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CHAOS FOR EXIMINING THE FUNDAMENTAL PERIOD OF SOILS

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The traditional mathematical models associated with the analysis of earthquakes are mostly linear and may fail to describe and to forecast behaviors because in many cases the data they model may be highly nonlinear and complex. In this paper the implementation of Chaos theory for seismic time series analysis is presented. The tool, Recurrence Plots RPs, enables recognition and treatment of measured accelerations. The nonlinear attributes from RPs analysis can be used as filters to reveal patterns in the vibration of soils.

The technique presented in this paper permits to estimate the natural period of the vibration directly from the accelerograms recorded on soft soils. Using a RP allows measuring higher mode frequencies of the soil as well as modal damping. Vibration periods satisfy the classic 1D equation S wave theory and are truthfully related to determinism. Through the numerical conclusions of this investigation it can be argued about the presence of free vibrations, the wave soil energy radiation episodes and the energy amplification of incoming stationary seismic shear waves or dynamic soil amplification.

An important deduction of this study is that the RPs of rock-like materials exhibit a complex recurrent behavior with irregular cyclicities that qualifies them as dynamical systems and their behavior as typical for nonlinear or chaotic systems. This means that these materials are highly sensitive to initial conditions, e.g. small differences in directivity, fault mechanism or distance, yield widely diverging outcomes. Then the linear analysis techniques applied to rock-like materials either fail or become meaningless to describe seismic responses and the spectral relations derived from these preprocessing techniques do not produce meaningful results.

Using Chaos theory the geological materials can be seen as systems that evolve, under a macro perspective, in a similar way, but there are important differences between materials responses and they can be linked to certain determinism or sensitivity to initial conditions. For very soft soils it is possible to obtain vibration periods and they can be labeled as "predictable" behaviors, but as the soils become stiffer the slightest change in initial conditions or noise may cause the system to enter a very different trajectory and the use of the 1D equation could be prohibitive. Considering this warning as valuable, the discrepancies between theoretical soil dynamic amplification and the in situ measurements can be explained: the rock-like (considered as outcropping) and the soft soils are from poles apart dynamic nature.