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The real evidence of effects from source to freefield as base for nonlinear seismology

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Authors developed in last time the concept of "Nonlinear Seismology-The Seismology of the XXI Century". Prof. P. M. Shearer, California Univ. in last book:(i) Strong ground accelerations from large earthquakes can produce a non-linear response in shallow soils; (ii) The shaking from large earthquakes cannot be predicted by simple scaling of records from small earthquakes; (iii) This is an active area of research in strong motion and engineering seismology. Aki: Nonlinear amplification at sediments sites appears to be more pervasive than seismologists used to think. Any attempt at seismic zonation must take into account the local site condition and this nonlinear amplification (Tectonophysics, 218, 93-111, 1993). The difficulty to seismologists in demonstrating the nonlinear site effects has been due to the effect being overshadowed by the overall patterns of shock generation and propagation. In other words, the seismological detection of the nonlinear site effects requires a simultaneous understanding and splitting up (if it is possible. . . and if it is necessary!) the effects of earthquake source, propagation path and local geological site conditions. To see the actual influence of nonlinearity of the whole system (seismic source-path propagation-local geological structure) the authors used to study the free field response spectra which are the last in this chain and they are the ones who are taken into account in seismic design of all structures. Soils from last part of this system(source-freefield) exhibit a strong nonlinear behaviour under cyclic loading conditions and although have many common mechanical properties require the use of different models to describe behavior differences. Sands typically have low rheological properties and can be modeled with an acceptable linear elastic model and clays which frequently presents significant changes over time can be modeled by a nonlinear viscoelastic model The real evidence of site effects from source to freefield analysis was conducted by using spectral amplification factors for last strong and deep Vrancea earthquakes (March 04,1977;MW =7.5;h=94.5 km; August 30,1986;MW=7.1;h=134.5 km; May 30 1009;MW=6.0;h=90.9 km; May 31, 1990; MW=6.4 ;h=86.9 km).The amplification factors decrease with increasing the magnitudes of strong Vrancea earthquakes and these values are far of that given by Regulatory Guide 1.60 of the U. S. Atomic Energy Commission and IAEA Vienna. The concept was used for last Stress Test asked by IAEA Vienna for Romanian Cernavoda Nuclear Power Plant.. The spectral amplification factors were: SAF= 4.07 (MW =7.1); 4.74(MW=6.9) and 5.78 (MW=6.4), unction of earthquake magnitude. The analysis indicates that the effect of nonlinearity could be very important and if the analysis is made for peak accelerations, it is 48.87% smaller assuming that response of soil to earthquake with MW=6.4, it is still in elastic domain. In other 25 seismic stations here are values between 14.2% and 55.4%. The authors are coming with new quantitative real and recorded data in extra-Carpathian area with large alluvial deposits / sediments, thick Quaternary layers etc.