Geop480: Lectures (19)

Engineering Seismology-3

The Refraction Microtremor (ReMi) Method

Outline

- ❑Remi
- ❑Equipment
- ❑Data Acquisition
- ❑Remi Method
- ❑Case Works

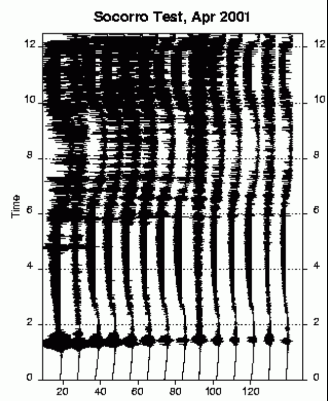
Recall: ReMI for Shallow Shear Velocity

Low-frequencies, 1-20 Hz, so bad geophone plants still work.

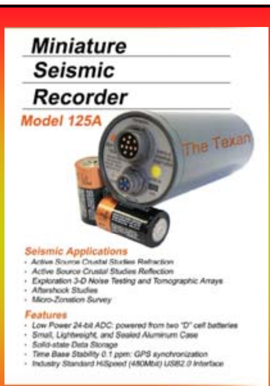
Modified after 2005 Presentation of Dr.J.Louie

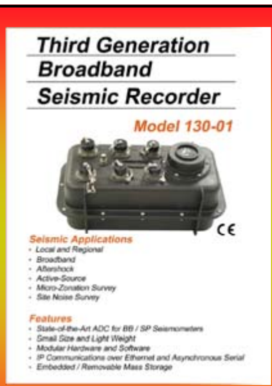
IRIS Deployment in Venezuela, 2001

"line" of fifteen Reftek 125 "Texan" recorders



From: http://www.passcal.nmt.edu/%7ebob/passcal/venezuela





That is what named as "Model 130-01" which was ordered for ESD in 2006.

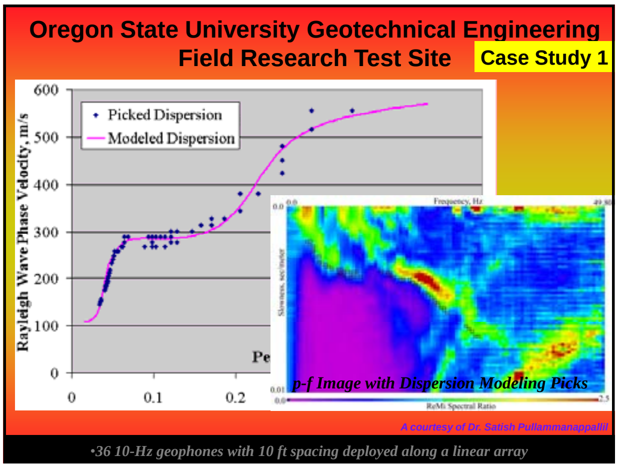
From: http://www.reftek.com/productshome.html#Seismic%20Recorders

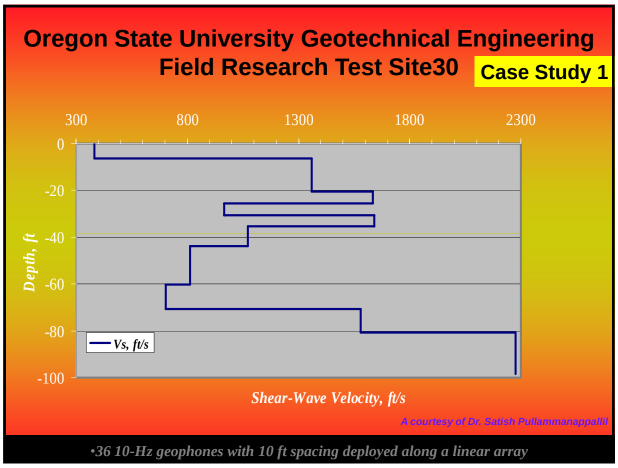
Texan for REMI:

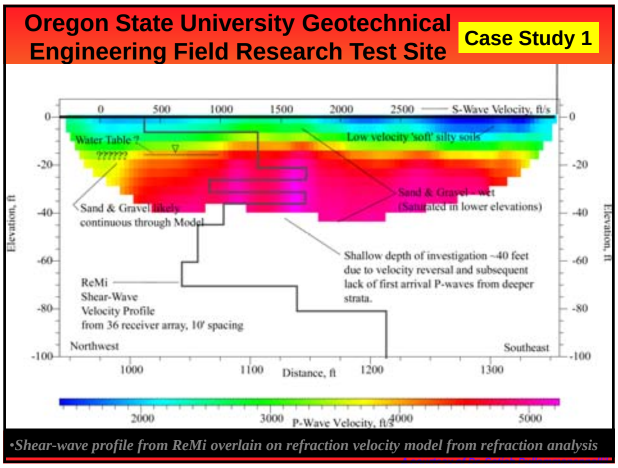
- Approximately 60 km in length
  - Followed San Gabriel River Bike Path
  - 20 m takeout interval, 300 m array, recorded for 30 min
- 4 teams, 3 people each, 4.5 days
- 120 IRIS/PASSCAL "Texan" single-channel recorders mated to a vertical 4.5-Hz geophone

Supported by USGS, NEHRP ERP
and IRIS-PASSCAL

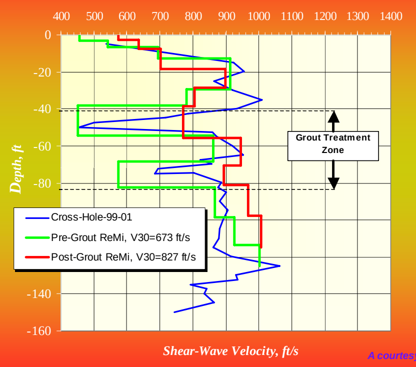
Modified after 2005 Presentation of Dr.J.Louie


Oregon State University Geotechnical Engineering
Field Research Test Site
Case Study 1
Rayleigh Wave Phase Velocity, m/s
Picked Dispersion
Modeled Dispersion
p-f Image with Dispersion Modeling Picks
A courtesy of Dr. Satish Pullammanappallil
•36 10-Hz geophones with 10 ft spacing deployed along a linear array


Oregon State University Geotechnical Engineering
Field Research Test Site30
Case Study 1
Depth, ft
Vs, ft/s
Shear-Wave Velocity, ft/s
A courtesy of Dr. Satish Pullammanappallil
•36 10-Hz geophones with 10 ft spacing deployed along a linear array


Oregon State University Geotechnical Engineering Field Research Test Site
Case Study 1
S-Wave Velocity, ft/s
Water Table ?
Low velocity 'soft' silty soils
Sand & Gravel – wet
(Saturated in lower elevations)
Sand & Gravel likely
continuous through Model
Shallow depth of investigation ~40 feet
due to velocity reversal and subsequent
lack of first arrival P-waves from deeper
strata.
ReMi
Shear-Wave
Velocity Profile
from 36 receiver array, 10' spacing
Northwest
Southeast
Elevation, ft
Distance, ft
P-Wave Velocity, ft/s
•Shear-wave profile from ReMi overlain on refraction velocity model from refraction analysis

Wickiup Dam, Deschutes National Forest, Oregon



A courtesy of Dr. Satish Pullammanappallil

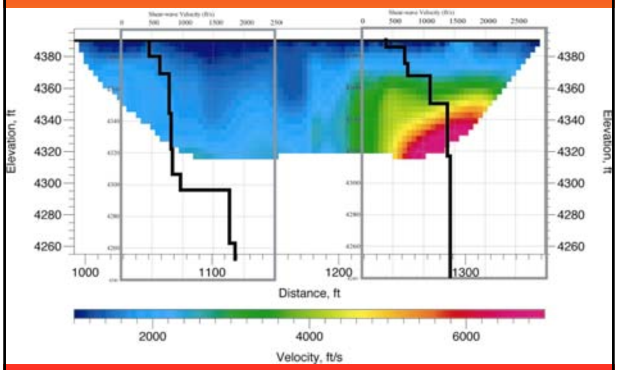
Case Study 2

•*Comparison of Cross-hole and SeisOpt ReMi at Wickiup*

Case Study: ReMi Study across fault zone

Purpose: Verify Depth to bedrock

Case Study 3



A courtesy of Dr. Satish Pullammanappallil

Shallow Shear Velocity and Seismic Microzonation of the Urban Las Vegas, Nevada Basin

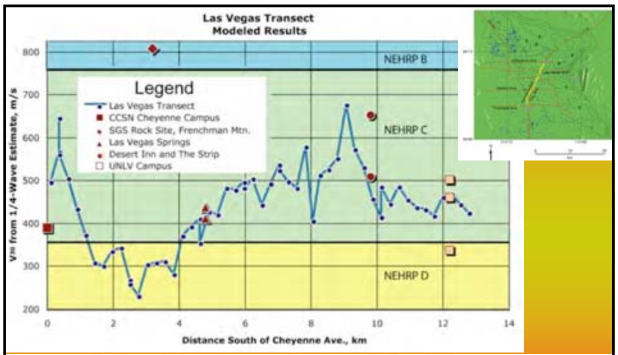
By *James B. Scott, Tiana Rasmussen, Barbara Luke, Wanda J. Taylor, J. L. Wagoner, Shane B. Smith, and John N. Louie*

In press in *BSSA, vol. 96*, no. 3 (June, 2006).

Case Study 4

Abstract

Las Vegas Valley has a rapidly growing population exceeding 1.5 million, subject to significant seismic risk. Surveys of shallow shear velocity performed in the Las Vegas urban area included a 13 km-long transect parallel to Las Vegas Boulevard ("The Strip"), and borehole and surface-wave measurements of 30 additional sites. The transect was completed quickly and economically using the refraction microtremor method, providing shear velocity versus depth profiles at 49 locations. The lowest velocities in the transect, NEHRP D class, are near intra-basin faults found near I-15 and Lake Mead Boulevard. Calcite cementation of alluvium (a.k.a. caliche) along the Las Vegas Strip elevates Vs30 values to 500-600 m/s, NEHRP C class. Our transect measurements correlate poorly against geologic map units, which do not predict the conditions of any individual site with accuracy sufficient for engineering application. Some USDA soil map units do correlate, and Vs30 predictions based on measurements of soil units match transect measurements in the transect area. Extending soil-map predictions away from the area of dense measurement coverage generally failed to predict new measurements. Further, for several test sites the predictions were not conservative, in that the soil model predicted higher Vs30 than was later measured (predicting lesser potential ground motion). Subsurface information is needed to build a Vs30 model extending predictions throughout Las Vegas Valley. A detailed stratigraphic model built by correlating >1100 deep well logs in Las Vegas predicts Vs30 better than surface maps, but again only in parts of the Valley well-measured for velocity. The stratigraphic model yields good predictions of our transect Vs30 measurements. It is less accurate, although at least conservative, when extended to sites away from the transect.



ig. 3: Depth-averaged values of Vs30 for 49 points along the Las Vegas transect. Vs30 values are slowness-veraged from 49 modeled velocity-depth profiles. Eighteen of the transect locations were independently modeled y different analysts; all of the values they obtained are plotted. Refer to fig. 1 for geographical reference fo ransect distances. Vs30 values obtained by various techniques at sites off the transect are also plotted afte rojection onto the transect.

Case Study 4 *Scott et al., 2006*

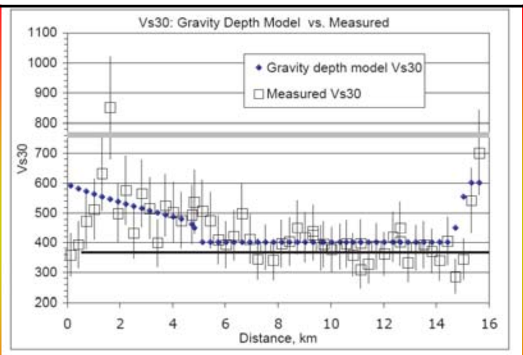


Fig.8: Vs30 according to an alluvium-depth model derived from a basin-gravity survey (Abbott and Louie, 2000) versus the measurec values of Vs30 along the transect, with ±20% error bars on the

Case Study 4 *Scott et al., 2006*

Applications

- ReMi V_s profiles can be used for:
  - *Earthquake site response*
    - *IBC site classification based on 100 ft (30m) average shear-wave velocity*
    - *Site amplification maps*
  - *Mapping the subsurface and estimating the strength of subsurface material*
    - *Couple with P-wave information one can derive Poisson ratio and other engineering parameters*
  - *Complementing seismic refraction analysis in areas characterized by near-surface velocity reversals*
    - *Maps low velocity zones that refraction cannot*
    - *Extend depth of investigation in some cases*
  - *Finding buried cultural features such as dumps and fill material in submerged structures*
  - *Offshore projects*
    - *Soil classification*
    - *Depth to bedrock*

A courtesy of Dr. Satish Pullammanappallil

Conclusion

- Compares well with previously used 1-D shear wave measurement techniques: Economic, accurate and reliable
  - *Correlates with SCPT measurements*
    - *Detects velocity reversals*
  - *Matches average velocities obtained using OYO logger*
  - *Greater depth of investigation compared to borehole and surface methods*
  - *Trends similar to velocity measurements from cross-hole*
  - *Data acquisition and analysis takes about 3 to 4 hours*
- Determine subsurface properties
  - *Derive parameters useful for geotechnical engineering*
  - *Determine properties of buried fill material*
- Perform site specific seismic characterization studies efficiently & economically
  - *Minimizes number of boreholes required*
  - *No permitting required*
  - *Can be carried out in urban settings*
    - *Uses ambient noise as seismic energy source*
- Offshore application
  - *Determine seismic soil classification standards for offshore projects*

A courtesy of Dr. Satish Pullammanappallil