COUPLING PARAMETERS OF THE MIT OBS
AT TWO NEARSHORE SITES

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Abstract. A model representing the coupling of an ocean-bottom seismometer (OBS) to the seafloor as a mass-spring-dashpot system satisfactorily explains the results of transient tests performed on different instruments during the Lopez Island intercomparison test. In this paper, we compare the results obtained for the MIT OBS at Lopez Island to results from similar tests at a dockside site at Woods Hole, Massachusetts. The vertical instrument response at the Lopez Island site shows a highly damped resonance at a frequency of 22 Hz, whereas the response at the Woods Hole site shows a marked resonance at 13 Hz. The difference between the responses at the two sites can be qualitatively attributed to the difference between the surficial sediments.

1. Introduction

A fundamental problem limiting the interpretation of waveforms recorded by an ocean-bottom seismometer (OBS) has been the lack of a model to characterize the coupling between sensed motion and the sea-floor motion in the absence of the OBS. Progress toward solution of this problem has recently been made by Sutton et al. (1981a) and Zelikovitz and Prothero (1981), who adapted a model from the engineering literature (e.g., Richart et al., 1970) in which a structure sitting on sediment is represented as a mass-spring-dashpot system. Briefly, the system can be parameterized by a resonant frequency and a damping constant, both of which are functions of the instrument geometry and mass and of the physical properties of the underlying sediment. For the OBS situation, a coupling constant which includes the effect of instrument buoyancy multiplies the system forcing function (ground motion in the absence of the instrument), and a correction factor must be added to the mass of the instrument to compensate for the hydrodynamic force of the water when the water moves relative to the instrument. Near the resonant frequency, the OBS motion is amplified relative to the overall ground motion we wish to measure, and the amplification is determined by the damping of the system and the buoyancy of the instrument. At
frequencies above the resonant frequency, the response is attenuated.

The equation describing the response spectrum of the system is (Sutton et al., 1981a; Equation (11-E)):

$$\frac{I}{Z} = \frac{(1-C) \left[-\omega^2 + \frac{2D}{1-C} \omega_c \omega_i + \frac{\omega_c^2}{1-C}\right]}{(-\omega^2 + 2D \omega_c \omega_i + \omega_c^2)}$$  \hspace{1cm} (1)

where $I$ is the OBS motion, $Z$ is ground motion in the absence of the OBS, $C$ is the buoyancy factor ($C=1$ for the transient tests described in this paper), $\omega$ is the angular frequency, and $\omega_c$ and $D$ are the system resonant frequency and damping (expressed as a fraction of critical damping), respectively. The amplitude response is illustrated in Figure 1.

![Amplitude response of the OBS-sediment system relative to ground motion in the absence of the OBS. The parameters are described in the text (from Sutton et al., 1981).](image)

Fig. 1. Amplitude response of the OBS-sediment system relative to ground motion in the absence of the OBS. The parameters are described in the text (from Sutton et al., 1981).

The model predicts that, for vertical motion and $D \leq 0.425$,

$$\omega_c = 2 \left[ \frac{\mu}{1-\nu} \frac{R}{M^*} \left(1-2D^2\right) \right]^{1/2}$$  \hspace{1cm} (2)

and

$$D = 0.85 \left[ \frac{\rho_s}{1-\nu} \frac{R^3}{M^*} \right]^{1/2}$$  \hspace{1cm} (3)

where $R$ is the radius of the bearing area of the instrument; $M^* = M + M_v$, where $M$ is the mass of the instrument and $M_v$ is a term due to the hydrodynamic force.