Air Wave Attenuation By Moving-Window LMO Stack

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Seismic Approach to Quality Management of HMA

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SUMMARY

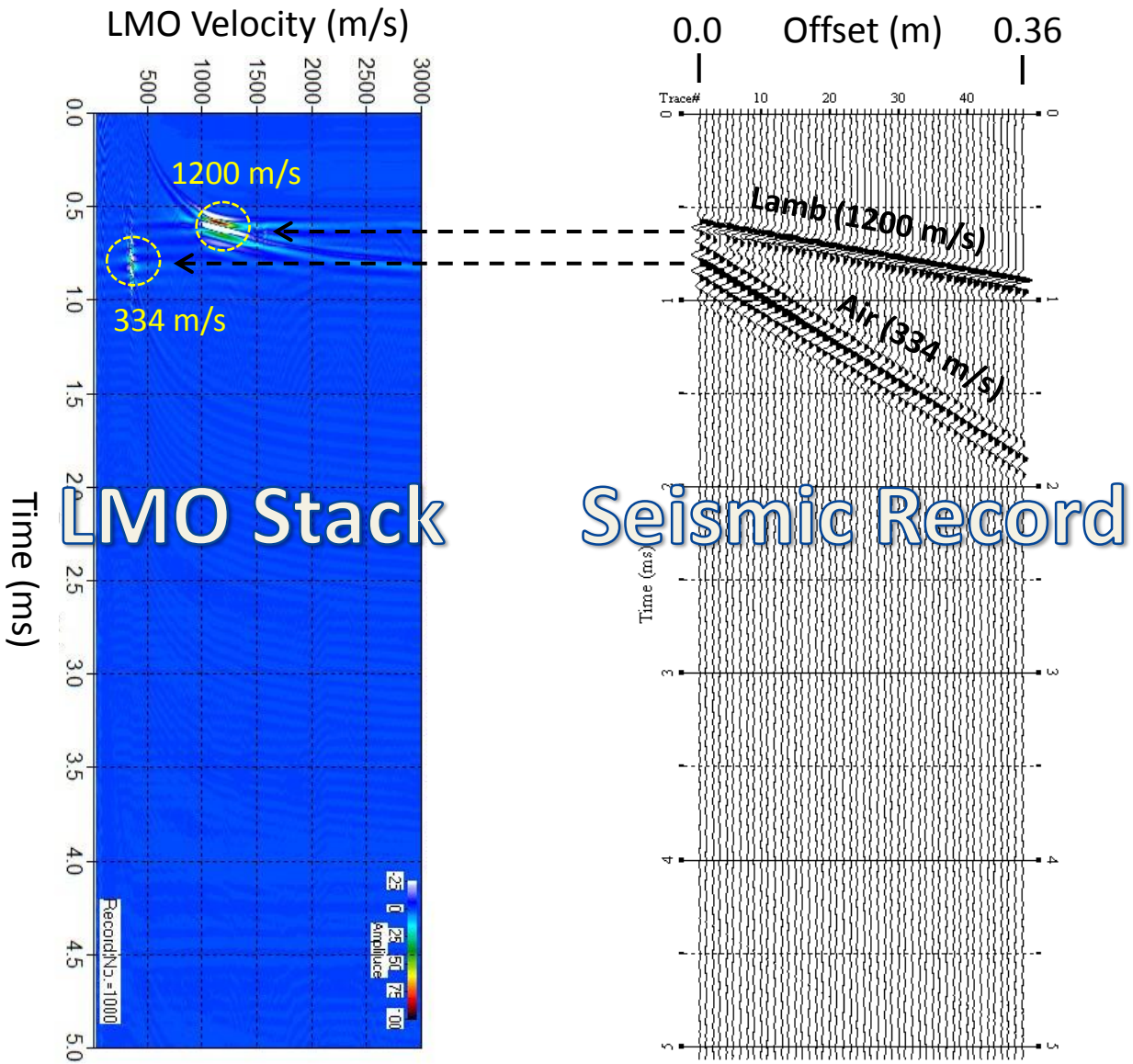
- Direct air (sound) waves generated at and coming from the impact point are the most troublesome noise for the microphone measurement of leaky-mode Lamb waves that have to be suppressed by means of both acquisition and post-acquisition efforts.
- Inclusion of air wave in the measurement can result in following adverse effects; (1) it may consume a given dynamic range of AD conversion that can result in a relatively low resolution available for low-energy Lamb waves at high frequencies (e.g., > 15 kHz), (2) this poorly-resolved high frequency components of Lamb wave can result in a less-reliable evaluation of seismic velocity (Vs), and (3) strong air waves at relatively low frequencies (e.g., < 10 kHz) can mask the "curved" part of the Lamb wave dispersion (A0) that is critical to accurately evaluate the thickness (H) of pavement.
- In previous summary posted here, several different multichannel data-processing approaches were considered for their effectiveness in attenuating the air waves (noise) while preserving the Lamb waves (signal) as mush as possible. They included fk-filtering, muting, and fk-muting approaches. They all turned out having pros and cons for the final goal of velocity (Vs) and thickness (H) evaluation of the HMA layer. This indicates all of them can be useful in different combinations under different condition of the acquired data; e.g., data with a low SN ratio vs. a high SN ratio, etc.
- The methodological development further continued to come up with a more effective approach based on the linear-move-out (LMO) approach.
- This report summarizes a new successful approach that uses a moving-window LMO stack to remove the air wave event of a specific propagation velocity (e.g., 334 m/s). Test results with synthetic and real field data sets indicate the effectiveness is superior over the previous conventional approaches (e.g., fk, mute, etc.), especially for the Impact Echo (IE) method that can evaluate the thickness (H) independently from the analysis of propagating waves. This part of the result will be reported in next summary report. A brief description of the method and results are presented here.

Linear Move Out (LMO) Stacking

LMO stack can clearly identify linear events in their occurrence at different times with different velocities as shown in the left-side panel display.

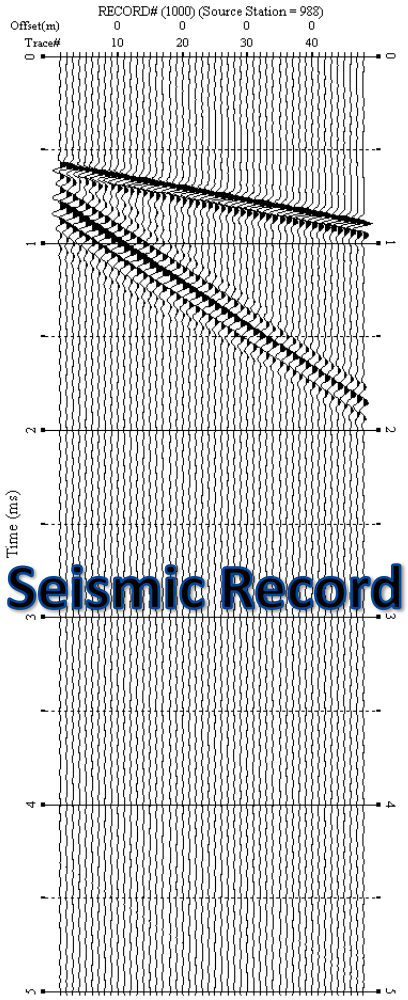
The right-side panel display shows a modeled (synthetic) record that contains both Lamb and air waves of different propagation velocities, 1200 m/s and 334 m/s, respectively, and occurring at slightly different times.

This indicates the LMO stack can be used not only to identify a specific linear event, but also to filter it out through the approach outlined in the next page.

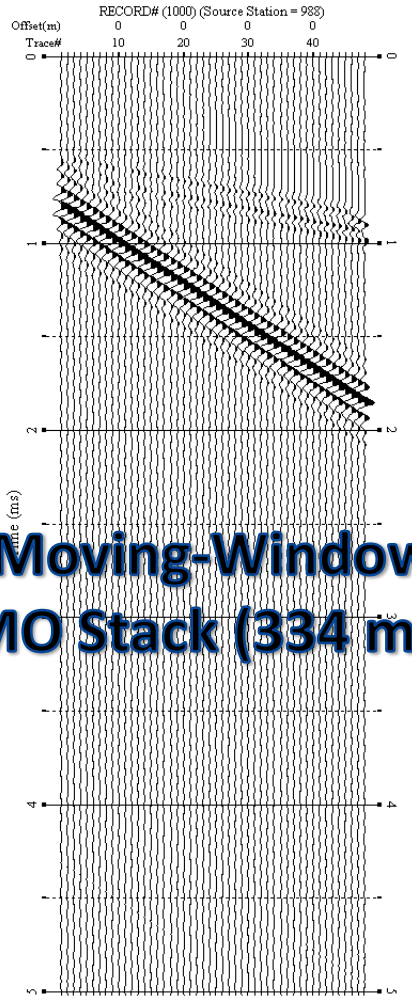


Air-Wave Attenuation by Moving-Window LMO Stack

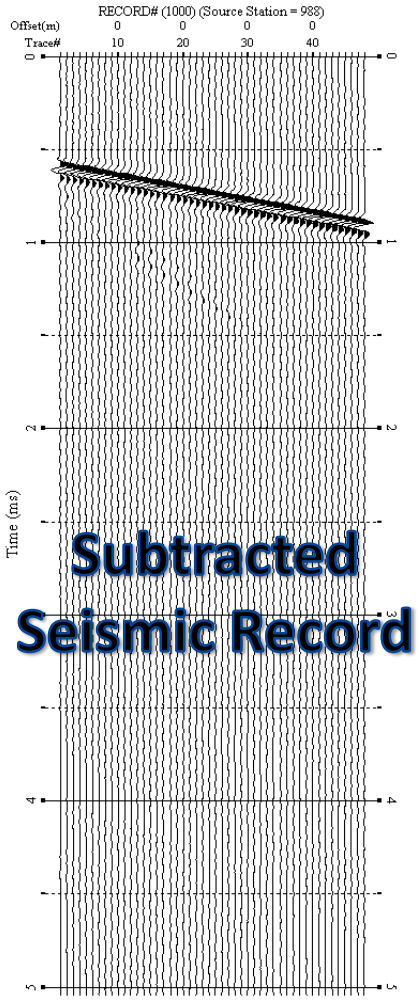
An LMO stack is applied to every trace in the seismic record (left) with a move-out velocity of air waves (334 m/s) with a moving window of 3 traces from both sides (i.e., previous and next traces). The new record created in this way (center) shows mostly the air-wave arrivals, while the Lamb arrivals are highly attenuated. When this record is subtracted from the original record, the resultant record (right) shows air waves are mostly removed.



Seismic Record



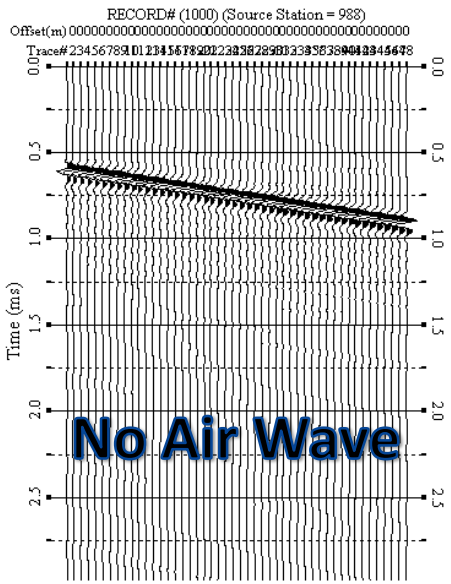
Moving-Window LMO Stack (334 m/s)



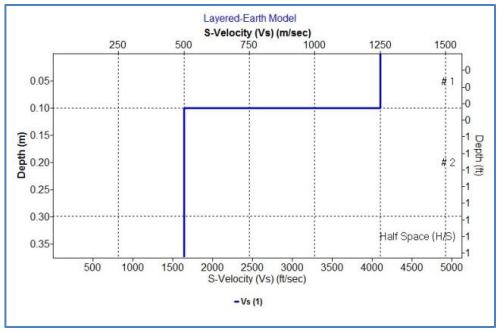
Subtracted Seismic Record

Air-Wave Influence on Dispersion Image

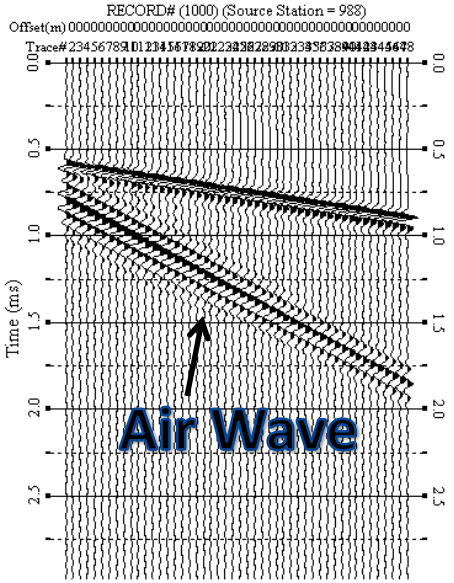
Modeled Seismic Record



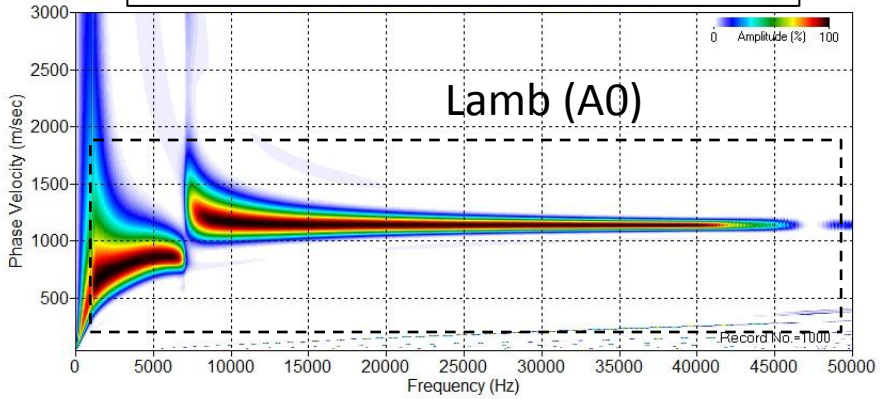
Velocity (Vs) Model



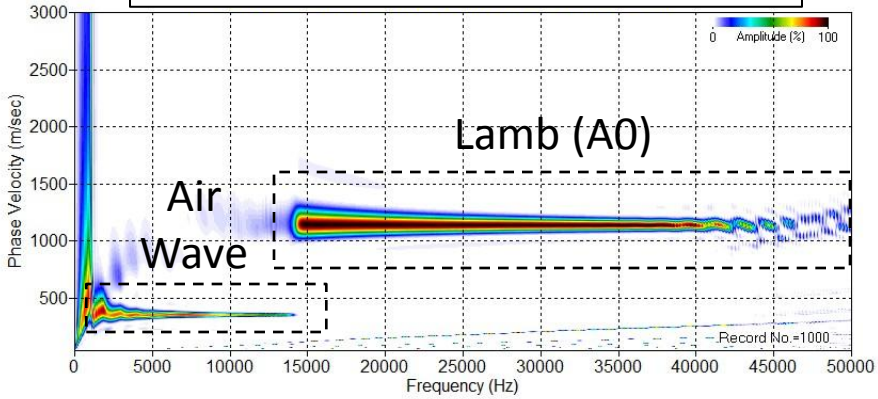
Modeled Seismic Record



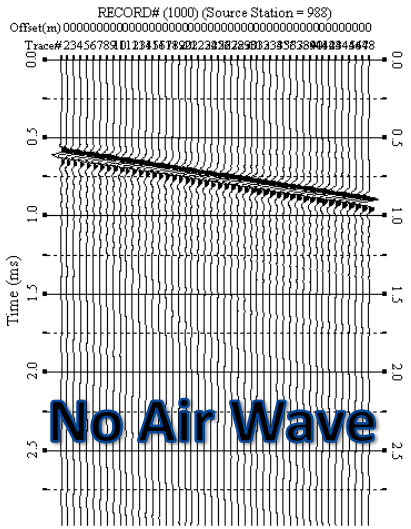
Complete Lamb (A0) Dispersion Trend

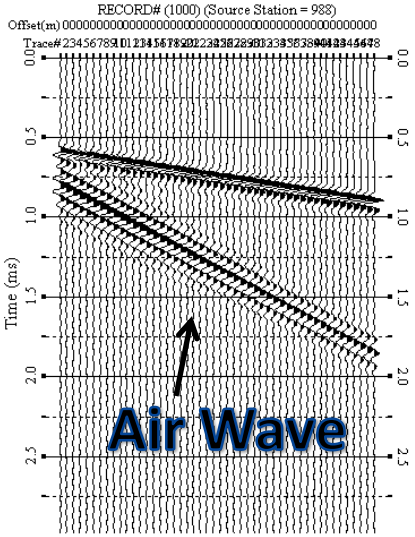


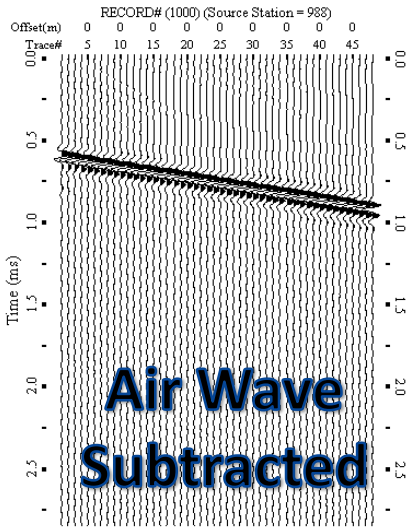
Lamb (A0) Dispersion Trend Hampered by Air Wave Trend

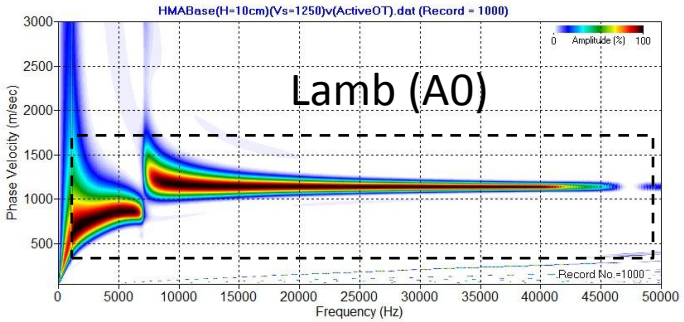


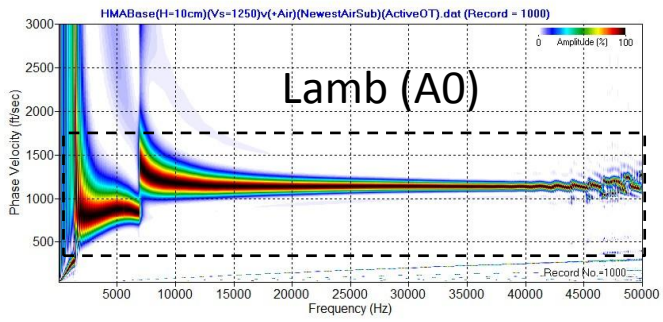
Air-Wave Subtraction and Dispersion Image (Test on Synthetic Data)

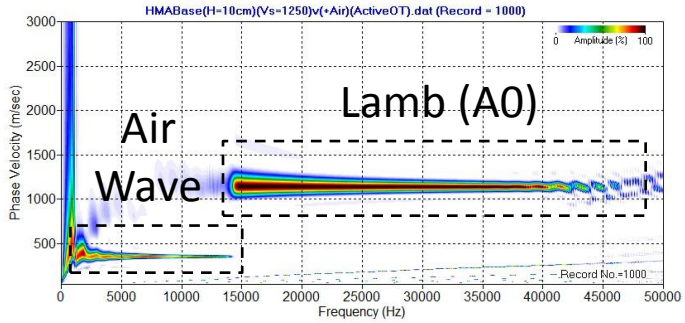






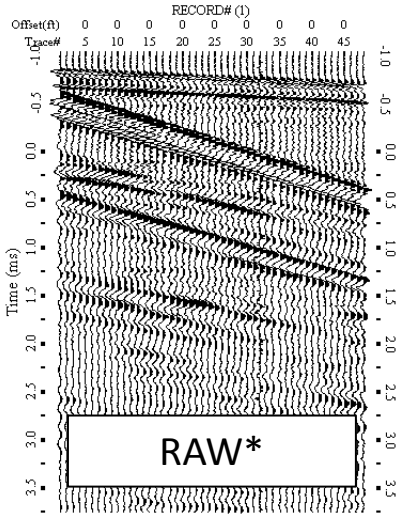


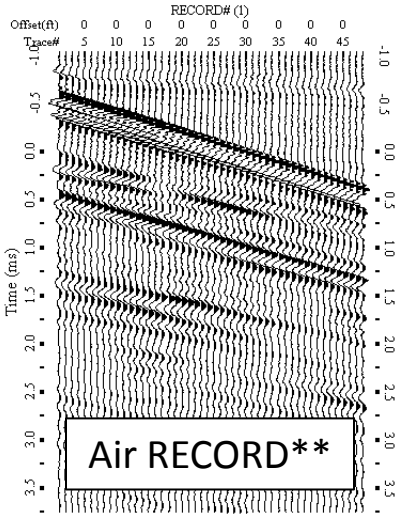


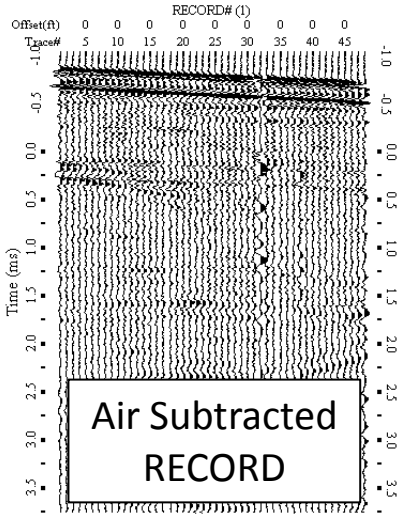


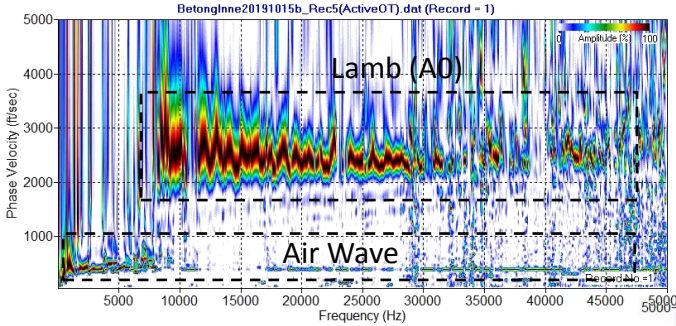
Original Lamb (A0) dispersion trend is well recovered.

Air-Wave Subtraction and Dispersion Image (Test on Real Data)









Collected by using a 48-channel MEMS microphone array at Lund University.

***Obtained by applying the moving-window LMO stack with a stacking velocity of 334 m/s.*