

Closure to “Ground Vibration Measurements near Impact Pile Driving”, by Athina Grizi, Adda Athanasopoulos-Zekkos, Richard D. Woods.

The authors would like to thank the discussor for his interest in this work. The discussor states that there are no connections of the obtained results with the problem of dynamic settlement or any investigations of dynamic settlement in the paper and therefore the references to dynamic settlement are irrelevant in the paper. The authors point out in the Introduction and Background section that little has been reported on vibratory settlement from pile driving even though the importance of that problem is recognized. The emphasis of this paper as suggested by its title is on Ground Motion Measurements. Readers can make their own extension of the reported results to settlement through the close relation of settlement to PPV and strain which is reported in the paper or wait for future publications based on this research where that connection will be made. Furthermore, the authors assert that those references help reinforce the justification for making the measurements reported in the paper.

The discussor states that the zone classification is not clear referring to the labeling in Fig. 2. The authors agree that a conclusive definition of three zones surrounding a driven pile has not yet been arrived at. The distribution of buried sensors in the experiments described here did not cover the full extent of the postulated zones. It is even possible that more zones should be included in the model but current data does not allow that additional refinement. The discussor writes that measured ground motion close to the pile/soil interface was not compared with Eq (2), however Figures 18 and 19 show the calculated interface PPV along with PPV at each of the buried sensors.

The discussor also mentions that the origin of Eq (3) is not clear. The authors found that both parts of the equation, i.e. geometrical attenuation and material attenuation, was presented in Bornitz (1931). Mintrop (1911) presented the geometric attenuation term and Golitsin (1912) presented the material attenuation term independently, but neither combined the terms as did Bornitz (1931). The α term in Eq (3) is dependent on frequency as the discussor says, and that dependence is included in the reference cited by the authors, Woods (1997) and they agree with the discussor that Eq (3) is attractive for both researchers and practitioners because it includes both geometric and material damping.

The discussor criticizes the application of the material damping term of Eq (3) (Golitsin, 1912) because Golitsin applied this form of damping to earthquake generated waves of long wavelength and low frequency and he claims this term should not be used for higher frequency and shorter wavelength vibrations. However this expression for material damping can be derived from first principles for any “low loss” material with damping as demonstrated by Santamarina et al (2001). The Santamarina derivation does limit the application to “low loss” materials so while this model of attenuation could be applicable to earthquake waves at great distance from the source as for Golitsin (1912) the application to material immediately adjacent to a pile during driving is technically invalid.

The discussor states that collected experimental data indicate that the coefficient (α) depends on the energy of vibration sources, the dominant frequency of waves propagated in the medium of soil, the distance from the source and the soil stratification at a site. Experimental data reported

by Woods and Jedele (1985) indicated similar results except that the source energy was not a factor where 7 different sources were studied. Furthermore, based on the previous discussion on Eq. (3) the authors have explained that they adopted Eq (3) as an approximate model for attenuation of vibrations from pile driving. The equation contains both important attenuation factors and can be molded to fit the data. Other models could be adopted but do not contain both separate terms for geometric and material damping terms. The authors acknowledge an additional damping factor could be in play at the sites studied, that is, the attenuation that accompanies multiple reflections and refractions caused by soil layering. At this stage of analysis, only a homogeneous medium is considered. However, the authors disagree with the discussor's comment that the application of Eq (3) in the paper has no basis and yields wrong results. Furthermore, as shown in Figure 21, the α coefficient can be used to fit both near field (buried sensors) and far field data (surface geophones), contrary to the discussor's comment.

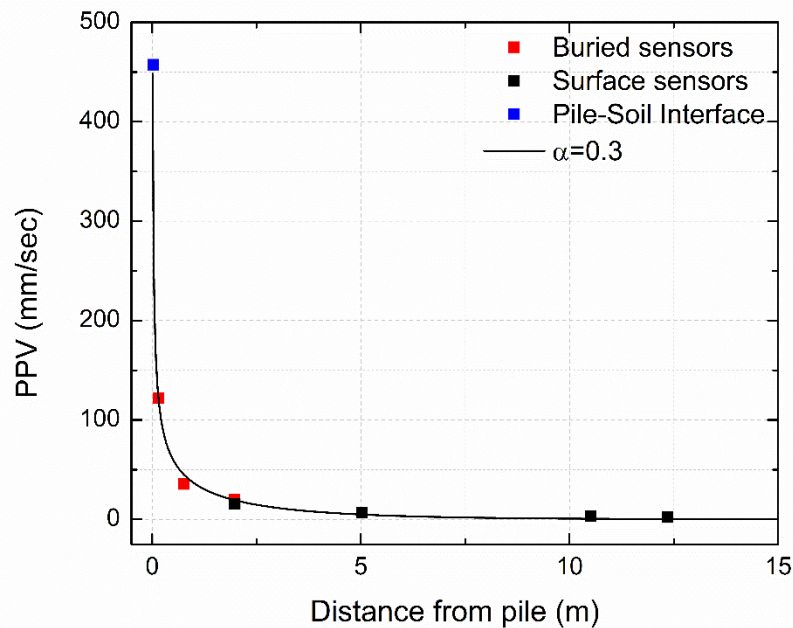


Figure 21: Attenuation curves fitted to in-depth measurements (7.8 m) and surface geophones' data at M-139 site

The sites and the resources available to the writers were not conducive to extensive examination of wave propagation in all directions from the driven pile. However, the potential difference in vibration propagation from the open side of an H-pile and the flange side of the pile was studied with a result that at one or more equivalent pile diameters from the pile face, wave propagation was identical in both directions. The frequency content of each blow of the diesel hammer was recorded and analyzed, however the length of this paper did not allow a detailed analysis of the frequency content of the blows. Future papers may address this issue.

References

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