SHALLOW SHEAR-WAVE REFLECTION SEISMIC APPLICATIONS IN THE KRUENG ACEH RIVER DELTA

I. Arsyad, U. Polom

Summary

As part of the project “Management of Georisk” (MANGECO) of the Federal Institute for Geosciences and Natural Resources (BGR), Hannover, high resolution shallow shear wave reflection seismic was applied in the Indonesian province Nanggroe Aceh Darussalam (NAD), Sumatra, in cooperation with the Government of Indonesia and the local counterpart Dinas Pertambangan dan Energi of NAD.

The investigations should support earthquake site effect classification for the reconstruction process and the groundwater exploration activities with the main focus on the city of Banda Aceh and the surrounding region of Aceh Besar. The shear wave seismic investigations were combined with standard geotechnical engineering techniques like Cone Penetrometer Testings for a comprehensive site evaluation and have been supplemented partly by shallow P-wave seismic applications for the derivation of elastic subsurface parameters and the detection of groundwater spots.

Results show that high resolution shallow shear wave seismic is a useful tool to evaluate the subsurface stiffness in terms of International Building Codes for local site effect analysis. Furthermore, due to the resulting depth penetration of 100 m and more, this method leads to a better understanding of the sedimentation process for the Krueng Aceh river basin and can help to identify possible aquifer layers.

Acquisition parameters

- **Period:** 20th Nov. – 12 Dec. 2005
- **Instrument:** GEOMETRICS GEODE
- **Shot Locations:** 49
- **Seismic Source:** GGA wheel barrow mounted shear-wave source system
- **Sweep Type:** 20-250 Hz linear, 10 s
- **Recording:** 100 ms Taper at both sides
- **12 s**
- **Sampling:** 1 ms
- **Receivers:** 48 channel Geode system used for seismic data acquisition
- **Source type:** 4-fold \( [+2Y]-[-2Y] \) alternated
- **Geophone type:** SM 6H (10 Hz), single units
- **Geophone spread:** 2D variable split spread, SH-SH configuration
- **Recording filter:** out
- **Vertical stack:** 4-fold \( [+2Y]-[-2Y] \) alternated vibrations
- **Receivers:** 48 channel Geode system used for seismic data acquisition
- **Source type:** 4-fold \( [+2Y]-[-2Y] \) alternated
- **Geophone type:** SM 6H (10 Hz), single units
- **Geophone spread:** 2D variable split spread, SH-SH configuration
- **Recording filter:** out
- **Vertical stack:** 4-fold \( [+2Y]-[-2Y] \) alternated vibrations

Acknowledgements

The authors are gratefuly acknowledged to the Government of Indonesia and the local Government of Nanggroe Aceh Darussalam for the support and permissions.

All photos courtesy Guenther Druivenga.

This work is kindly supported by the Federal Institute for Geosciences and Natural Resources (BGR), Hannover, and was founded by the Federal Ministry of Economic Cooperation and Development, Government of Germany.
Conclusions

The seismic site effect evaluation by shallow high resolution seismic investigations was a useful method in the sedimentary regions of the Aceh province and could be successfully applied. Especially shallow shear wave reflection investigations were able to explore the subsurface stiffness up to 100 m in high resolution leading to geotechnical site classifications in terms of the IBC 2003. Beyond this, the results are also useful for detailed insights in the basin sedimentation processes of the Krueng Aceh river delta, concerning the exploration of new areas for safe building foundation and groundwater aquifer detection.

Using a small vibratory seismic source, this technique was applied successfully in areas of high site density in the city of Banda Aceh and also in areas of compacted surface soil like farm tracks in the surrounding, mostly agricultural environment. Obviously, the man made land fillings lead to decreasing velocity gradients at the surface, yielding an efficient suppression of Love surface waves and refracted S-waves in the SH-wave recordings. This results in a clearly increasing S/N ratio of the reflected wave field and therefore much better conditions for the data processing. Whole seismic data acquisition was supported by staff people from the local office of the Dinas Pertambangan dan Energi, Provinsi Naggroe Aceh Darussalam, some field help and drivers subsequent to an initial training by doing.

The resulting seismic depth sections show a lot of differences within the holocene Krueng Aceh basin sediments. Near the north coast in the area of Banda Aceh city mostly horizontally layered soft to very soft sediments were detected. Sediments in the western part seem to be folded, which is probably due to the tectonic activities near the Great Sumatra fault zone. The south east part of the basin near the volcanics seems to be uncritical in terms of earthquake site effects. Further investigations are required concerning low velocity spots in the basin centre.

Results

SITE CLASSIFICATION

The site classification systems considered in this study are the International Building Code (IBC 2003) system (International Code Council 2003). The IBC system is based on the average shear wave velocity over the top 30 m (Vav30).

Soil classification by shear wave velocity and material properties:

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Soil Name</th>
<th>Average Soil Properties for Top 30 m (100 feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Vav30 (m/s)</td>
<td>Standard Penetration Test, N (blows/foot)</td>
</tr>
<tr>
<td>S0</td>
<td>Hard Rock</td>
<td>&gt;1,500</td>
</tr>
<tr>
<td>S1</td>
<td>Rock</td>
<td>760 to 1,500</td>
</tr>
<tr>
<td>S2</td>
<td>Very Dense Soil and Soft Rock</td>
<td>360 to 780</td>
</tr>
<tr>
<td>S3</td>
<td>Soft Soil</td>
<td>180 to 360</td>
</tr>
<tr>
<td>S4</td>
<td>Soft Clay</td>
<td>180 to 360</td>
</tr>
</tbody>
</table>
| S5              | Su < 23.9 kPa - Soft soil requiring site-specific evaluation | A site also may be classified as soft soil if more than 3 m of soft clay is present.