## 6.2 Flow Resistivity

### *6.2.1 Pre-testing Assessment*

In order to compare the experimental results, an estimate of the flow resistivity of uncompressed material values were compiled in Table 6.1. Estimated values between 250 Hz and 400 Hz were taken from the previous report using the three-microphone technique [39]. Additional AFB and fiberglass values (from unknown measurement techniques) were taken from the manufacturer's data brochure [32]. Although these values were not likely obtained using Tao et al.'s technique, a general trend can be analyzed. As expected, it can be seen in Table 6.1 that the denser the material the higher the flow resistivity. It is unclear why the flow resistivity values reported in the manufacturer's data vary with thickness.

**Table 6.1 – Estimated Flow Resistivity**

| Material Type | Thickness (Inches) | Estimated Flow Resistivity (MKS rayls/m) |
|---|---|---|
| R24 | 4" | 12,000 [39] |
| AFB | 4" | 12,300 [39] |
| | 3" | 16,600 [32] |
| | 1.5" | 15,000 [32] |
| DD2 | 4" | 18,000 [39] |
| Fiberglass | 8" | 2,800 [39] |
| | 3.5" | 4,800 [32] |
| | 2.5" | 3,600 [32] |

It is expected that compression will result in a smaller (denser) sample that, therefore, experiences a higher flow resistivity [36].

Dr. Ramakrishnan previously tested several samples for their flow resistivity and transmission loss using Doutres et al.'s three-microphone method [39]. The following chapter compares the current results to the three-microphone results. Several graphs have been extracted from the report for an easier comparison.

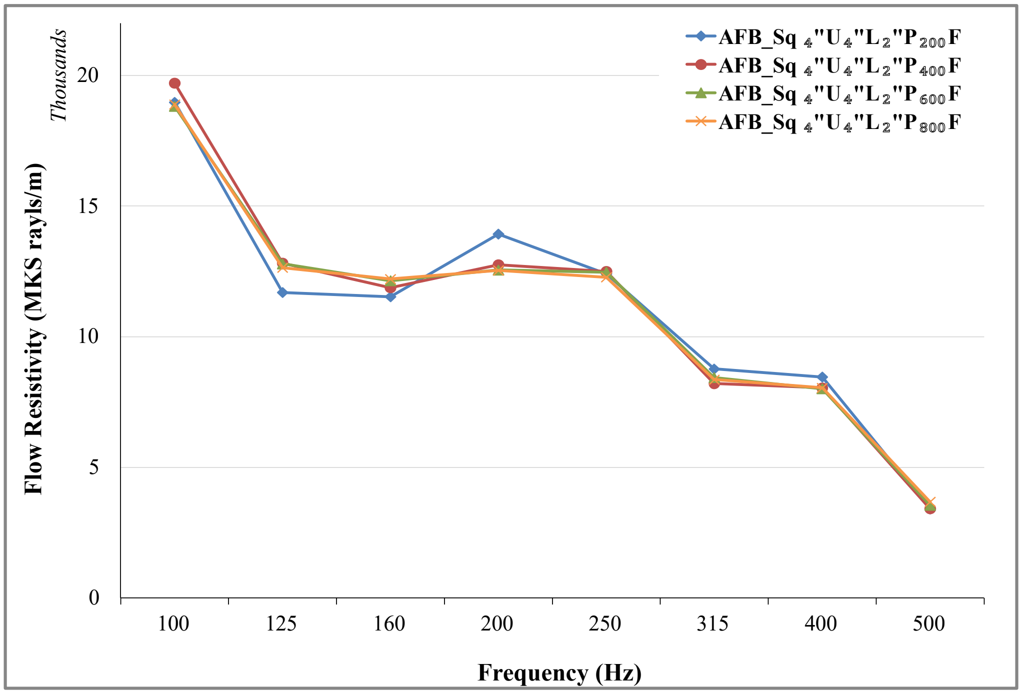


**Figure 6.10 – Flow resistivity of AFB 4" samples for different white noise durations**

Unlike the absorption coefficient results reported in Figure 5.1, flow resistivity did not show much sensitivity to white noise duration, as shown in Figure 6.10 for an AFB 4" sample. Similarities in the results from all four tested durations were evident, with the exception of the 200 points line varying slightly more. It is possible that the flow resistivity results are not as sensitive to the averaging time, since they are based on the initial absorption coefficient testing, which is all 800 points. Due to limited time, most of the air gap tests for the flow resistivity were conducted using 400 points, since this graph indicates there is negligible difference.

Only the flow resistivity results for the square samples are presented in the current paper. The reasoning behind this restriction is twofold. First, Tao et al.'s paper experimental results were limited to the ranges of 80 - 500 Hz. Thus, the same limitation was applied herein. Secondly, a circular frame (for the air gap) was not fabricated in time for testing. Therefore, the measurement accuracy of the air gap behind the circular sample was deemed unreliable. To account for the adjustment, the data cut-off was altered to 500 Hz for the square samples.

### *6.2.2 Fiberglass*

In Dr. Ramakrishnan's previous study, the flow resistivity results for an 8" thick fiberglass sample and its compressed 4" results are shown in Figure 6.11. The results were quite steady and indicated a gradual flow resistivity increase as the frequency increased. Resonance at 190 Hz and 480 Hz in the uncompressed results was magnified in the compressed samples.

Eight different flow resistivity fiberglass results from the current study have been plotted together in Figure 6.12. Two groupings were identified: stable uncompressed (2"and 4") samples, and fluctuating compressed (2" and 4") samples. The 2" uncompressed sample showed only a slightly higher flow resistivity than the 4" uncompressed sample. As the sample was compressed from 4" to 2" the flow resistivity more than doubled and peaked at 200 Hz.

In comparison, the current uncompressed samples results were within range of the three-microphone method results. However, the compressed in comparison fluctuated more and doubled in the flow resistivity results.

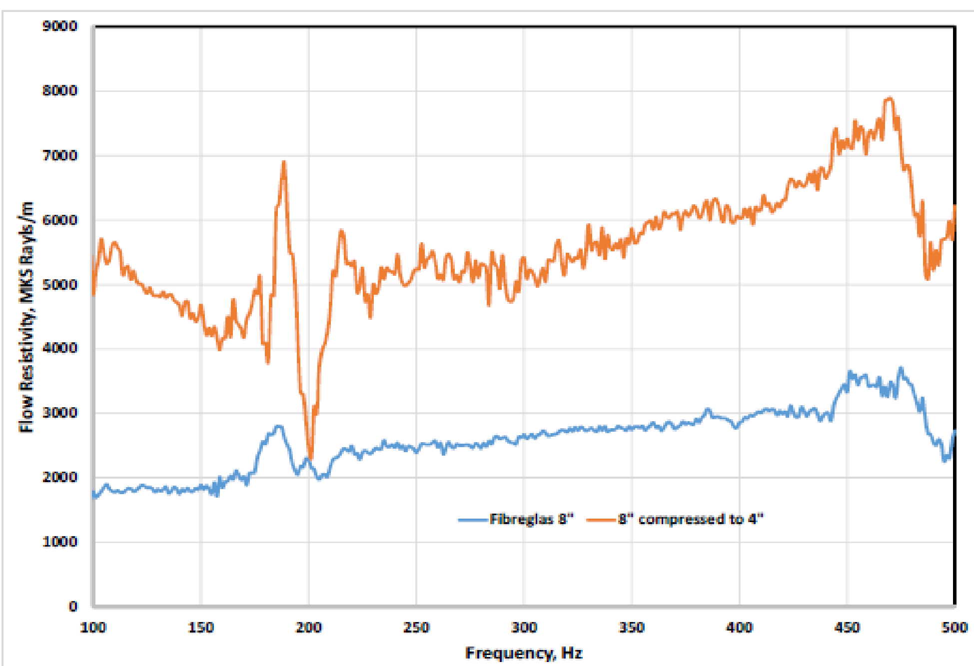


**Figure 6.11 – Three-microphone method: Flow resistivity of fiberglass 8" sample** [39]

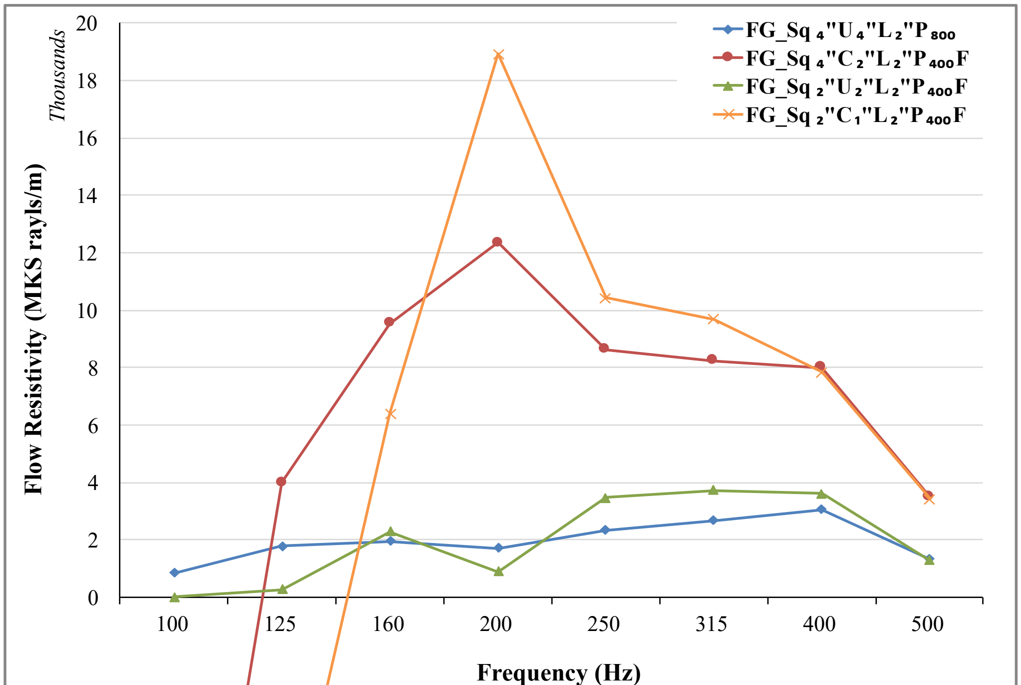


**Figure 6.12 - Flow resistivity of fiberglass square samples**

### *6.2.3 R24*

The three-microphone study flow resistivity results are presented in Figure 6.13 for a 4” thick R24 sample compressed to 3”. The uncompressed (blue line) sample results were steady with a couple of peaks near 190 Hz and 480 Hz. The compressed sample progressively peaked near 225 Hz to 45,000 MKS rayls/m before gradually decreasing to level off at 25,000 MKS rayls/m.

Current study results in Figure 6.14 did not show two distinct groups, since the 4” compressed (red line) results merged with the 2” uncompressed (green line) results near 350 Hz. Despite the crisscrossing of lines, compression did double the flow resistivity, with a clear offset between the uncompressed and compressed samples.

In comparison, the current study’s flow resistivity ranges were similar to the three-microphone results between 100-250 Hz. Both data sets were around 12,000 MKS rayls/m for the uncompressed samples, while the 4” compressed samples were both approximately 25,000 MKS rayls/m.

Similar results were obtained using air gaps of 2”, 4” and 6” for the R24 uncompressed 4” samples (not shown). However, the 6” gap seemed to have fewer fluctuations.

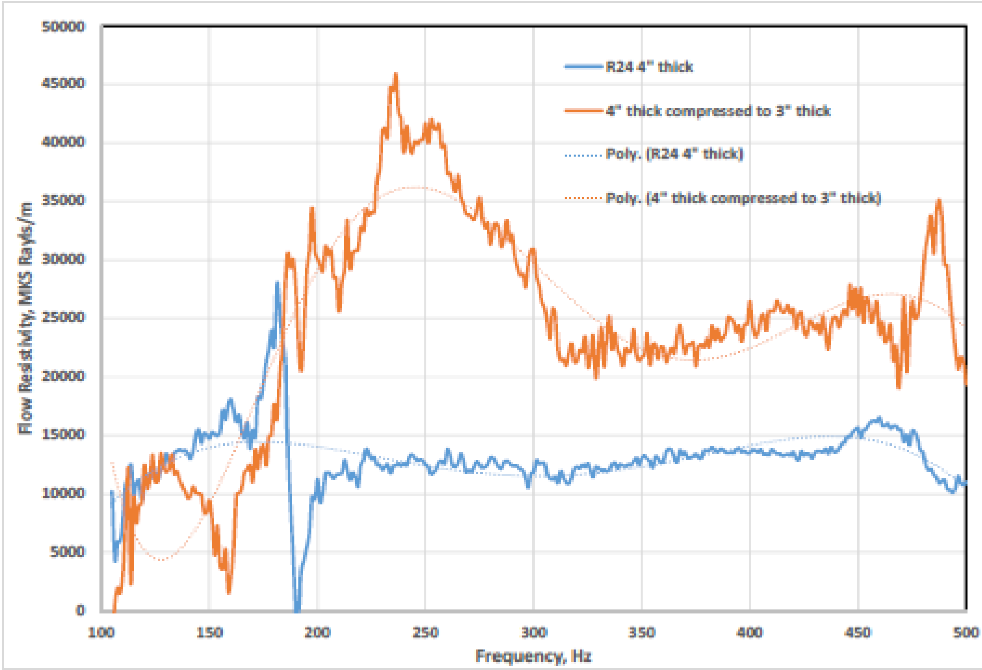


**Figure 6.13 – Three microphone method: Flow resistivity of R24 4" sample** [39]

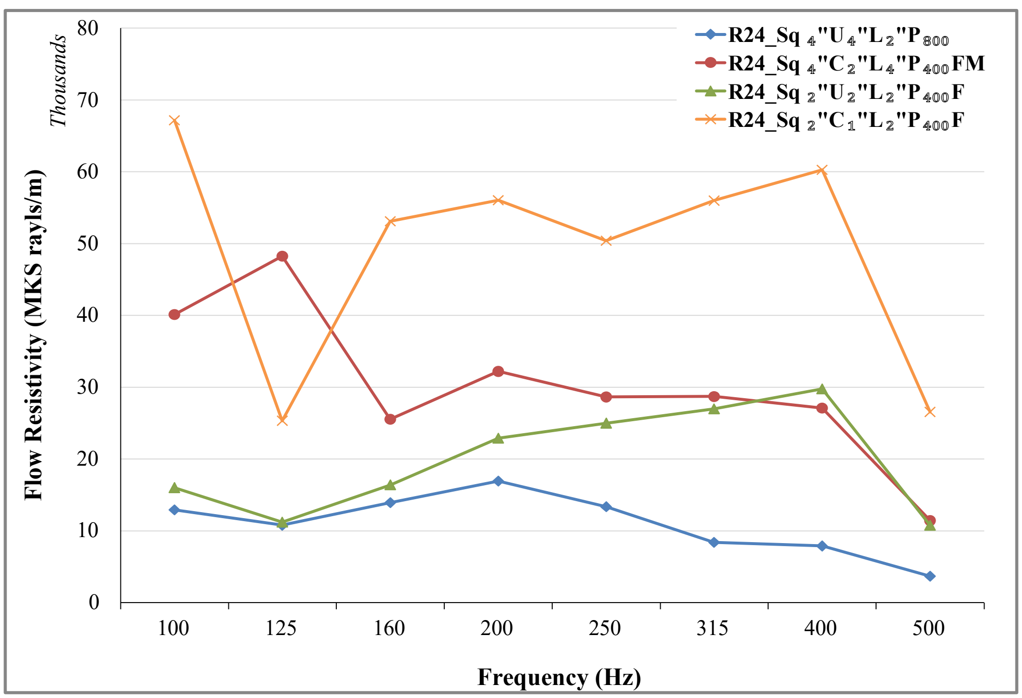


**Figure 6.14 – Flow Resistivity for R24 square samples**

### *6.2.4 AFB*

In the previous study, a 4” thick AFB sample was compressed (Figure 6.15) with rather stable results past 250 Hz. Resonance was present in both samples near 200 Hz and 480 Hz. As expected, the flow resistivity increased as the samples were compressed; however, unlike the other samples, the compressed result did not double in value, instead reaching only 1.5 times greater than the uncompressed value.

Two groups (uncompressed and compressed results) are illustrated in the current paper`s data (Figure 6.16). The 2” uncompressed sample resulted in only a slightly higher flow resistivity than the 4” uncompressed sample. Compression did double the flow resistivity results. All the data lines had a common decline after 400 Hz.

In contrast to the three-microphone results, the current results were less stable; however, for the 4” uncompressed sample, the current study shared similar values, hovering around 12,000 MKS rayls/m between 125-250 Hz before declining.

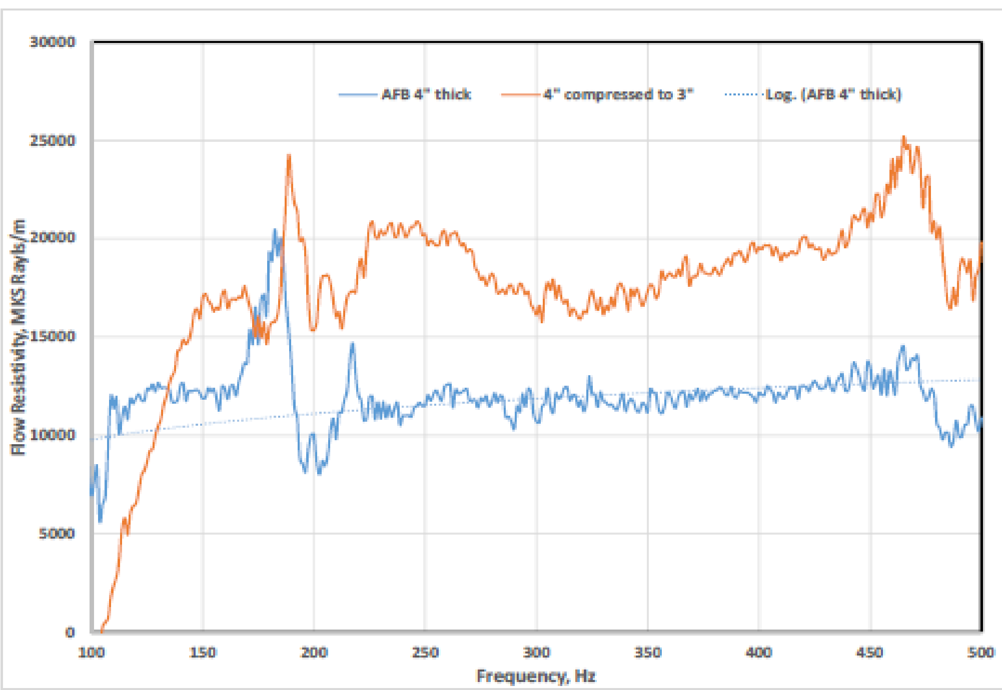


**Figure 6.15 - Three microphone method: Flow resistivity of AFB 4” sample** [39]

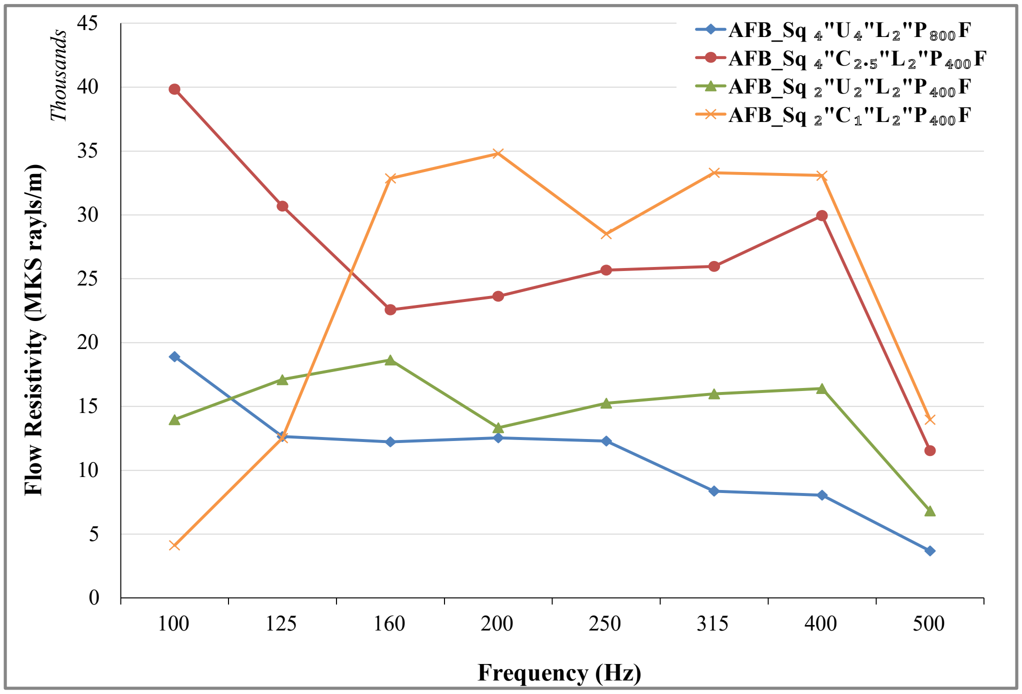


**Figure 6.16 - Flow resistivity of AFB square samples**

### *6.2.5 DD2*

Due to the high density of the DD2 samples, only the uncompressed state was tested. Figure 6.17 shows the three-microphone results for 2” and 4” thick DD2 samples. The results demonstrated resonance near 200 Hz, and the 2” data was seen to have flow resistivity ranges close to the 4”, but with more noise.

The results from the current study comparing the different air gaps of 2” and 4” for both uncompressed samples are shown in Figure 6.18. Two separate groups were observed, with the 2” samples nearly 10,000 MKS raysl/m higher than the 4” samples. The 4” frame lowered the absorption performance slightly.

Unlike the three-microphone results, the flow resistivity for the 2” was more stable and had a higher flow resistivity than that for the 4” sample. In general, the 2” sample shown in Figure 6.18 approached closest to 22,000 MKS rayls/m, while the previous study for both 2” and 4” samples plateaued around 18,000 MKS rayls/m.

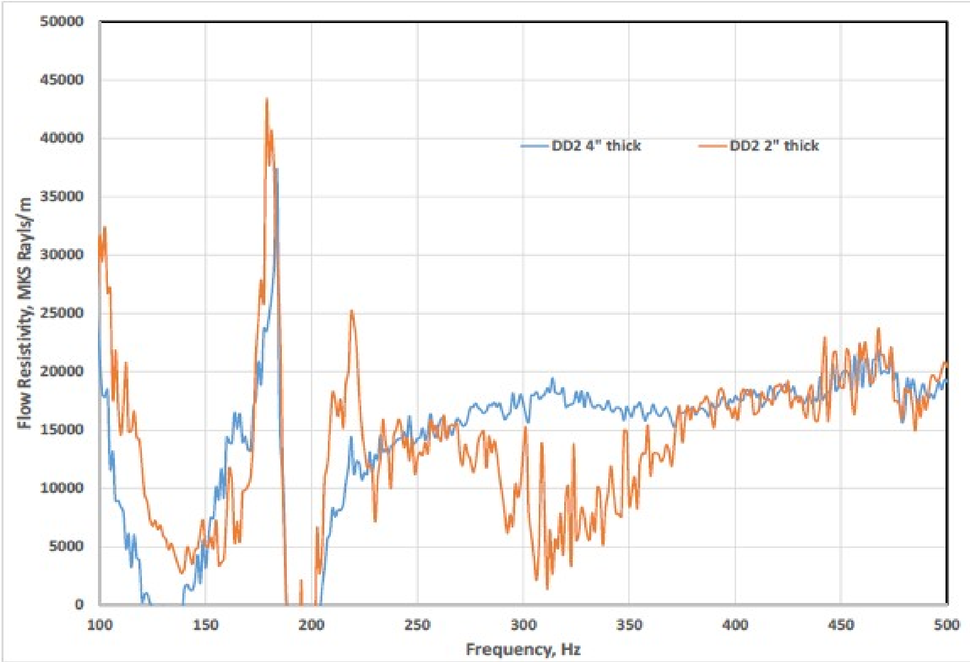


**Figure 6.17- Three microphone method: Flow resistivity of DD2 4" sample** [39]

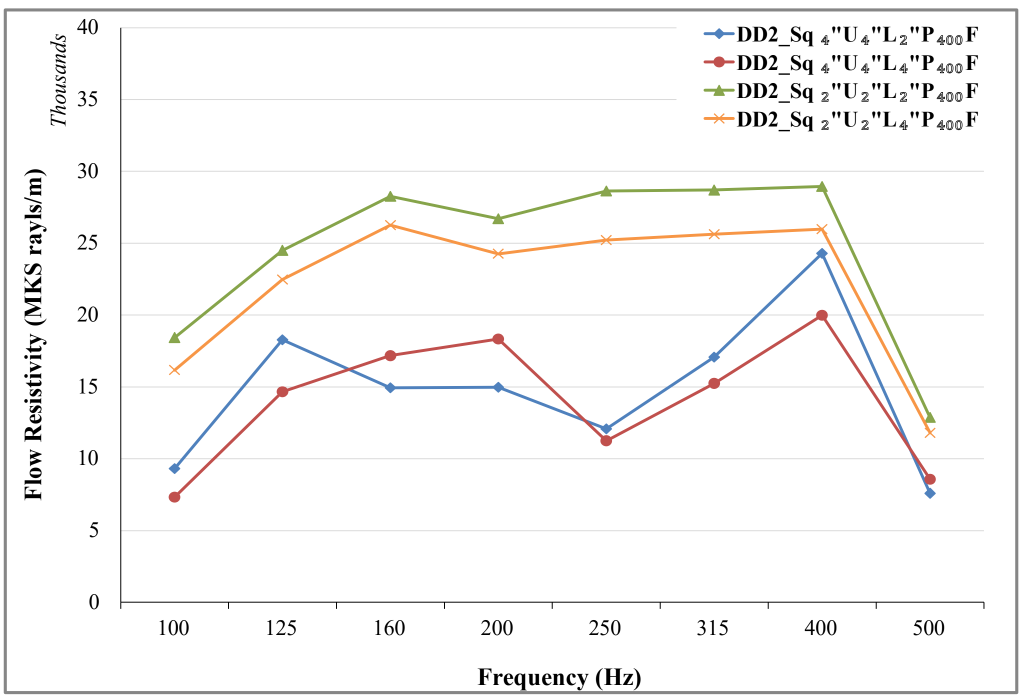


**Figure 6.18 – Flow resistivity of DD2 square samples**

*6.2.6 Flow Resistivity Results Summary*

Overall, the flow resistivity results showed an increase as the samples were compressed. Limited to the square samples, a general relationship presented in Figure 6.19 was observed across all four sample types, with the exception of DD2. A dip at 250 Hz was observed in the 2" compressed samples as well.

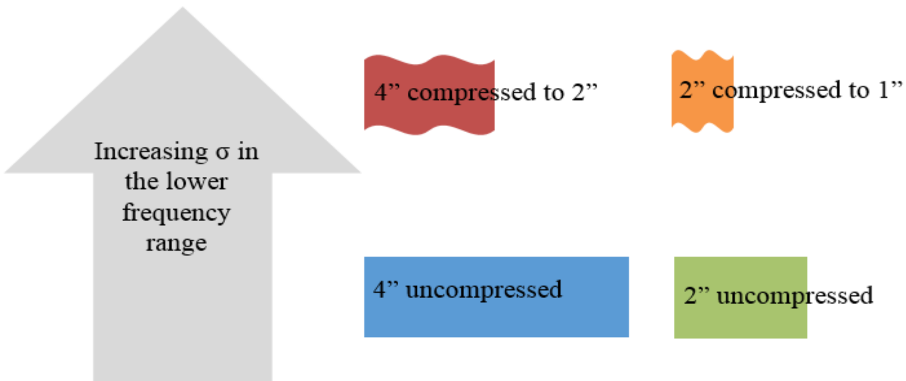


**Figure 6.19 – Graphical representation of increasing flow resistivity**

A summary of the observations are detailed under the following headings.

- Influence of L (Air Gap)

  According to Tao et al., a 4" gap resulted in better accuracy over the 2". Comparing the various air gaps 2"and 4" gap, the 4" lowered the flow resistivity results slightly.

- Influence of Thickness

  Most of the flow resistivity results for all the samples were independent of thickness with the exception of DD2. The 2" DD2 samples appeared to be more stable than the 4" samples. However, all 4" samples were within ranges listed in Table 6.1.

- Influence of Compression

  In general, the flow resistivity increased as the samples were compressed and was independent of the thickness of the sample. Any slight resonance is exaggerated in the compressed results.

- Influence of Frequency Range (circular vs square samples)

  Tao et al.'s results are limited to the range from 80-500 Hz. Overall, the test results for the circular samples in this part of the experiment were very widespread making it inconclusive and were not presented a part of the current report. It is possible that a circular frame is required to help maintain the air gap behind the specimen.