KSU-11-7

I. RESEARCH PROJECT TITLE

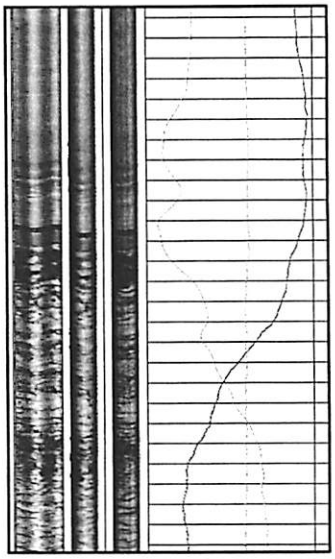
Integration of downhole and cross-hole P- and S-wave velocity measurements, acoustic televiewer downhole imaging, and surface seismic waves for elastic moduli evaluation and fracture anisotropy analysis

II. RESEARCH PROBLEM STATEMENT

Recent design standards for bridge structures require integrating comprehensive geotechnical site characterization. Furthermore, Evaluation of dynamic soil properties is important for proper seismic response analysis and soil modeling programs. Liquefiable layers and strong in-situ elastic anisotropy could play significant role as major contributors to lesser factors of safety. The geotechnical and geochemical site characteristics are a function of the subsurface soil condition, soil chemistry, elastic moduli anisotropy, and the geologic structure. Elemental in a sound geotechnical site characterization is evaluation of in-situ shear modulus, Poisson's ratio, and stiffness; Q-related parameters. It is more dependable to build 3D spatial distribution of elastic moduli and rock mass quality (Q) rather than using point measurements, hence the significance of integrating downhole/cross-hole seismic and acoustic televiewer imaging with surface waves seismic method.

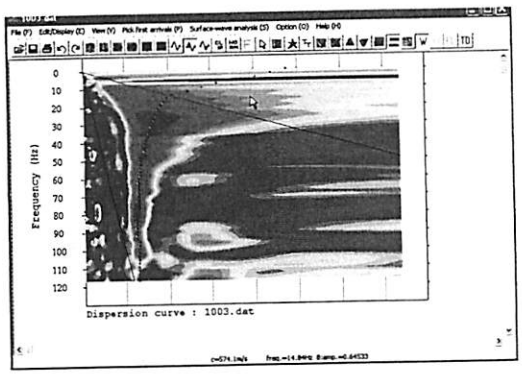
III. RESEARCH PROPOSED OR RESEARCH OBJECTIVES

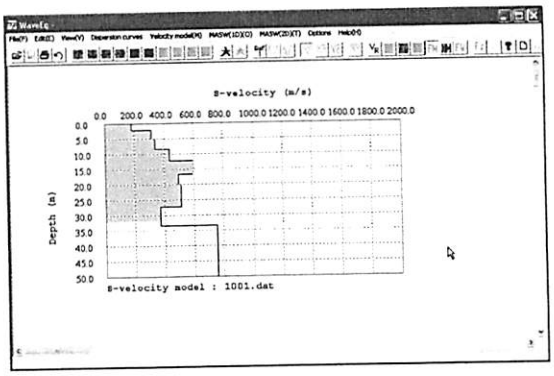
Seismic methods such as the down-hole or cross-hole method have been well established and accepted in geotechnical practice. Wave velocities are the major products of the seismic methods; the wave velocities of a geo-material depend primarily on the material's elastic stiffness and resilience (rigidity) moduli. In this investigation, we propose integration of high-resolution downhole and cross-hole shear and longitudinal seismic wave data with very high-resolution downhole acoustic televiewers images and surface waves dispersion analysis in order to achieve more robust three dimensional evaluation of in-situ dynamic elastic moduli, velocity (elastic moduli) anisotropy, and subsurface fractures orientation analysis. An appropriate synergistic interpretation of direct downhole velocity surveys and cross-hole seismic velocity tomography on one hand the shear wave velocities estimation from surface wave dispersion analysis offer great potential of well validated results. The purpose of the acoustic borehole imaging tool is to provide detailed, oriented caliper and structural information on the basis of high resolution, ultrasonic travel time and amplitude images. The travel time is used to determine accurate borehole diameter data that makes the tool ideal for borehole deformation description (stress field analysis).



In a workflow of geotechnical and geochemical investigation, our approach of in situ characterization that will also include soil characterization via knowing its chemical constituents can minimize soil disturbance effects and can reflect on the average elastic moduli in a relatively large domain adjacent to the test position. One of our research objectives is to deduce a 3D prediction for both vertical and horizontal stresses utilizing seismic velocity downhole data and tomographic inversion (back calculation) of cross-hole travel times.

Down-hole Acoustic Televiewer imaging, Gamma, Short period Resistivity: Transition from a shale to a slightly vuggy, fractured & weathered dolomite. gamma (black), SPR (red) and acoustic caliper (green). The acoustic imaging is represented by an unwrapped amplitude image log on the far left, and two amplitude and travel time composite logs to form 3D images .





Inversion (right) of surface waves velocity dispersion curve into 1D shear wave velocity with depth of 35 m to bedrock

IV. ESTIMATE OF FUNDING AND RESEARCH PERIOD

The anticipated period of accomplishing this project is 18 months, starting from May 2010. Estimated budget is $34,900 direct costs.

V. URGENCY AND PAYOFF POTENTIAL

The trend established by amendments to modern bride structure codes requires more comprehensive geotechnical site characterization. In the heart of sound geotechnical practice, is to establish reliable and representative elastic stiffness and shear (resilient) modulus estimates. This proposed research would benefit geotechnical characterization significantly through establishing 3D estimates of elastic moduli and stress state. The pay off potential mainly lie in high-value, reliable, cost-effective characterization that would overcome difficulty relating to effects of soil disturbance and to estimating horizontal stresses. The integration of surface waves dispersion analysis and inversion with downhole velocity measurements and cross-hole seismic velocity tomography estimates would limit effects of inaccessibility and reduce cost for a drilling program.

VI. IMPLEMENTATION STRATEGY

The implementation would be coordinated with KDOT personnel in such a way that we take into account research findings and provide cost-effective workflow. A careful assessment would be considered as to means of optimizing benefits of potential project findings in regard to drilling fewer boreholes without jeopardizing effectiveness of site characterization endeavors. This will incorporate establishing detailed 3D geotechnical characterization approach with cross validation and testing component.

VII. PROJECT PERSONNEL

Abdelmoneam Raef, Assistant Professor (Geophysicist) at KSU-Geology department, main area expertise includes geophysical data processing and interpretation, and Neural Networks applications to pattern classification and property prediction.

Saugata Datta, Assistant Professor (Geohydrologist) at KSU-Geology department, main area of expertise is in hydro-geochemistry, groundwater flow modeling.

VIII. SUBMISSION INFORMATION

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