

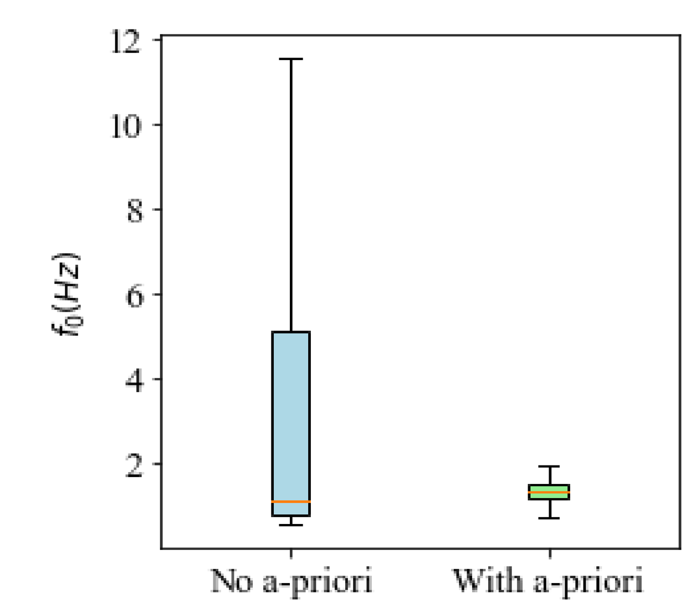


**Fig. 5 Box plots of fundamental frequency of soil considering no a-priori information and with a-priori information**

## Conclusions

The estimation of $f_0$ of soil should be accurate for analyses related to earthquake engineering. The amount of minimization of uncertainties in $f_0$ estimation using MASW testing has been evaluated. It was found that a-priori information leads to significant minimization in the uncertainties in the estimation of $f_0$. To improve the reliability and confidence in the results, it is strongly suggested to use a-priori information along with MASW testing.