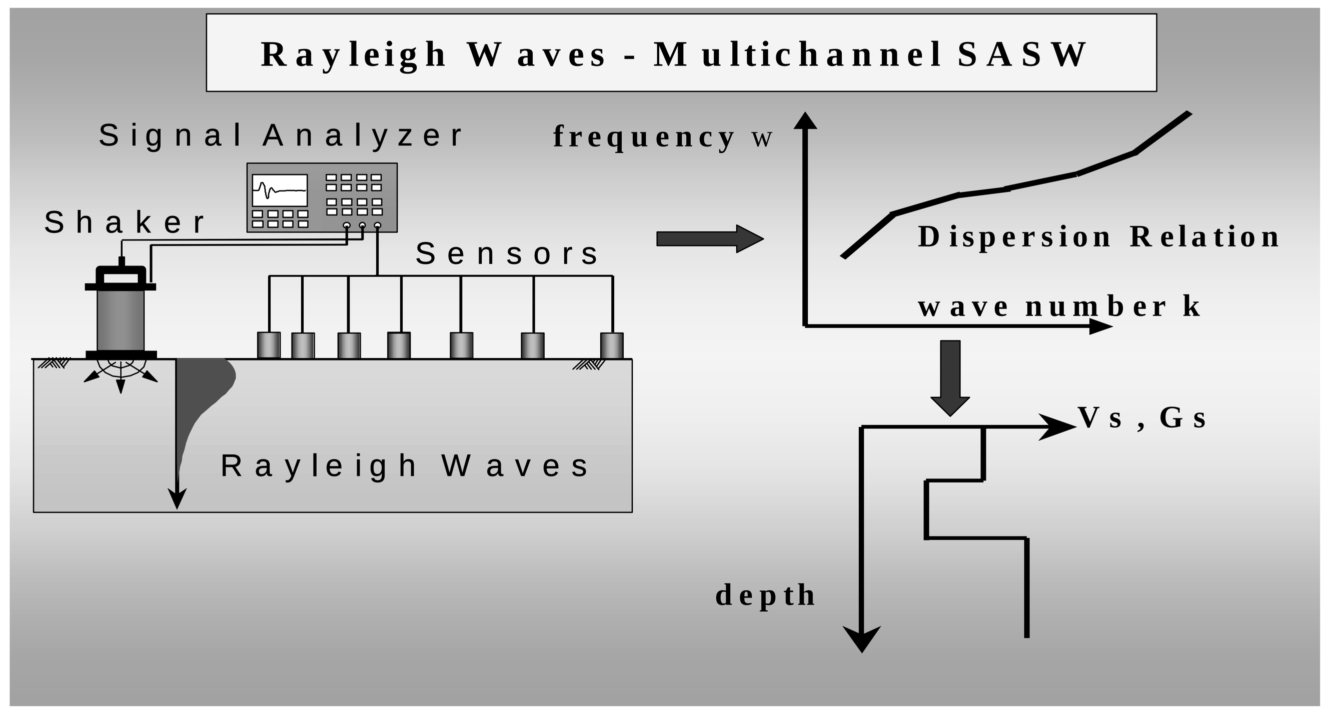
12th ECEE, 9-13 September 2002, London

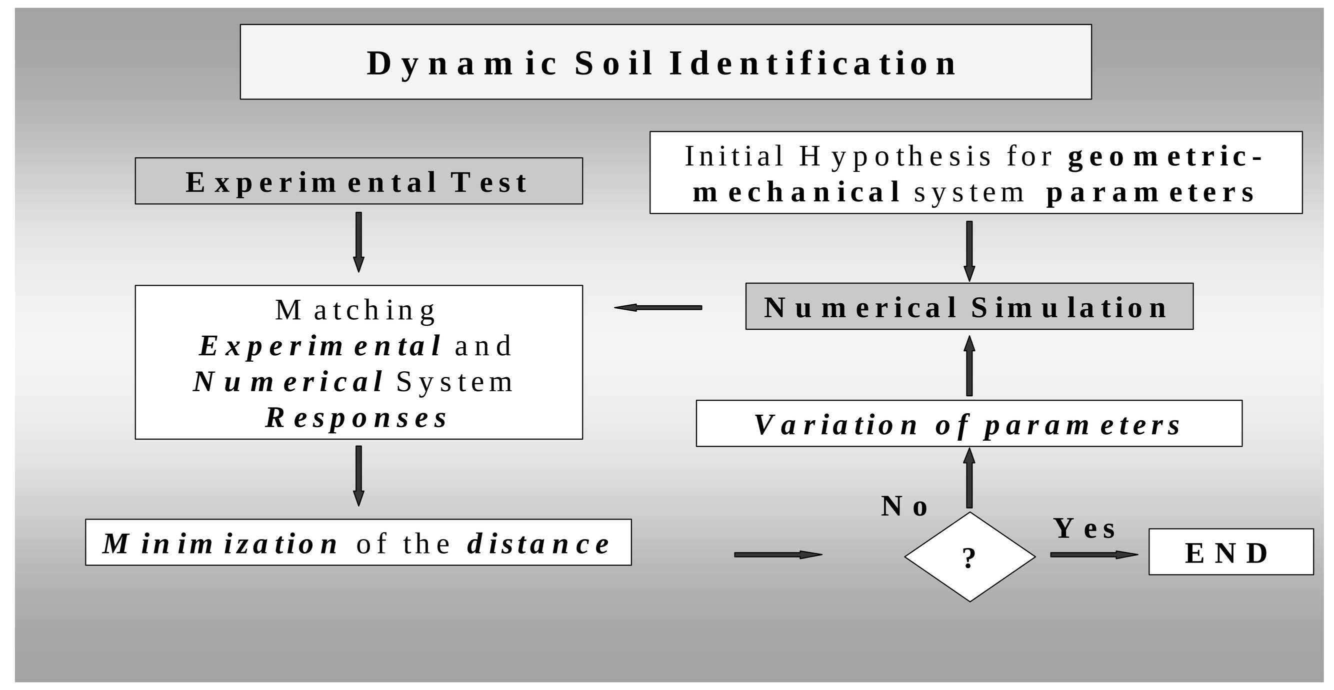
Geotechnical Soil Characterization Using Fundamental and Higher Rayleigh Modes Propagation in Layered Media

Vitantonio Roma[1], Glenn Rix[2], Carlo Lai[3], Gregory Hebeler[2]

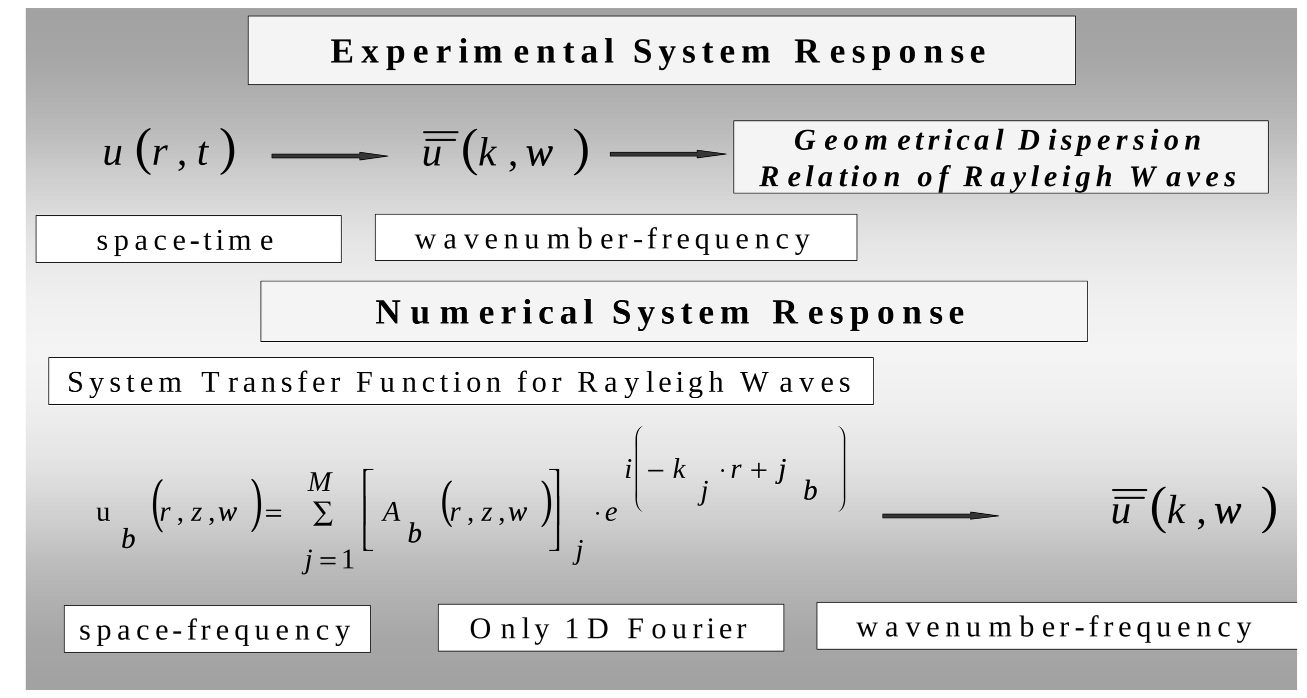
Multichannel SASW (Spectral Analysis of Surface Waves) is a non-invasive technique, based on the detection of Rayleigh waves on the free surface of the site. The wave field can be generated on the free surface by means of a point source, either impulsive or harmonic. From the measured travelling perturbation the Experimental Geometric Dispersion Relation of Rayleigh waves is evaluated, by 2D Fourier Transformation of the wave field from time-space domain to frequency-wave number domain. The Identification Procedure is based on iterative variation of the initial set of System Parameters, until the *distance* between the Experimental and the Numerically Simulated Dispersion Relations is minimized. The Numerical Simulation is obtained by only 1D Fourier Transformation of the Transfer Function of the System, which is available in analytical form. The physical concept the method is based on is that the Dispersion Relation of Rayleigh wave represents an intrinsic characteristic of the Layered Medium. With this method the 2D Fourier Transformation of the wave field as in the experiments is avoided; there is no need of Source characterization; sites with irregular stiffness profiles can be identified, since Higher Modes of Rayleigh are considered; Congruence between Experiment and Simulation is guaranteed in the receivers configuration. As an example the method has been successfully applied to the Site under the Leaning Tower of Pisa.



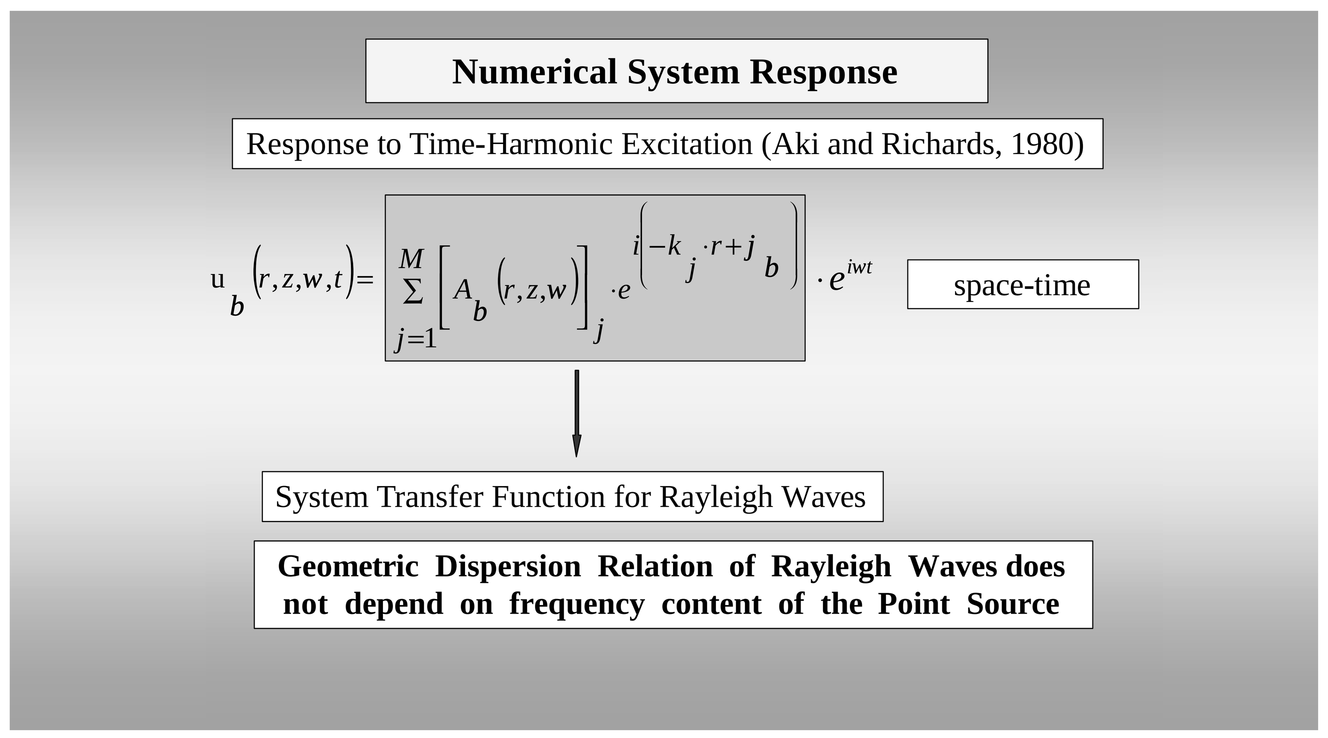
1) Experimental setup-System Response and Stiffness Profile



2) Inversion Procedure: Experimental Test + Numerical Simulation + Optimization Problem



3) System Response: Geometrical Dispersion Relation of Rayleigh Waves



4) Rayleigh Dispersion Relation as intrinsic characteristic of the Layered Media

Numerical System Response

Advantages

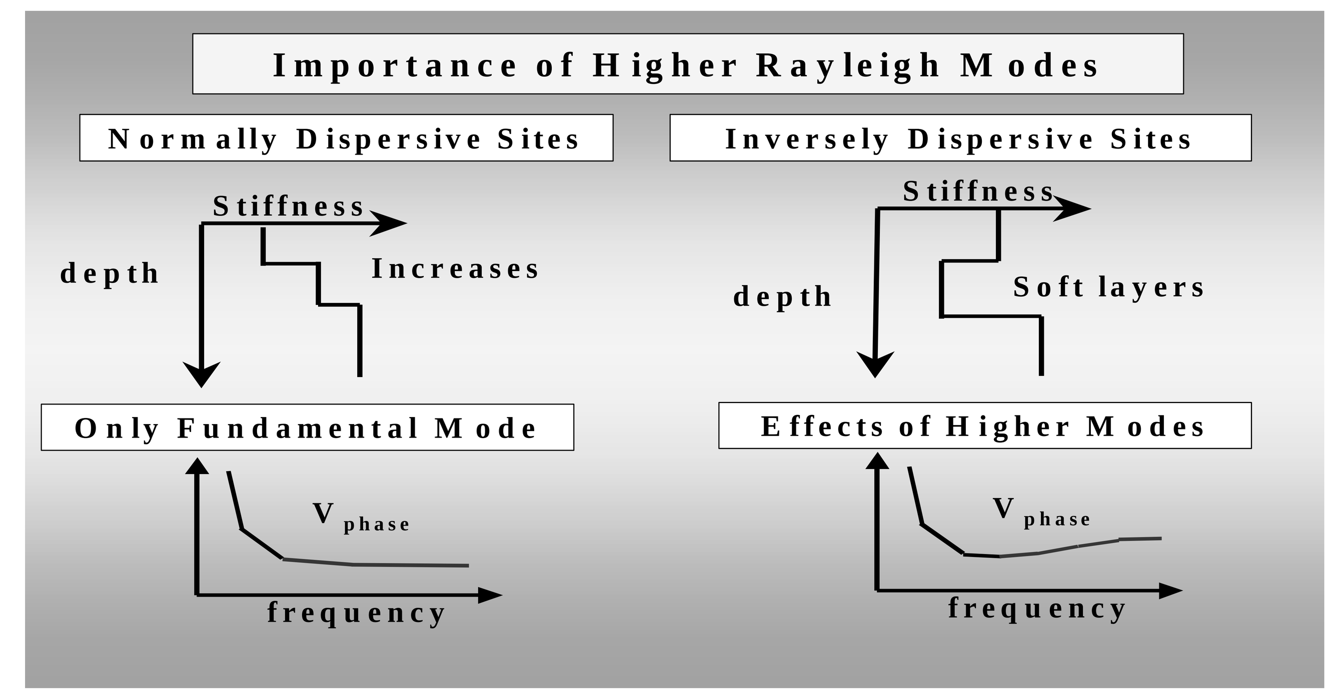
(1) No need for Source characterization used in the Experiment

(2) Congruence between Experimental and Numerical procedures (i.e. same configuration of receivers)

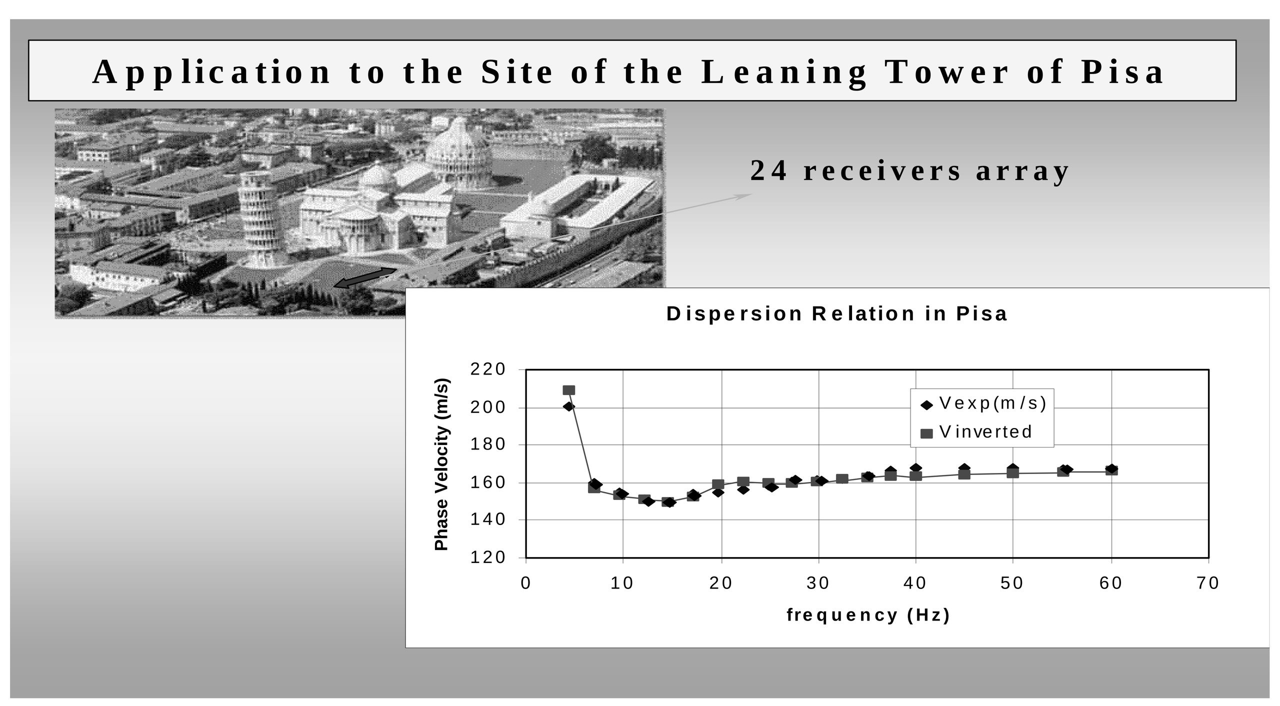
(3) Only 1D Fourier Transformation: time saving for Inversion Procedure

(4) Higher Rayleigh Modes are included in the Wave Propagation Simulation

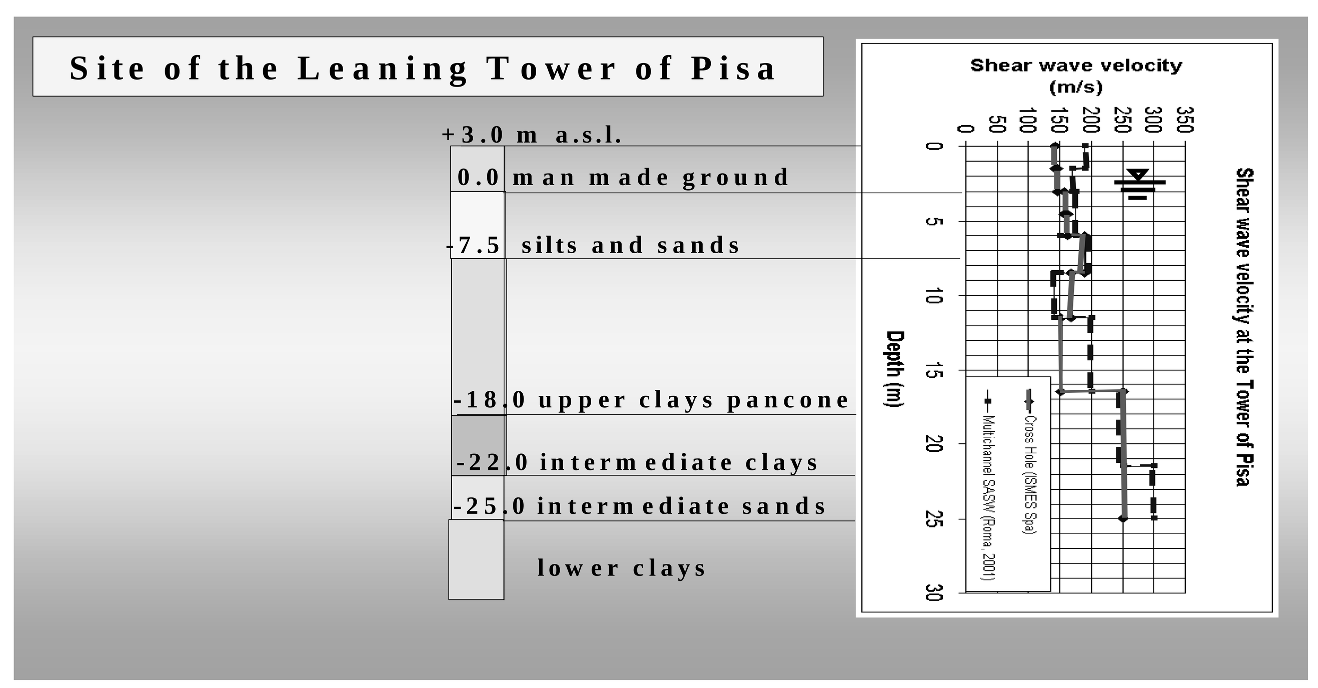
5) The Numerical Simulation can be performed using the System Transfer Function



6) For Site Identification with Irregular Stiffness Profile the Higher Modes of Rayleigh Waves must be considered



7) Experimental Response (rhombus) and Numerical Simulation at last iteration (solid squared line) of the Inversion Procedure at Miracles Square in Pisa



8) Comparison among Cross Hole and Multichannel SASW and the stratigraphy. The Site at Miracles Square in Pisa is Inversely Dispersive.

Conclusions

(1) Rayleigh Waves as a powerful means for Soil Characterization at very small strain level

(2) Non-Invasive technique promising for in Situ determination of Stiffness and Damping Profiles

(3) Application to Earthquake Engineering and Soil-Structure Static and Dynamic Interaction

(4) Higher Rayleigh Modes are included in the Wave Propagation Simulation

9) The proposed Numerical Simulation of Rayleigh Dispersion Relation as System Response is based on Wave Propagation in Layered Media and allowes for: (a) Congruence between experimental and theoretical procedures (b) Higher Modes of Rayleigh to be considered (c) No need of Source Characterization (d) Time saving in the iterative Inversion Problem

[1] **GEODATA** (GeoEngineering Consultants, Torino, Italy); [2] **GEORGIA INSTITUTE OF TECHNOLOGY** (Atlanta, USA); [3] **STUDIO GEOTECNICO ITALIANO** (Milano, Italy)