GROUND VIBRATION FREQUENCY CONTROL

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Why is Frequency Important?

Main Importance is Assessing Damage Potential

Eg. - USBM Frequency Dependant Damage Criteria

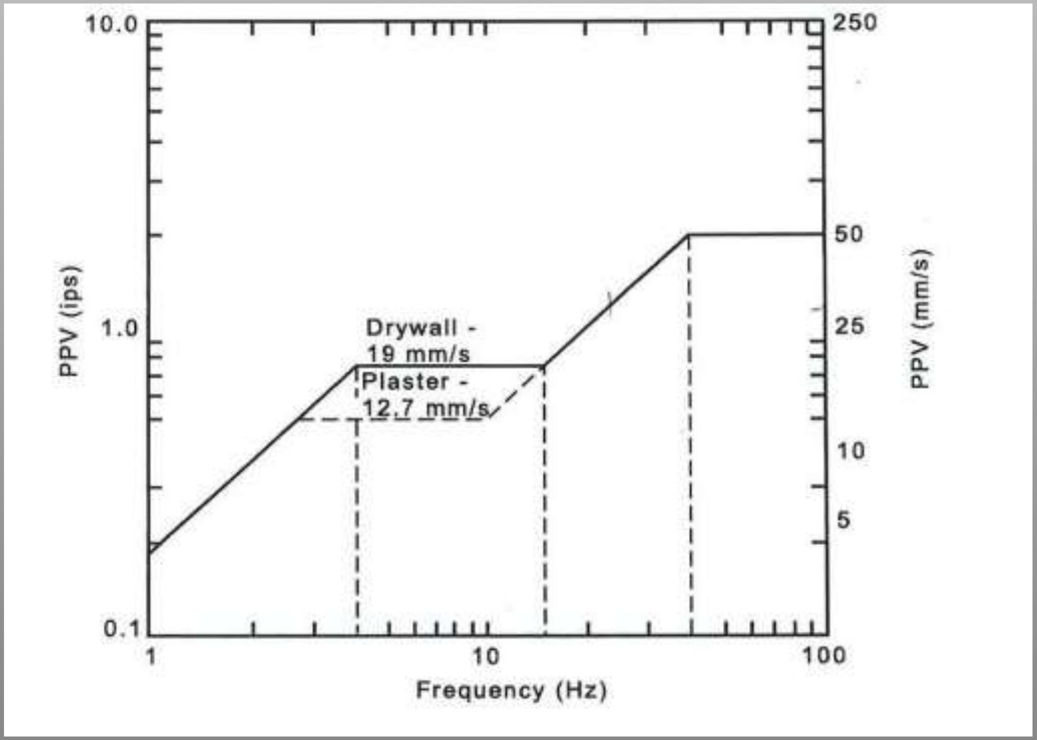


Figure J4.4.2.2 – USBM 'Safe' blasting Vibration Level Criteria

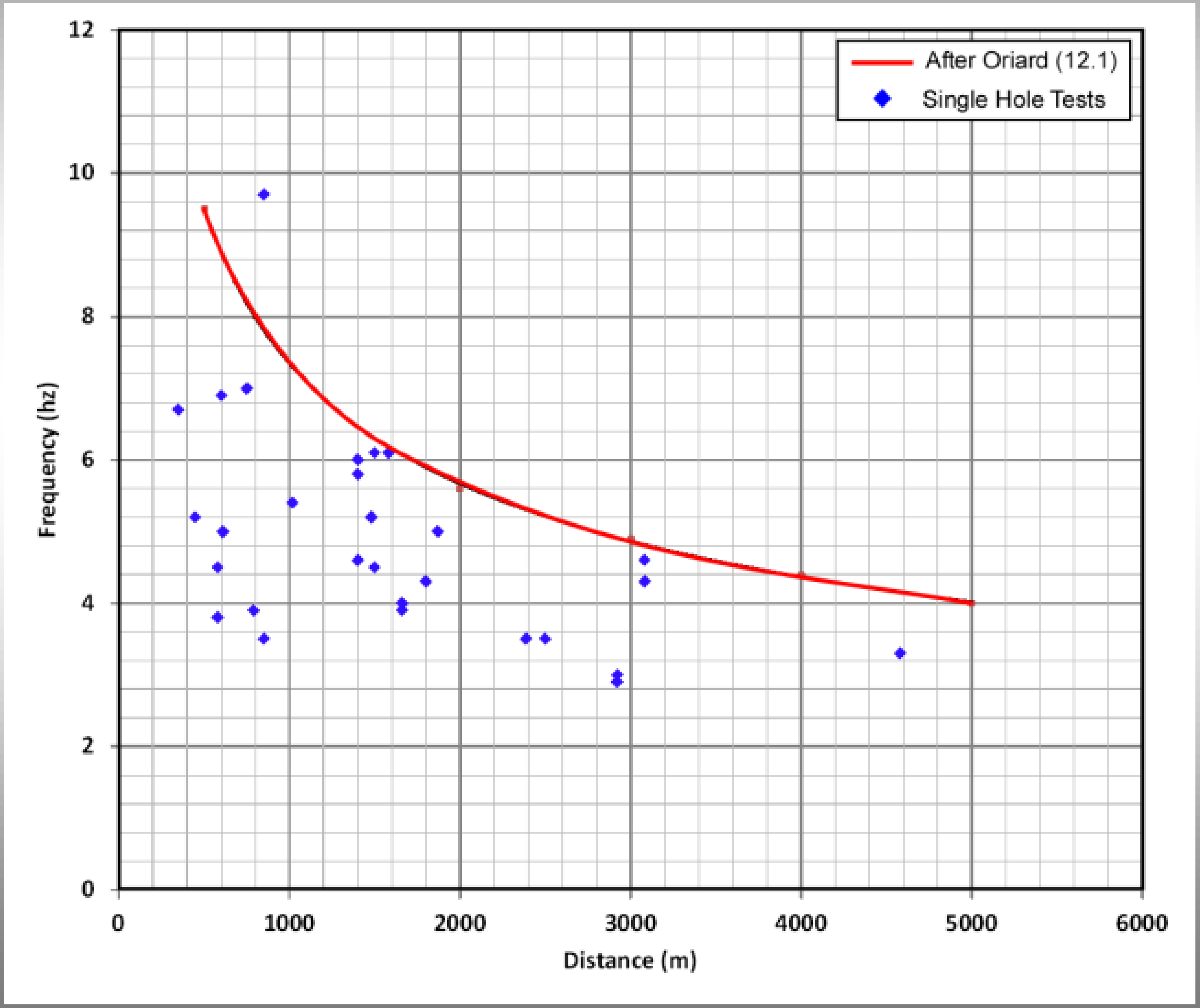
Oriard (2002) states "it is more difficult to develop a formatted method for calculating or predicting frequency over a large distance or from one geological setting to another, although general trends are well known".

Factors influencing ground frequency are:

- Natural frequency and frequency transmission characteristics of the ground;
- Reduction of frequency with distance;
- Forcing frequencies from the initiation sequence;
- Modification of the forcing frequency by a Doppler effect because of the moving source; and
- Sub harmonic split of the forcing frequency

Natural Ground Transmission Frequency

Dominant Frequency of single hole Test Blast vs Distance



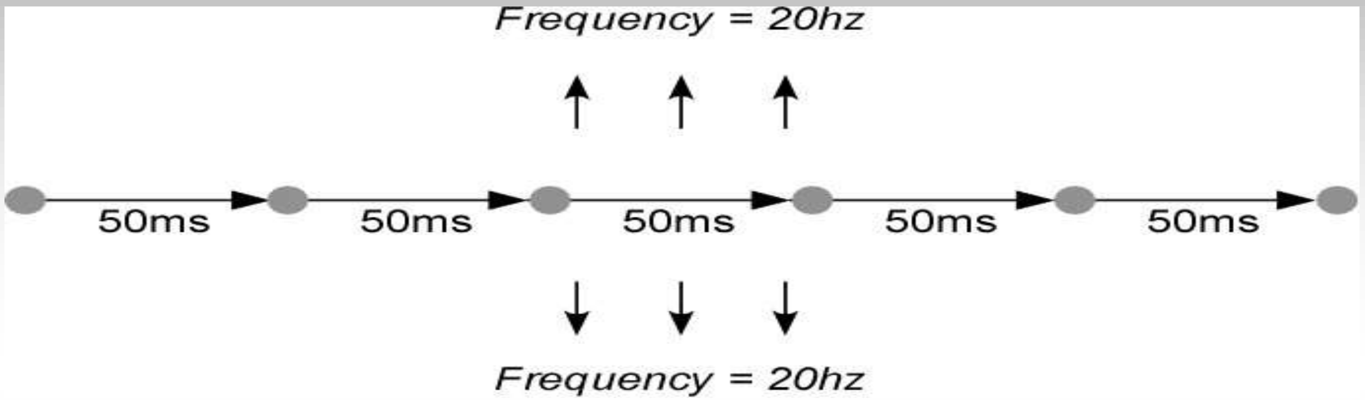
Forcing Frequencies

Timing Delay (ms)	Forcing Frequency (hz)	Sub harmonics (hz)			
		1	2	3	4
9	111	55.5	27.8	13.9	6.9
17	58.8	29.4	14.7	7.4	3.7
25	40	20	10	5	
42	24.4	12.2	6.1		
67	14.9	7.5			
100	10	5			
109	9.2	4.6			

Doppler Effect

Consider the following:

Single Row of Blastholes 5 m apart fired 50 ms apart



In the perpendicular direction the frequency generated is 20 hz.

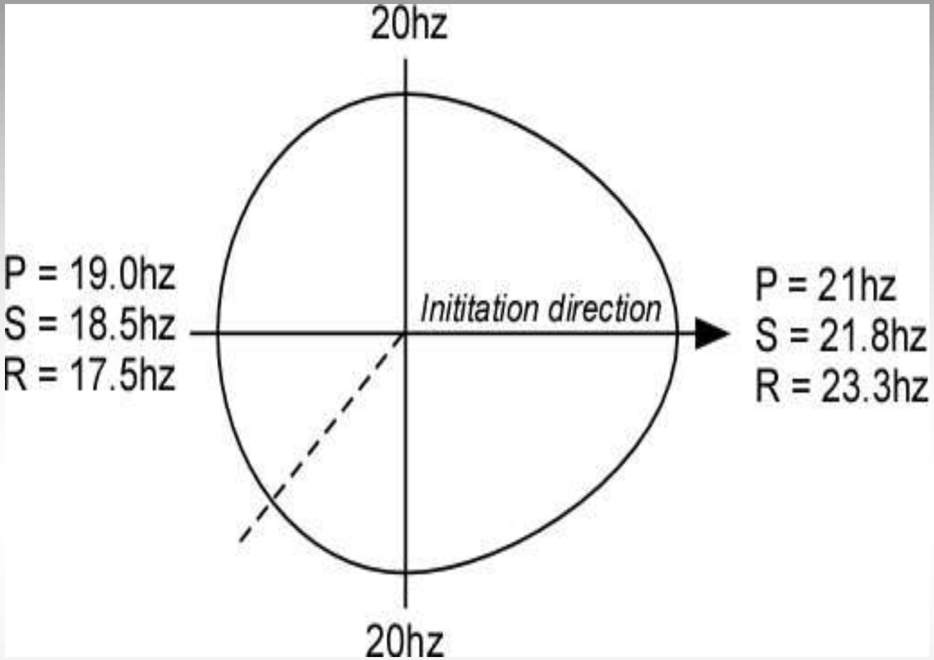
In the direction of initiation the frequency is increased because of the 5 m separation between blastholes. The travel time of the ground vibration depends on the wave velocity.

Pwave Velocity 2 m/ms TP = 2.5 ms

Swave Velocity 1.2 m/ms TS = 4.2 ms

Rwave Velocity 0.7 m/ms TR = 7.1 ms

The resulting frequencies can be represented by a frequency ellipsoid



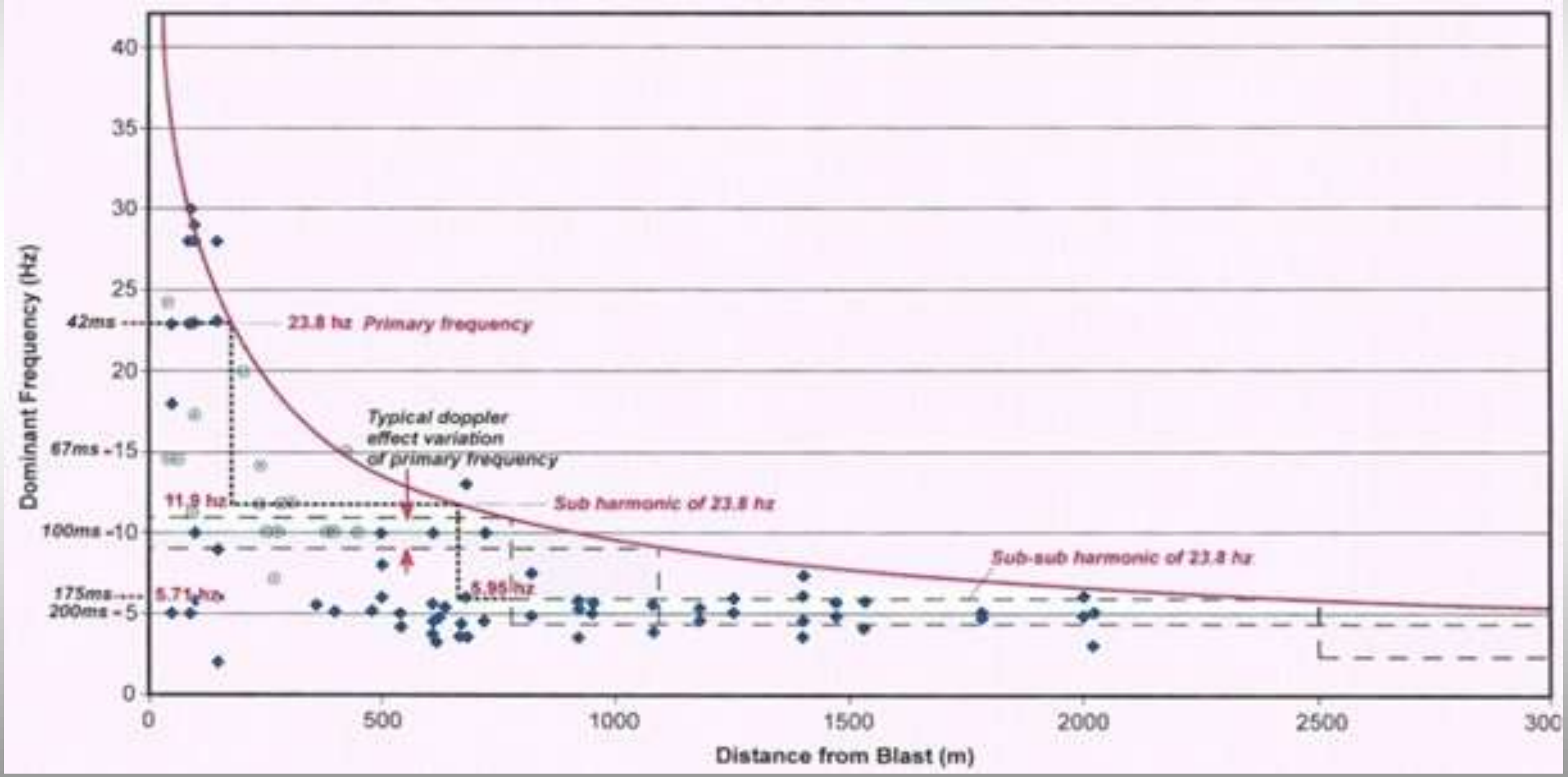
The forcing frequencies are 21.0 – 23.3 hz in the initiation direction

The forcing frequencies are 17.6 – 19.1 hz in the opposite direction

The forcing frequencies in other directions can be scaled off the ellipsoid

Sub Harmonic Split

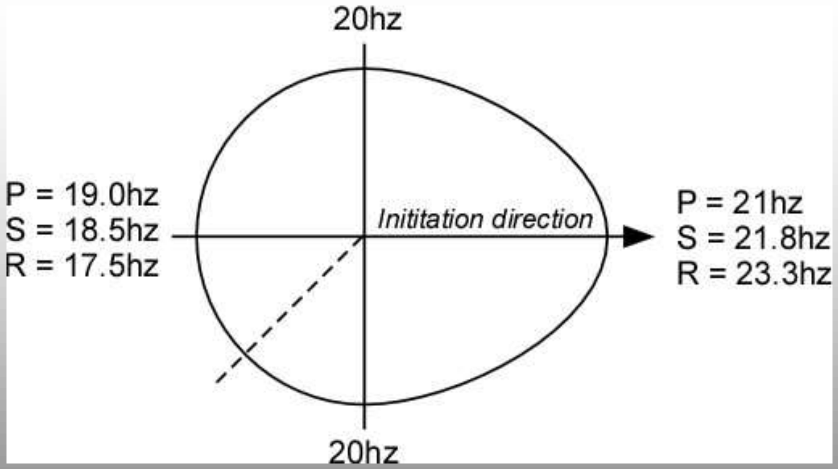
From our observations of coal overburden blasts, the forcing frequency reduces by sub harmonic splits with distance – as a distinctive halving rather than gradual reduction

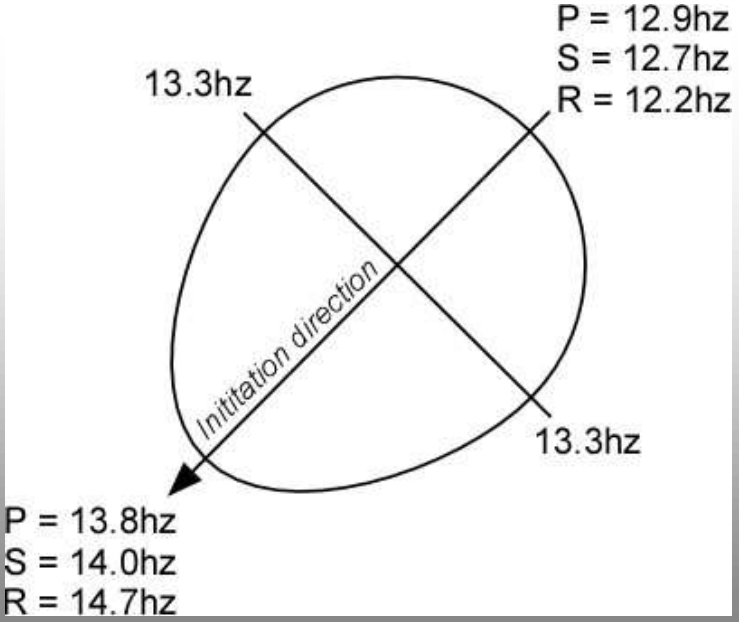


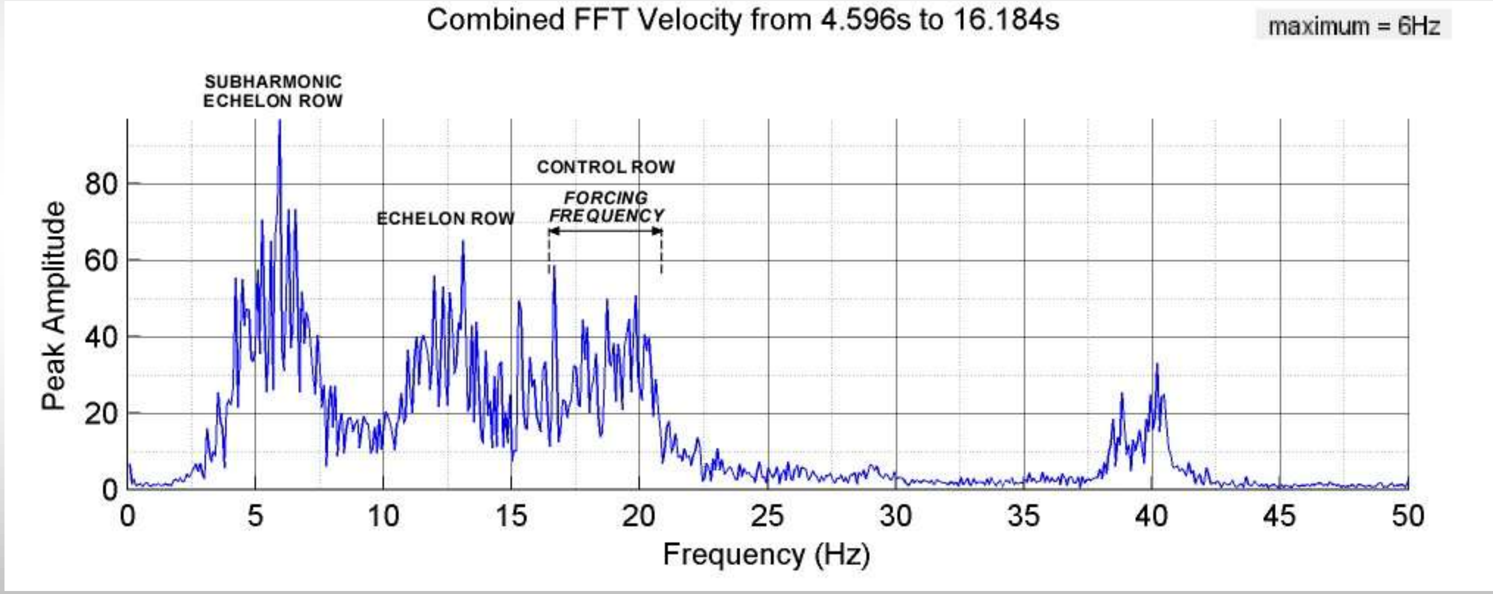
Example 1 Consider the frequency ellipsoids for a 50 ms control row; with a 75 ms echelon row. In the direction shown, the following FFT was recorded at about 600 m.

It can be seen that the control row forcing frequencies (16 – 20 hz) exist in a broad band:

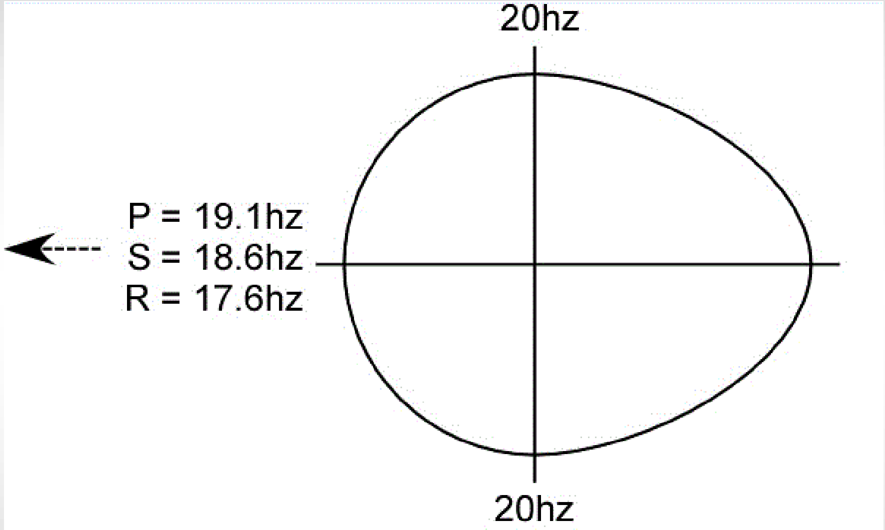
- The echelon row forcing frequencies exist in a broad band
- The most energy is in the sub harmonics of the echelon row

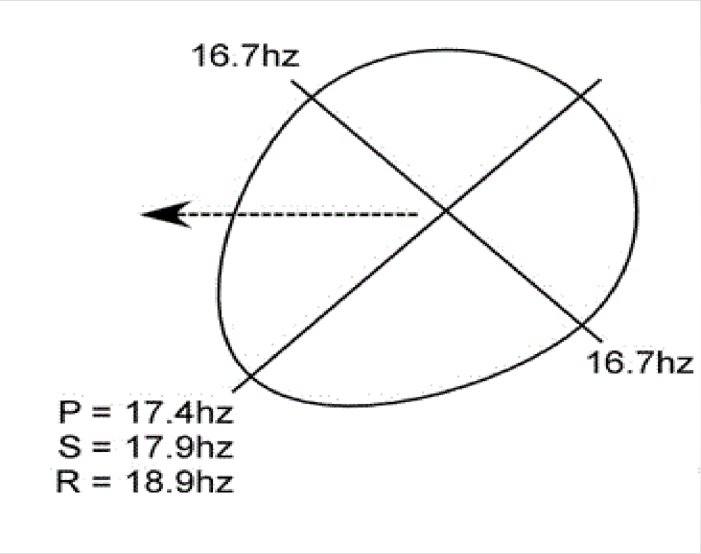





Combined FFT Velocity from 4.596s to 16.184s
maximum = 6Hz
SUBHARMONIC
ECHELON ROW
ECHELON ROW
CONTROL ROW
FORCING
FREQUENCY
Peak Amplitude
0
20
40
60
80
0
5
10
15
20
25
30
35
40
45
50
Frequency (Hz)

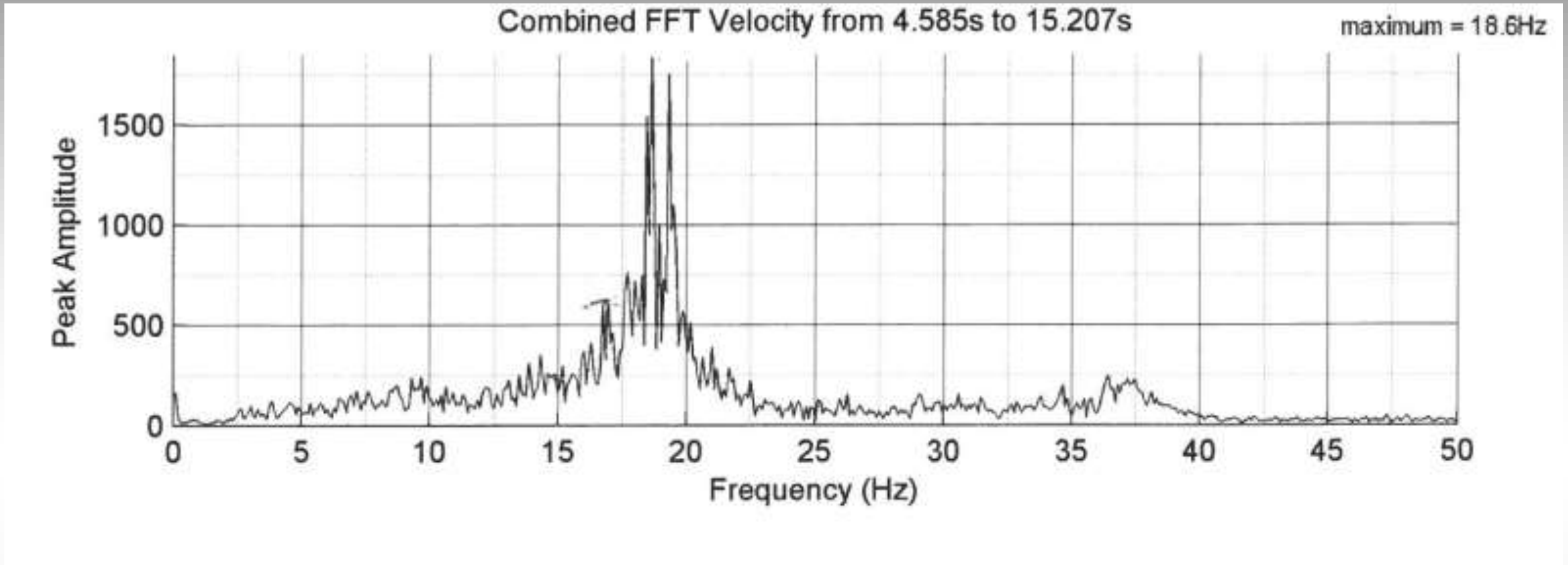
Example 2 Consider the frequency ellipsoids for a 50 ms control row with a 60 ms echelon row. The combination FFT at 100 m is as follows. There are 2 dominant frequencies of about 18 and 19 hz.

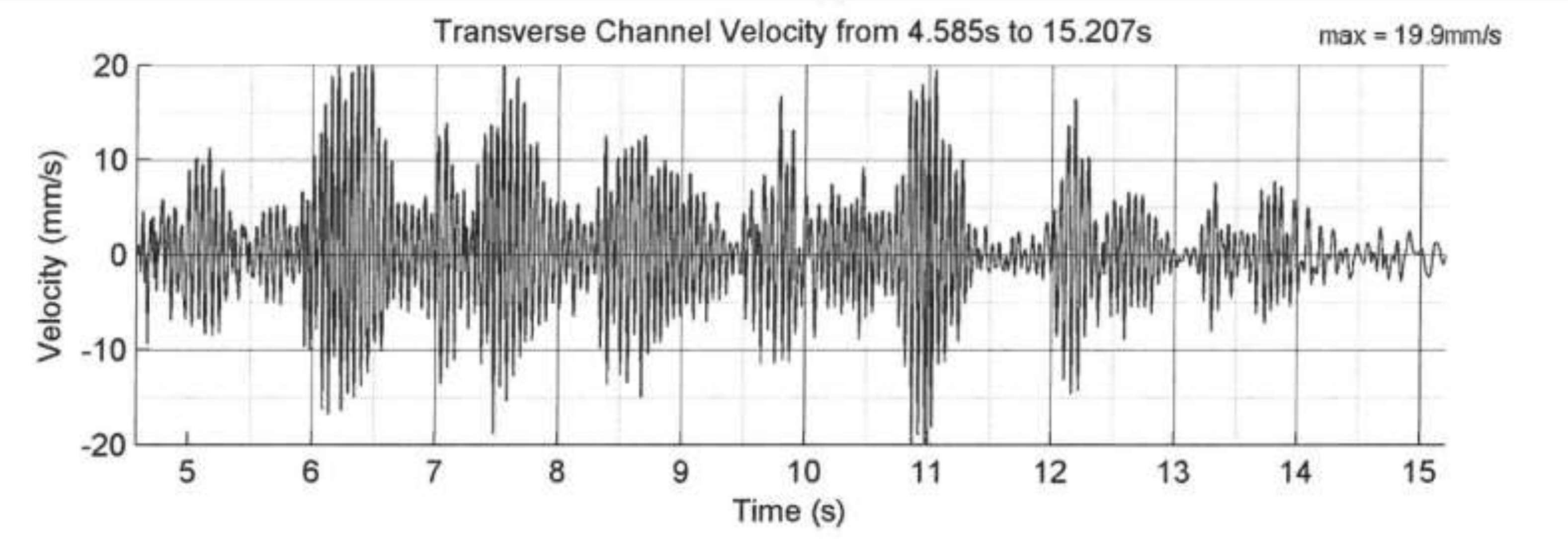




The PPV wave trace (transverse channel)

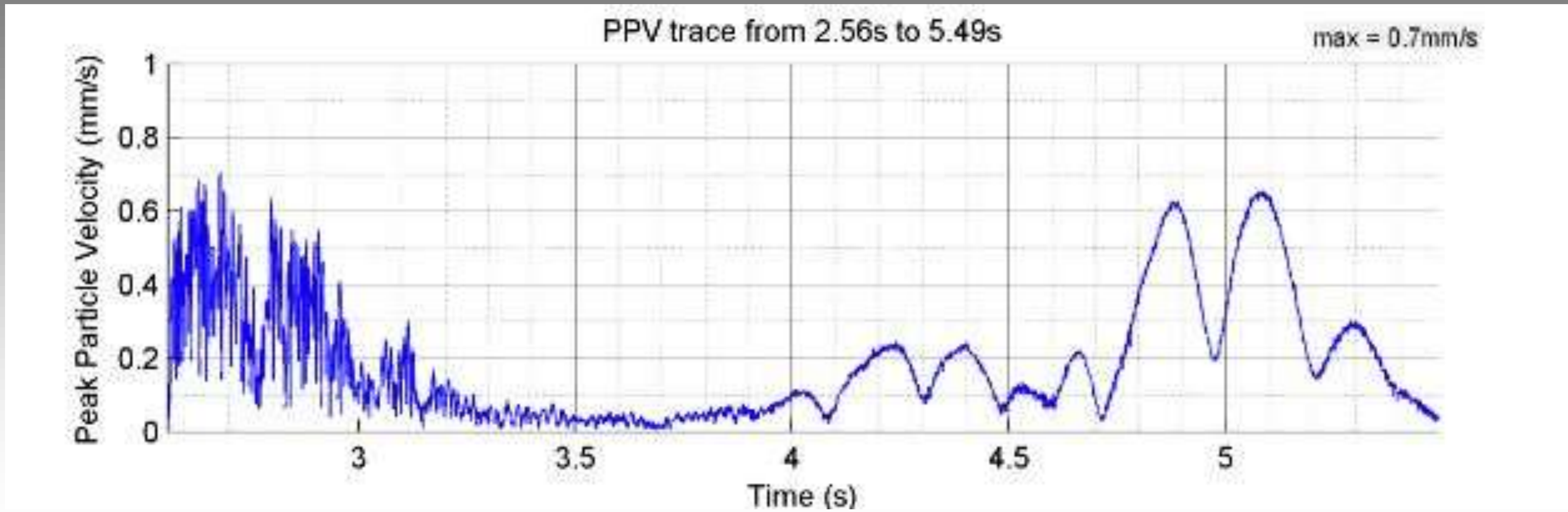
The two closely aligned frequencies resulting in the direction shown formed 'beats' which elevated the PPV from a predicted 17.9 mm/s to 28.5 mm/s.

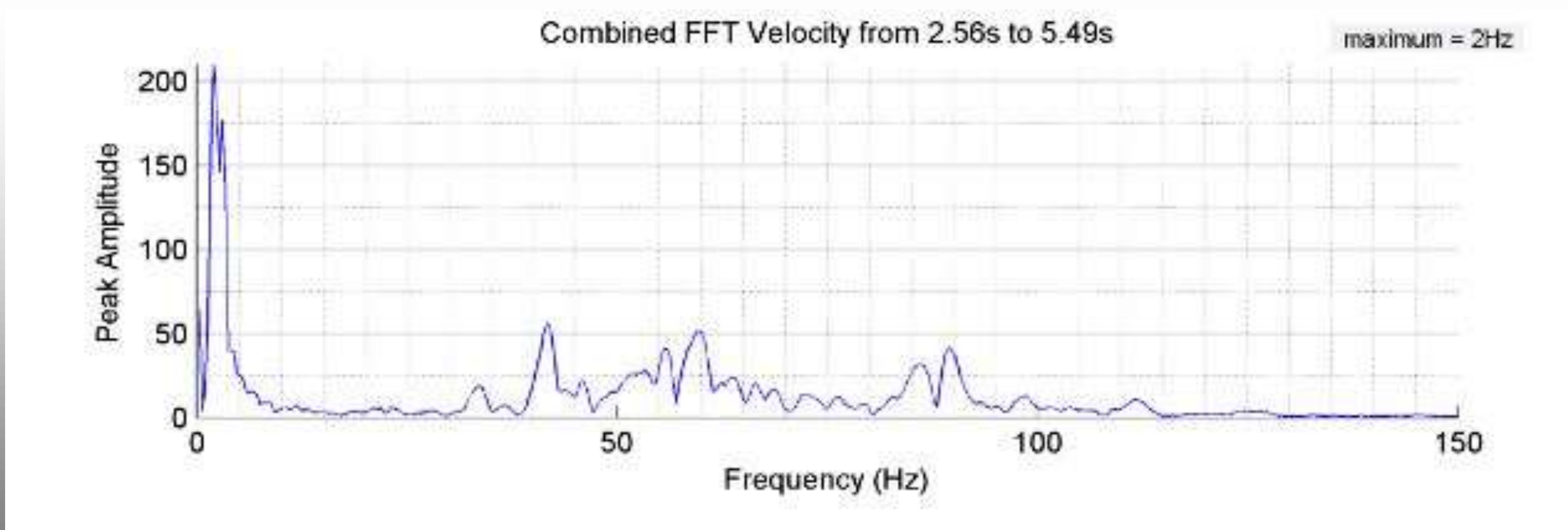




In Summary, Frequency control is not simple. All the general trends we are beginning to understand are thrown out the window when a clay layer is involved.

Consider the wave trace recorded at about 800 mm from a blast in basalt overlaying a layer of lacustrine sand and clay.


PPV trace from 2.56s to 5.49s
max = 0.7mm/s
Peak Particle Velocity (mm/s)
1
0.8
0.6
0.4
0.2
0
3
3.5
4
4.5
5
Time (s)


Combined FFT Velocity from 2.56s to 5.49s
maximum = 2Hz
Peak Amplitude
200
150
100
50
0
0
50
100
150
Frequency (Hz)