Influence of Stacking on the Resolution of Dispersion Image in Active MASW Survey

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Multichannel Analysis of Surface Waves (MASW)

- Seismic exploration method
  - Evaluating ground stiffness
  - 1D, 2D or 3D formats
- Mapping the shear wave velocity distribution in the subsurface space

www.masw.com
Types of MASW Surveys

- Procedure of generation of waves
  - **Active MASW method**
    - Various types of weight drops
  - **Passive MASW methods**
    - Passively generated from natural and anthropogenic activities
      - Passive roadside method – Traffic sources
      - Passive remote method – Microtremors, Tidal activities, Machine vibrations
  - **Combined Active and Passive Technique**
    - Numerical combinations of wavefields or dispersion images

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**Overall Procedure of Active MASW in a nutshell**

1. **Data Acquisition**
   - Using active or passive sources, geophones and a seismograph
2. **Dispersion Analysis**
   - Phase velocity V/S Frequency (or Wavelength) curve
3. **Inversion Analysis**
   - Shear Velocity V/S Depth curve
4. **Time domain data** → **Frequency domain**
5. **Dispersion analysis**
6. **Dispersion curve** ($\phi$, V/s f)
7. **Vs profile (V_s v/s Depth)**
Equipment of Active MASW Survey

- Hammer
- Plate
- The energy medium
- Geophones placed in a linear array
- Data Acquisition system
- Data Recording

Impact Generators in Active MASW Survey

- Sledge hammer
- Seismic source
- Body wave
**Concept of Dispersion**

- **Dispersion curve**
  - Adaptive Fourier Transformation of time-domain signal
    - Propagation velocity (Phase velocity) vs. frequency content
  - **Unimodal dispersion**
    - Each frequency associated with a single phase velocity
  - **Multimodal dispersion**
    - Existence of multiple phase velocities for a single frequency
      - Fundamental and Higher order modes

- **Dispersion Image Space**

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*www.masw.com*
Resolution of Dispersion Band

<table>
<thead>
<tr>
<th>Offset (m)</th>
<th>Resolution - Number of bin and pixel count (dpi)</th>
<th>Rank (CM/m)</th>
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</tr>
</tbody>
</table>

Factors affecting Resolution of Dispersion Band

- Data acquisition, preprocessing and processing parameters
  - Sampling frequency
  - Acquisition time
  - Offset distance
  - Inter-receiver spacing
  - Number of geophone receivers
  - Type of source
  - Number of stacks
  - Striker plate materials

Series of recommendations

Taipodia et al., Disaster Advances, 2017

Taipodia et al., Journal of Geophysics and Engineering, 2018
**Dispersion Image Stacking**

- A process to combine dispersion image so that the resultant dispersion image has higher energy

- Procedure
  - Repeat nearly equal impacts from 10 kg sledgehammer
  - Obtain dispersion image from each impact
  - Combine the dispersion energy from consecutive shots
  - Conduct inversion of the combined dispersion image

- Benefit
  - Stacking increases the energy at all low and high frequencies
  - Enhanced dispersion bandwidth
  - Identification of possible multimodal features

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**Experimentation Sites**

Sites, of different stiffness, at IIT Guwahati Campus
Stacked Dispersion Images from 10 kg hammer shots

1 Shot - 0 Stack
2 Shots - 1 stack
3 Shots - 2 Stacks
4 Shots - 3 Stacks

Enhancement in the dispersion energy and bandwidth and identification of multimodal features

Can lighter hammers be suitable alternative to heavier ones?

Depth of investigation v/s Ease of use and Portability

QUESTION
Can the 10 kg hammer be used to obtain similar results generated by 40 kg PEG?
10 kg Hammer vs 40 kg PEG (Dispersion images)

- Similar bandwidth of dispersion image
- Presence of multimodal features
- Lesser high frequency noise in stacked image

4 shots of 10 kg hammer

Single shot of 40 kg PEG

Shear Wave Velocity profiles from stacked images

- Influence of stacking on Vs profiles
  - Enhanced depth of investigation

Stacked shear wave velocity profiles from different hammer and PEG shots.
Conclusions

- Dispersion image stacking
  - Increases the resolution of the dispersion images
  - Increases the depth of investigation
  - Aids in recognizing multimodal features
  - Aids in application of a lighter portable active source for higher depth investigations

- Caution
  - Stacking also increases the incoherent noises
  - Caution to be exercised during extraction of dispersion curve

Taipodia et al., Indian Geotechnical Journal, 2018

FOOD FOR THOUGHT

Can a 1 kg hammer be used, with 30-40 stacks, to produce an equivalent record to that obtained from a heavier hammer?

More Reading ???


http://www.iitg.ac.in/arindam.dey/homepage/index.html#
https://www.researchgate.net/profile/Arindam_Dey11

Jumrik

Madhulatha
Thank You for Patient Hearing

Quantification of Resolution of Dispersion Image

Dispersion images obtained at Site 2 for various offsets (a) 0 m (b) 2 m (c) 4 m (d) 6 m (e) 8 m (f) 10 m (g) 12 m (h) 14 m
Quantification of Resolution of Extracted Dispersion Band

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<tr>
<td>14</td>
<td>2492</td>
<td>10</td>
</tr>
</tbody>
</table>

Extracted dispersion band using image processing algorithm considering various offsets (a) 0 m (b) 2 m (c) 4 m (d) 6 m (e) 8 m (f) 10 m (g) 12 m (h) 14 m