Application of Multi-Channel Analysis of Surface Waves (MASW) for Seismic Microzonation: A Case study of Dehradun City

A.K. Mahajan

Wadia Institute of Himalayan Geology33, GMS Road, Dehradun
akmahajan@rediffmail.com

Abstract

The multi-channel analysis of surface waves method (MASW) is a nondestructive seismic method to evaluate thickness of the soil column vis-a-vis shear wave velocity. Both the dispersion curve and the elasticity of Rayleigh waves are controlled by the subsurface velocity structure, in principle, one can invent either of them for shear wave velocity model. Surface waves traditionally have been viewed as noise on multi-channel seismic data designed to image environmental, engineering, and ground water targets by reflection seismic techniques (Steeples and Miller, 1990). A recent development incorporating concepts from spectral analysis of surface waves (SASW), developed for civil engineering applications (Nazarian et al., 1983), with multi-channel seismic acquisition methods as commonly used for petroleum exploration. Extending the common use of surface waves analysis technique from estimating 1-D shear wave velocities to detection and/or imaging required a multi-channel approach to data acquisition, permits the generation of a laterally continuous 2-D shear wave velocity field cross section (Park et al.,1999; Xia et al., 1999). This approach is called the MASW. Similar to the SASW approach, the MASW method derives Shear wave velocities for a layered earth model by inverting Rayleigh wave phase velocities. The MASW technique was tested at several sites in the Fraser River Delta where borehole shear wave velocity information was available, using a 24 channel array of vertical broad-band geophones (4.5 Hz) at 5 meter spacing. Recently this technique has also been applied at Dehradun for shear wave velocity–depth investigations for site characterizations. The survey was undertaken using 24 channel Geometrics Geode unit using 14.5 Hz frequency vertical geophones with hammer as a source. Considering the relative simple and basic equipment of seismograph (24 channels), seismic source (hammer striking a steel plate), the MASW technique represents a rather elegant and versatile approach to shear wave data acquisition. Changes in the selection of a source, the number of geophones and the geophone interval can quickly be made in order to select the optimum field parameters for survey in Dehradun city. It should be mentioned here that depth of investigation can be increased by using a dropping weight hammer and change in shot intervals.

Fifty three sites have been covered in an area of 65 sq km covering the municipal limits of the city. Based on background knowledge of geomorphology and geology, 4-5 sites have been covered from each area. The average shear velocity for the surface layers (5-6 meters) has been estimated to be around 220 meters/sec for most of the sites. However, in some of the sites the velocity of the upper soil layer (5-6 m) is less than 150 meters/sec. In general, the shear wave velocity ranges from 150 meters/sec in the top layer to 1000 meters/sec in the bottom layer of the soil column. Based on the average shear velocities of the upper 30 m of the soils, sites located in the heart of the city are predominantly classified as D (180-360m/s) in accordance with the 1997 NEHRP provision. Sites located in the northern part of the city have average $V_s$ values larger than 360 m/s thereby qualifying them as a class C site (360 -760 m/s). Having the shear wave velocity parameters of the upper 30 m soil column, shake response analysis has been carried out. The shear wave velocities of some of the sites have been correlated with the well log data to calibrate the shear wave velocity profiles. The
information of shear wave velocity along with the soil layers up to a depth of 30 meters becomes an input for shake response analysis. The dynamic material properties of each layer have been taken from the exiting literature. After defining the shear wave velocity, unit weight and dynamic properties of each layer, the strong motion data of Chamoli earthquake has been consider as another major input parameters to calculate the response of each site. The shake response analysis provided us with natural frequency of the soil column along with site amplification and response of each site.

To further improve upon the seismic microzonation it is important to have the core sample data up to 30 meters for some of the representative sites of a city which would be quite useful in defining the dynamic properties of the soil and calibrating the soil layer with the shear wave velocity. It is well known fact that we don’t have strong motion data for each city for major or moderate earthquake so in that case we have to make synthetic seismogram or need to use world wide earthquake strong motion data.