ACOUSTICAL ABSORPTION OF PAVEMENT CORES AND POROUS MATERIALS

Caltrans Quiet Pavement Research Program

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RESEARCH PLAN

- Measure Acoustical Absorption of Pavement Cores
- Measure Acoustical Absorption of Laboratory Samples of Known Properties and Test Numerical Model
- Prepare and Test High Porosity Laboratory Samples of Open Graded Asphalt and Infer Parameters

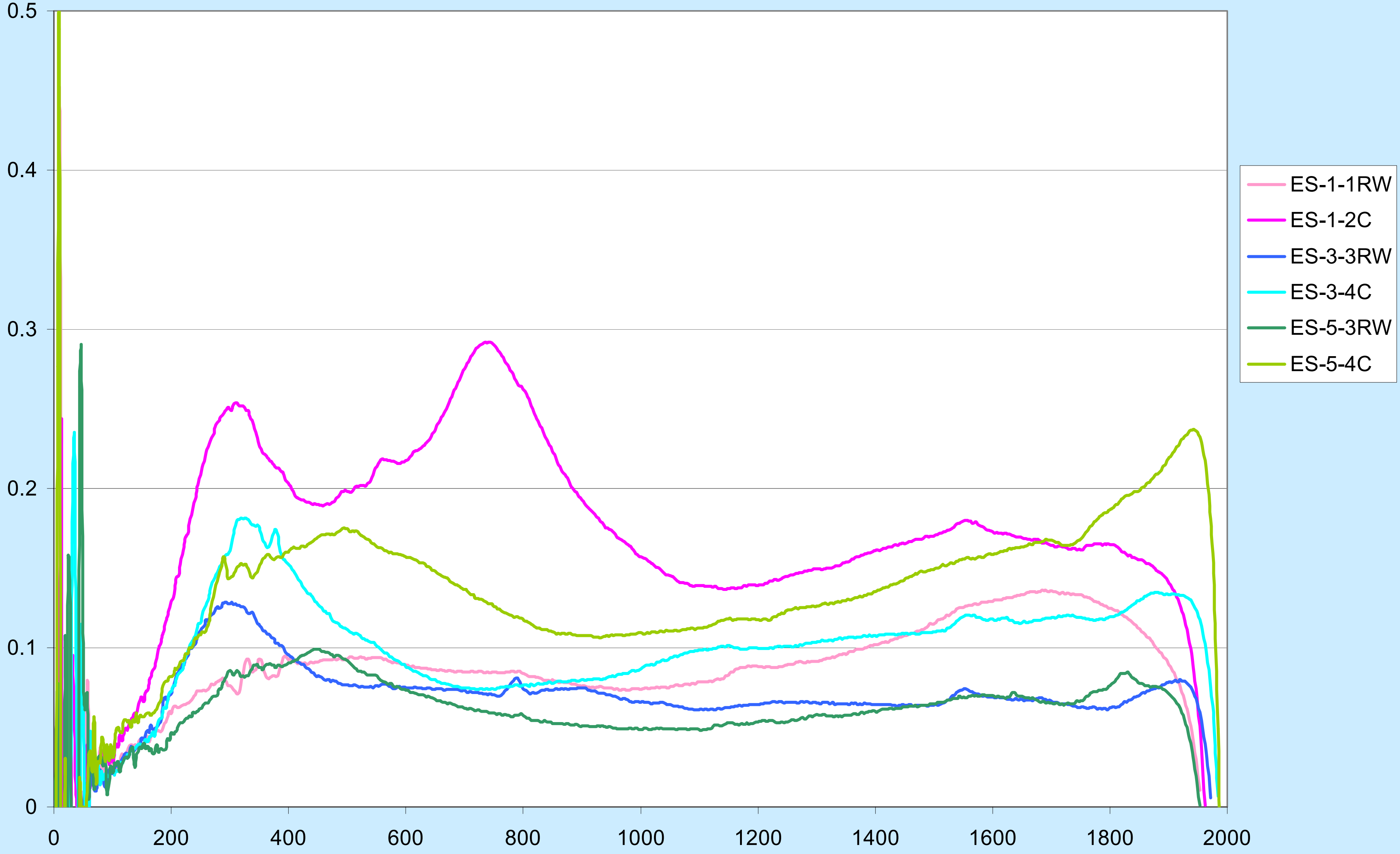
INSTRUMENTATION

- 100mm Impedance Tube with
- 63mm Diameter Sample Holder
- Custom 101-105mm Diameter Sample Holders
- 2-Microphone Transfer Function Technique
- ASTME-1050 - 98

PAVEMENT CORES

- Open Graded Asphalt - OGAC
- Dense Graded Asphalt – DGAC
- Gap Graded Asphalt – RAC-G

ABSORPTION SPECTRA



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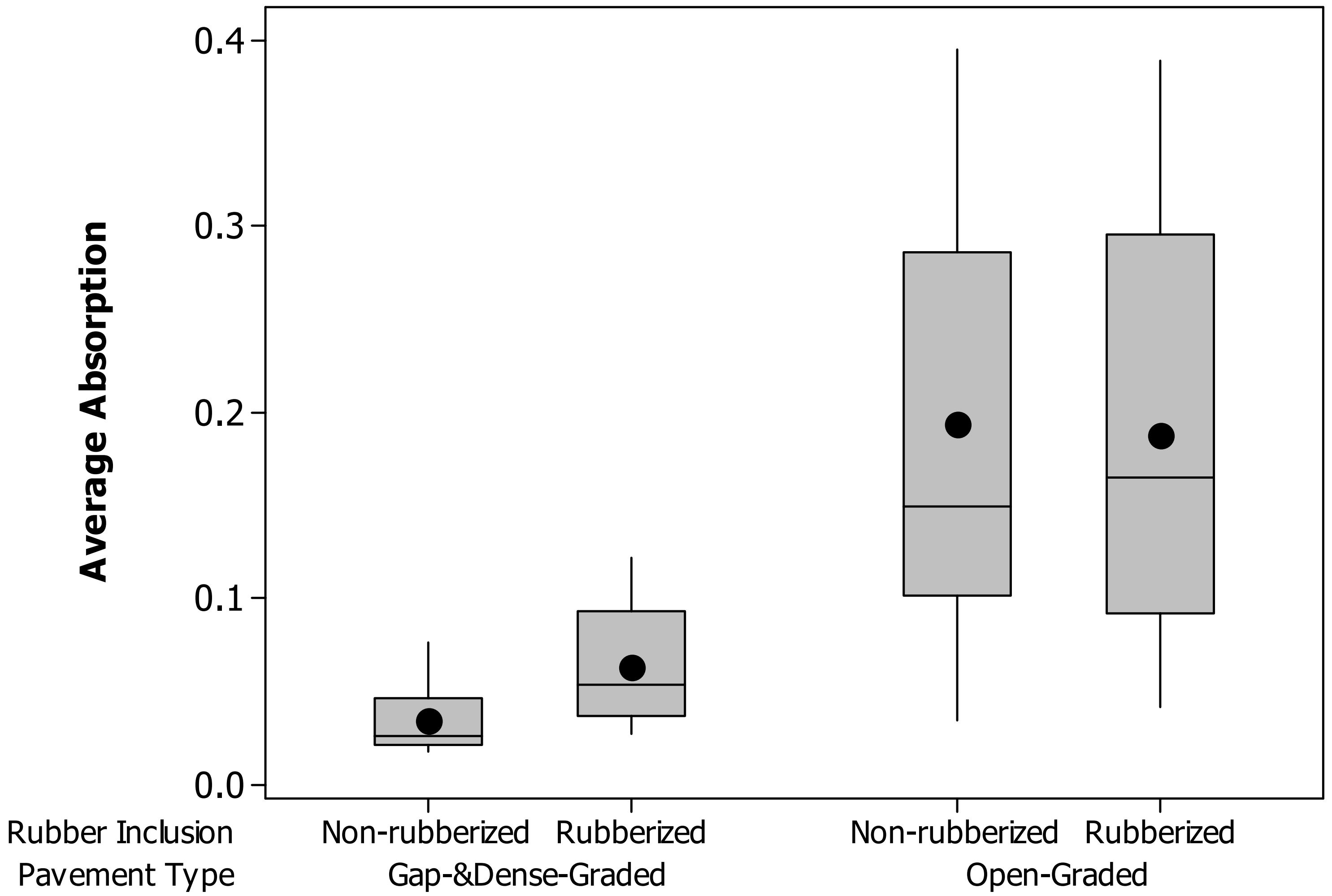
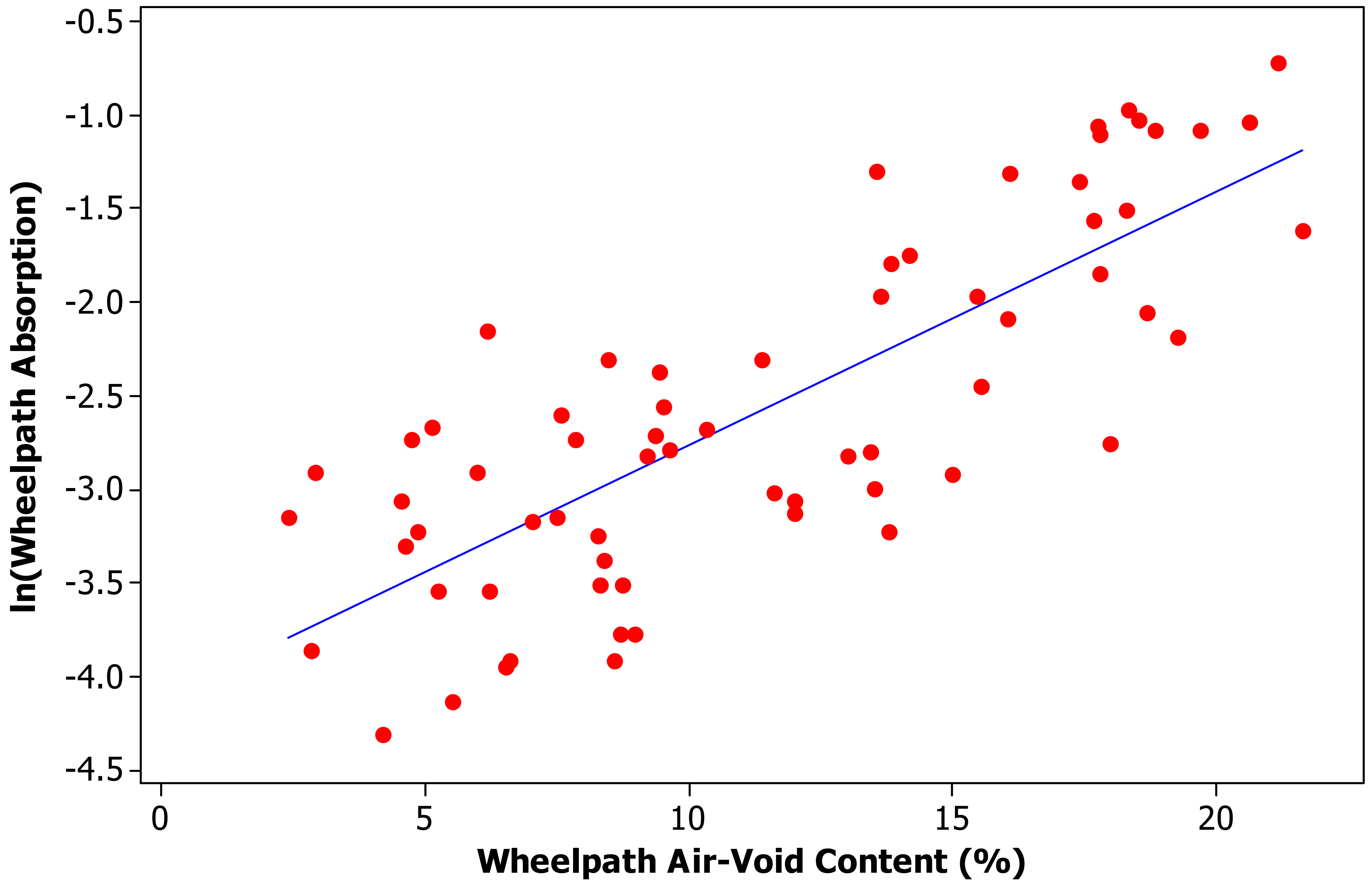
AIR VOID CONTENT - POROSITY

Core ID	CoreLok AV (%)	Thickness (mm)
ES-1- Center-OGAC	12.40	75
ES-1- Wheelpath-OGAC	9.40	75
ES-3-Center-OGAC	15.16	30
ES-3-Wheelpath-OGAC	10.32	30
ES-5-Center-RAC-G	11.82	30
ES-5-Wheelpath-RAC-G	13.00	30

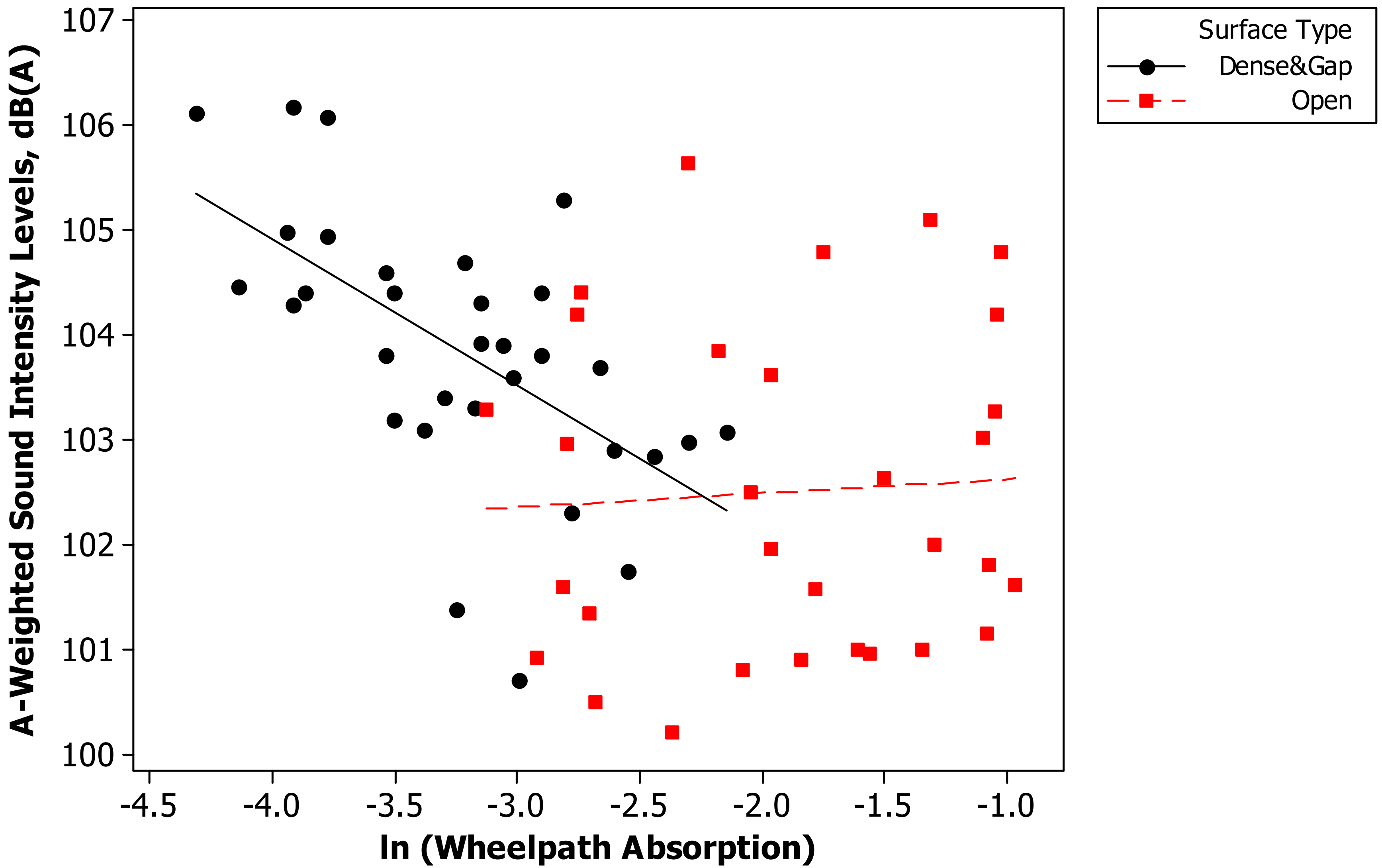
PAVEMENT TYPE

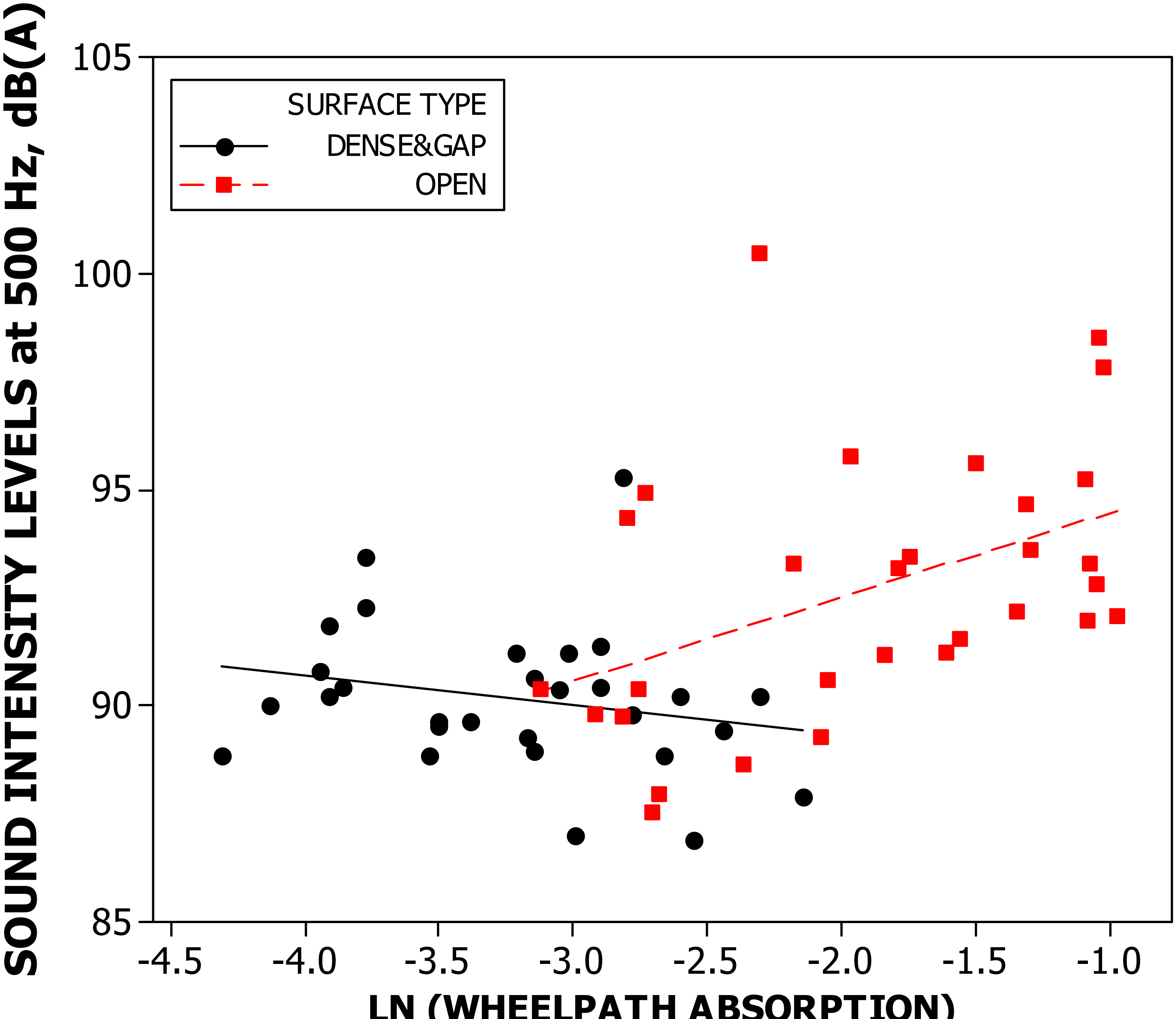




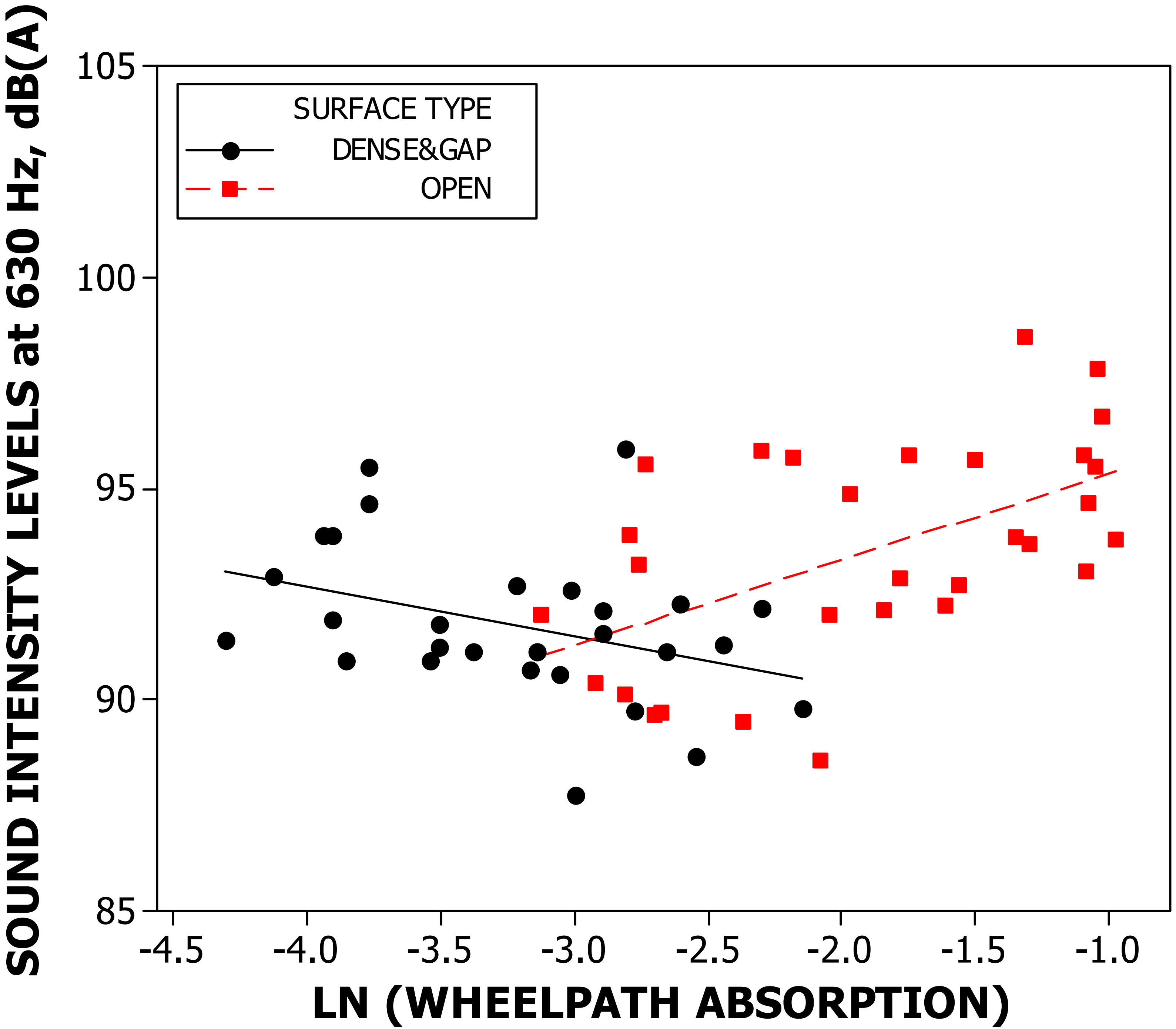
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
-4.0
-4.5
ln(Wheelpath Absorption)
0
5
10
15
20
Wheelpath Air-Void Content (%)

A-WT INTENSITY VS ABSORPTION

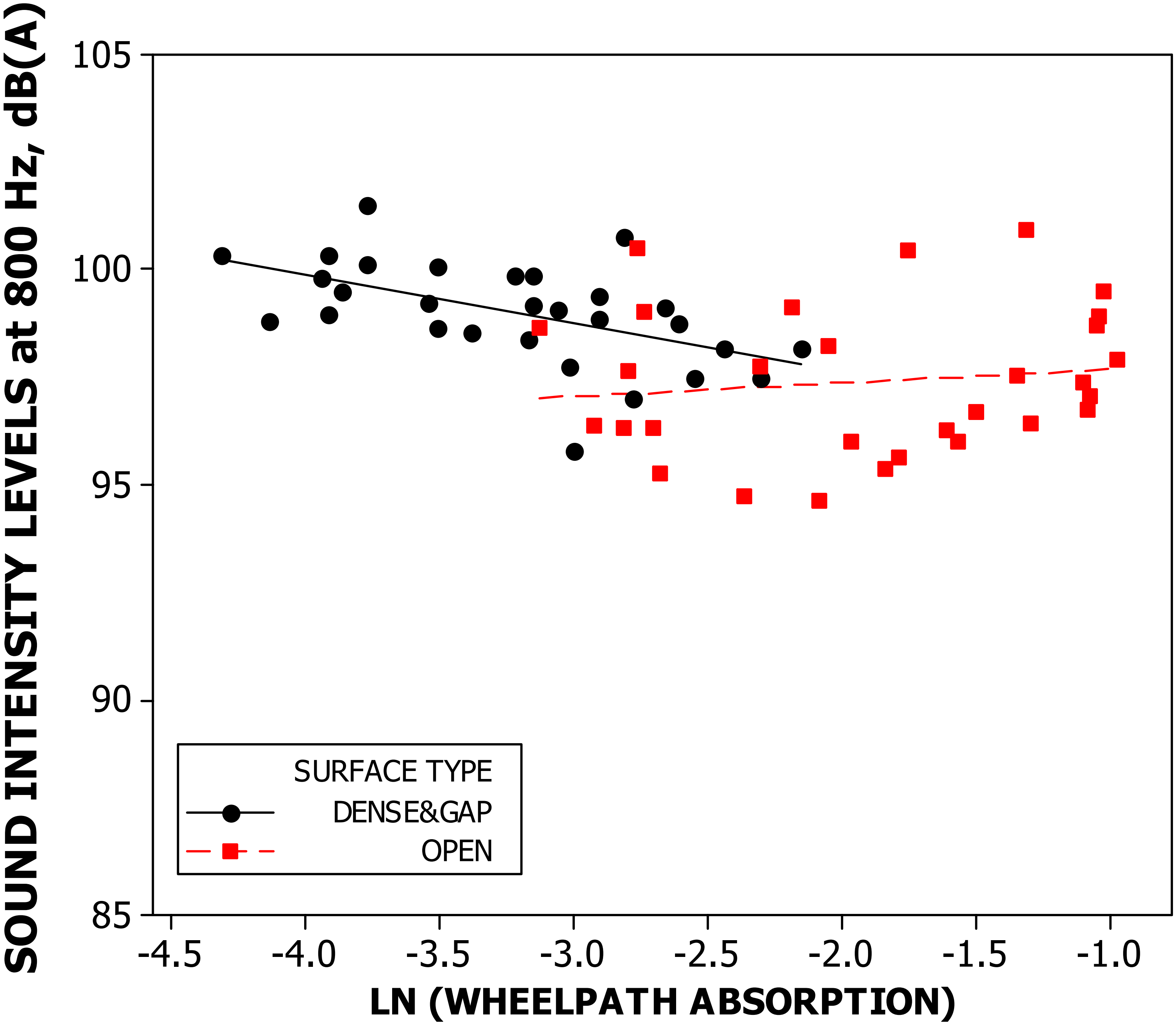


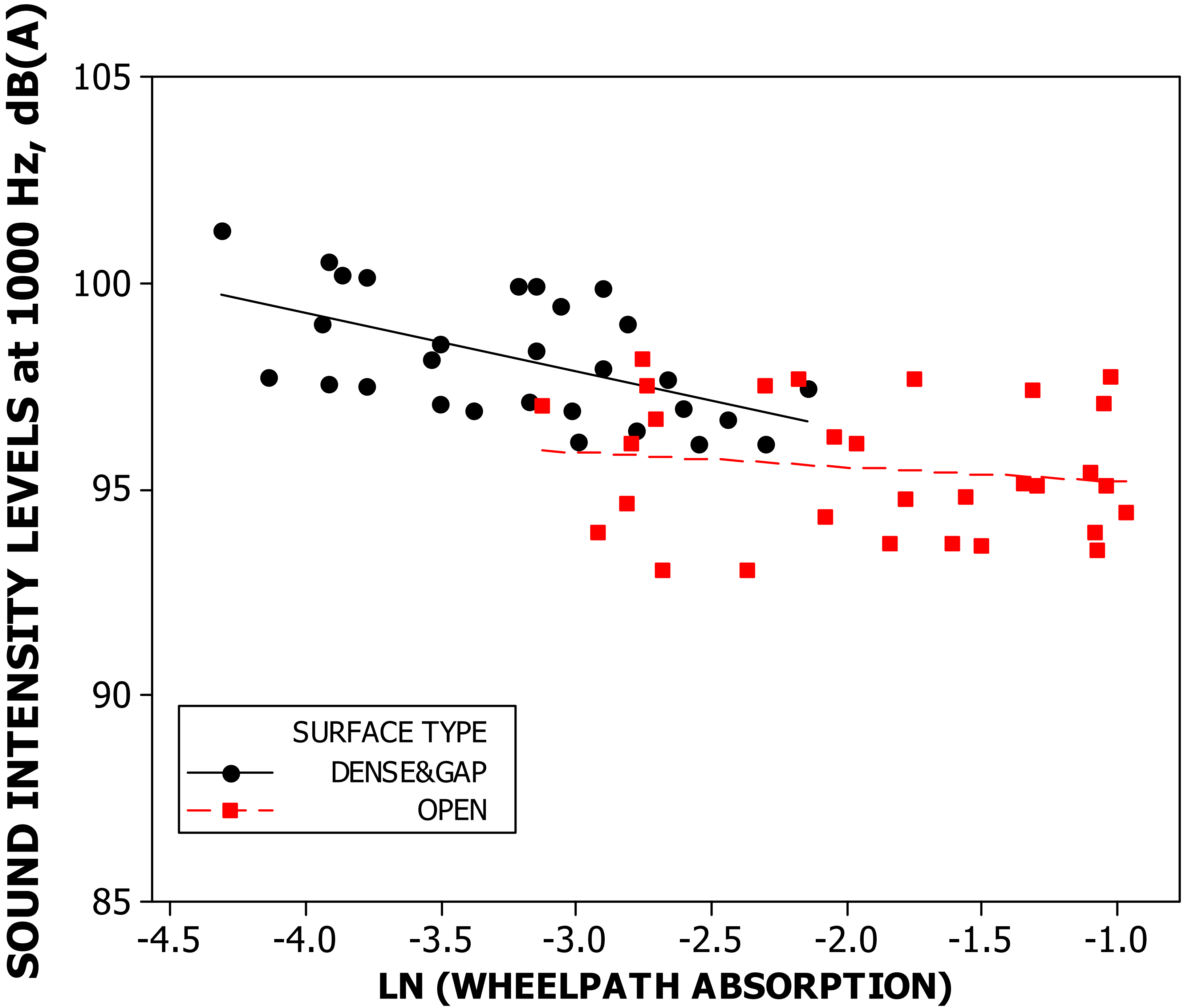


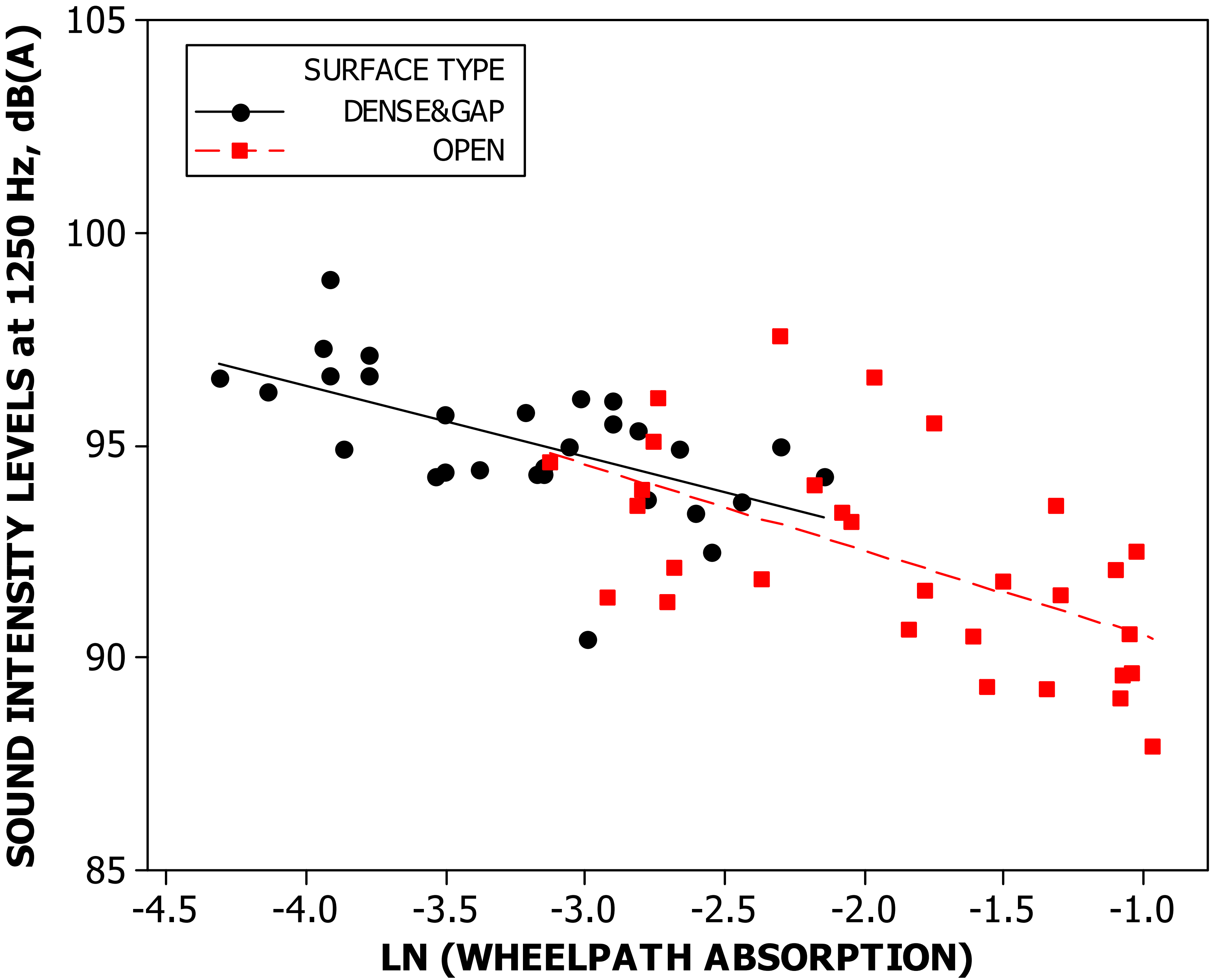
SURFACE TYPE
DENSE&GAP
OPEN
SOUND INTENSITY LEVELS at 500 Hz, dB(A)
105
100
95
90
85
-4.5
-4.0
-3.5
-3.0
-2.5
-2.0
-1.5
-1.0
LN (WHEELPATH ABSORPTION)



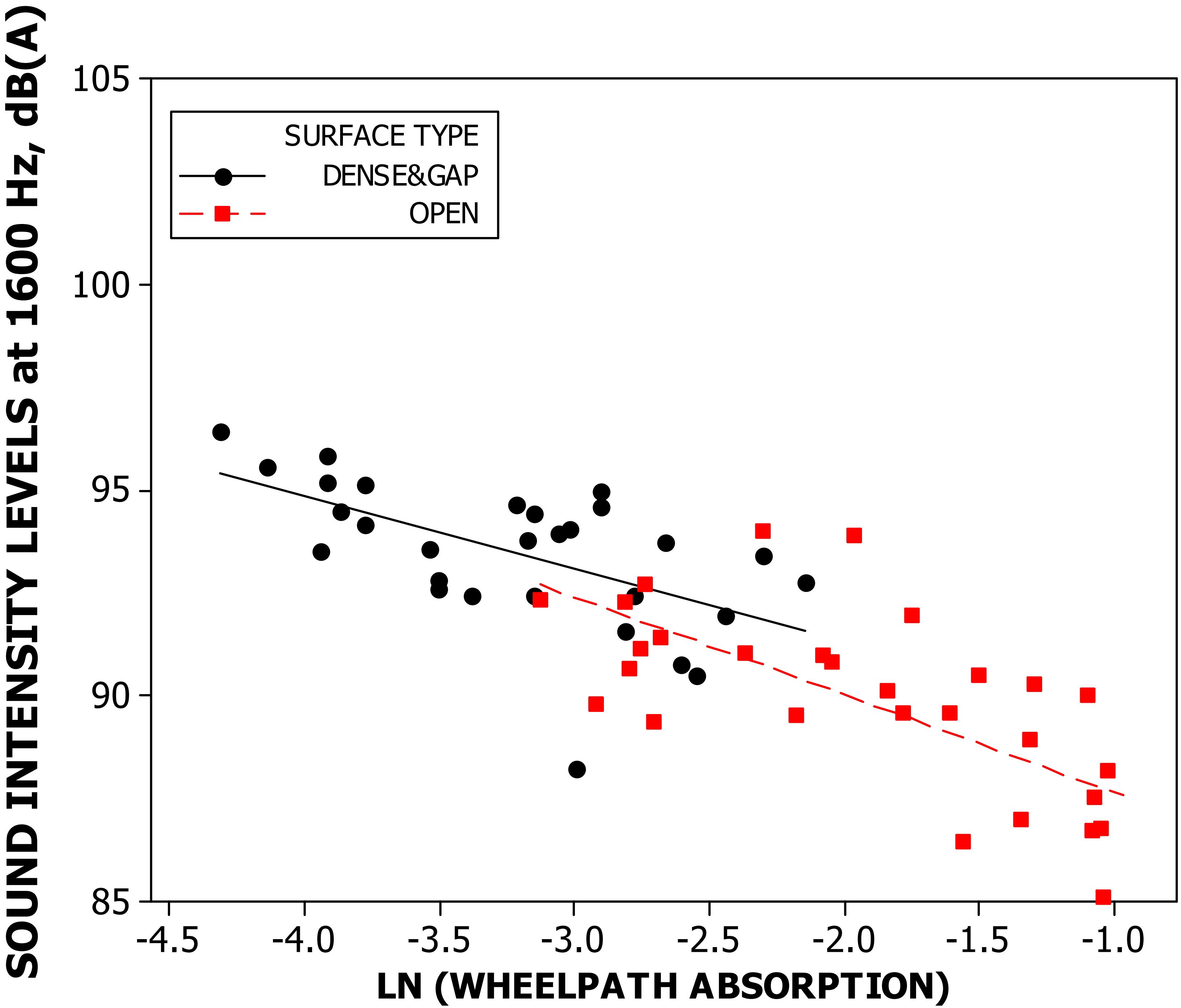
SOUND INTENSITY LEVELS at 630 Hz, dB(A)
105
100
95
90
85
SURFACE TYPE
DENSE&GAP
OPEN
-4.5
-4.0
-3.5
-3.0
-2.5
-2.0
-1.5
-1.0
LN (WHEELPATH ABSORPTION)


SOUND INTENSITY LEVELS at 800 Hz, dB(A)
105
100
95
90
85
-4.5
-4.0
-3.5
-3.0
-2.5
-2.0
-1.5
-1.0
LN (WHEELPATH ABSORPTION)
SURFACE TYPE
DENSE&GAP
OPEN


SOUND INTENSITY LEVELS at 1000 Hz, dB(A)
105
100
95
90
85
-4.5
-4.0
-3.5
-3.0
-2.5
-2.0
-1.5
-1.0
LN (WHEELPATH ABSORPTION)
SURFACE TYPE
DENSE&GAP
OPEN



SOUND INTENSITY LEVELS at 1250 Hz, dB(A)
105
100
95
90
85
SURFACE TYPE
DENSE&GAP
OPEN
-4.5
-4.0
-3.5
-3.0
-2.5
-2.0
-1.5
-1.0
LN (WHEELPATH ABSORPTION)


SOUND INTENSITY LEVELS at 1600 Hz, dB(A)
105
100
95
90
85
SURFACE TYPE
DENSE&GAP
OPEN
-4.5
-4.0
-3.5
-3.0
-2.5
-2.0
-1.5
-1.0
LN (WHEELPATH ABSORPTION)

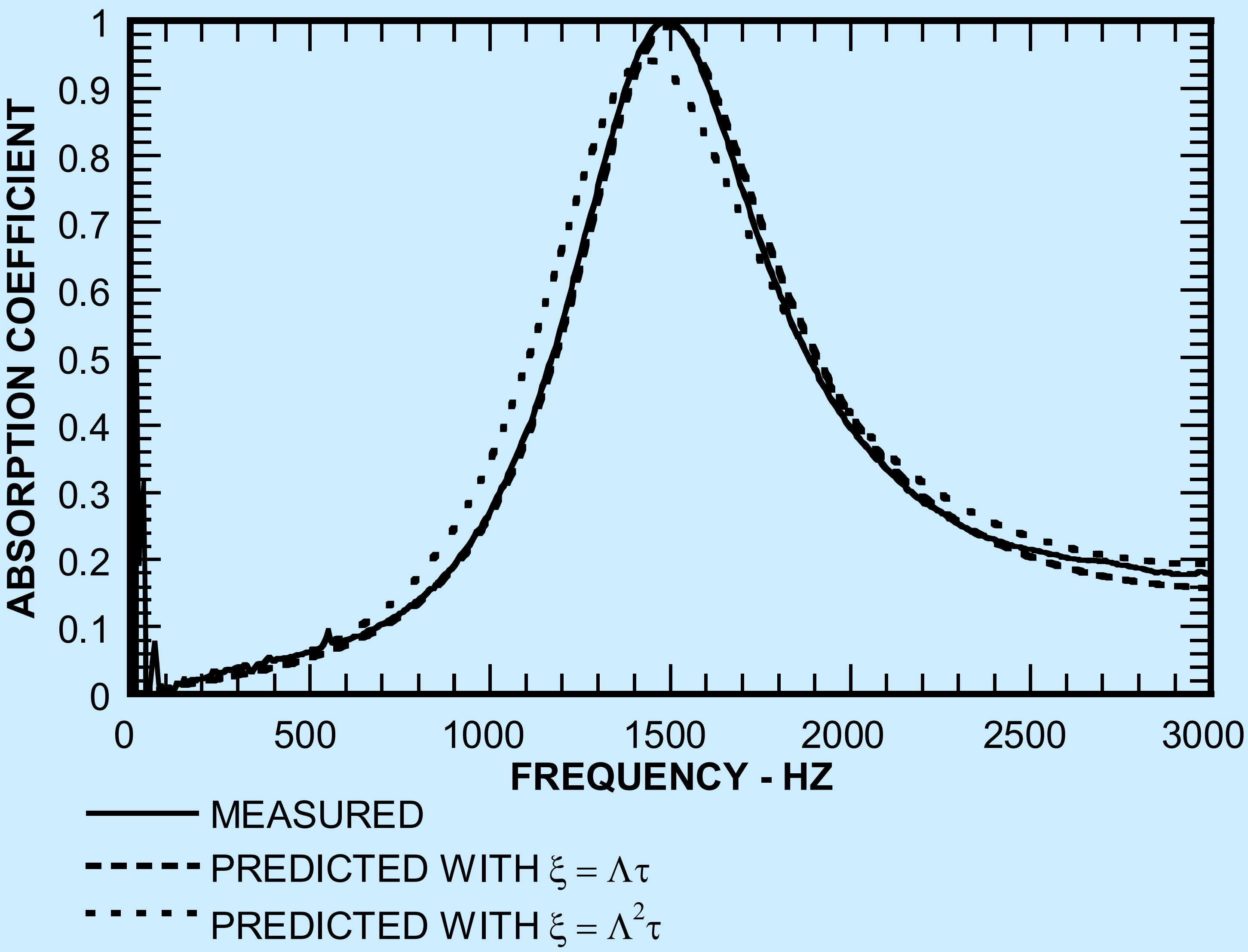
NUMERICAL MODEL

- Biot - 1956
- Zwikker & Kosten - 1946
- Vertical Heterogeneity
  - Porosity
  - Tortuosity
  - Pore Size or Hydraulic Diameter
  - Sinuosity

MODEL VERIFICATION

- 3.175mm Steel Dowel Pins in Parallel
  - Unit Tortuosity
- Glass Beads
  - Tortuosity = $1-(1-1/\beta)/2$

51MM LAYER 3.175MM STEEL RODS



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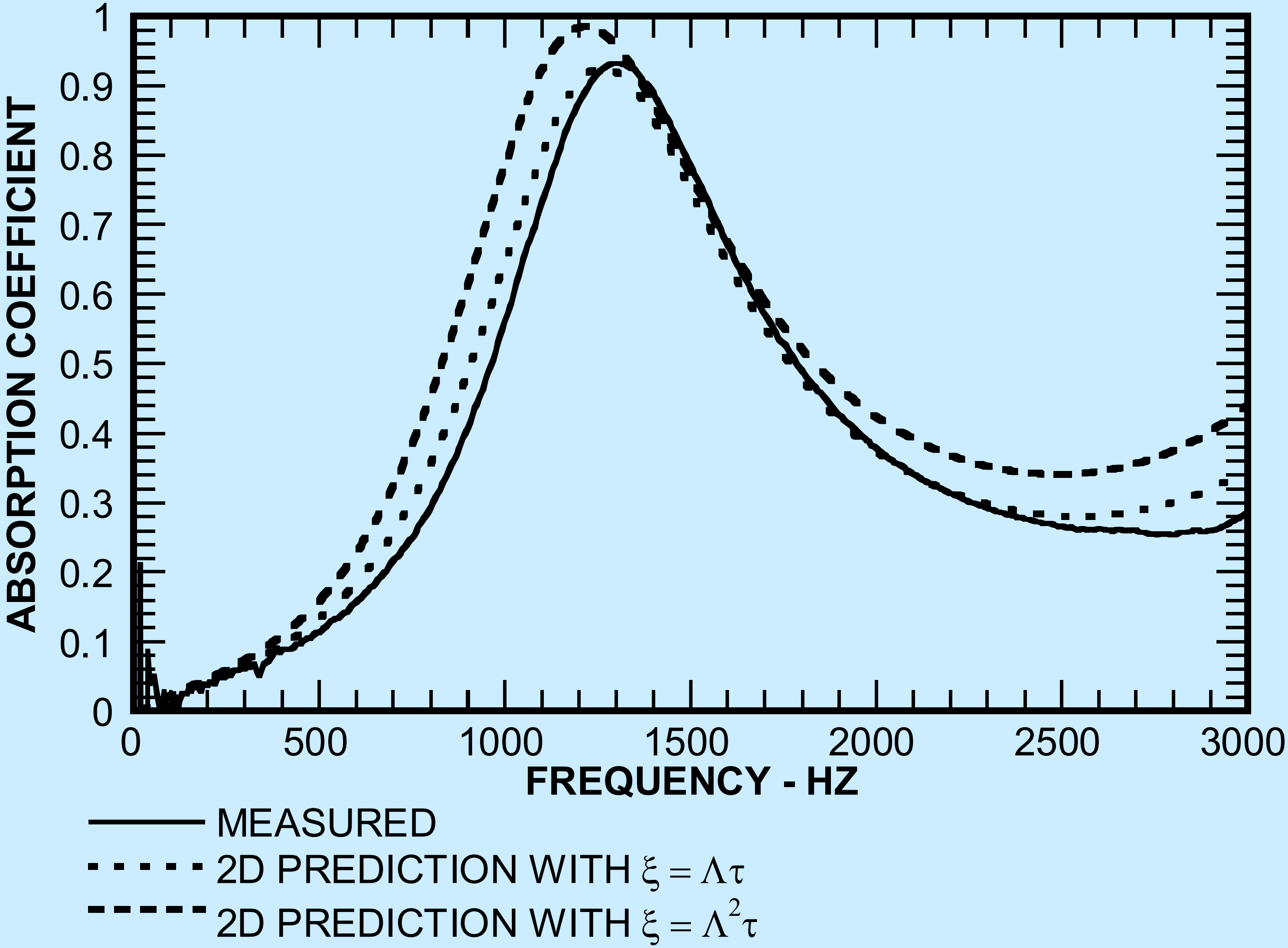
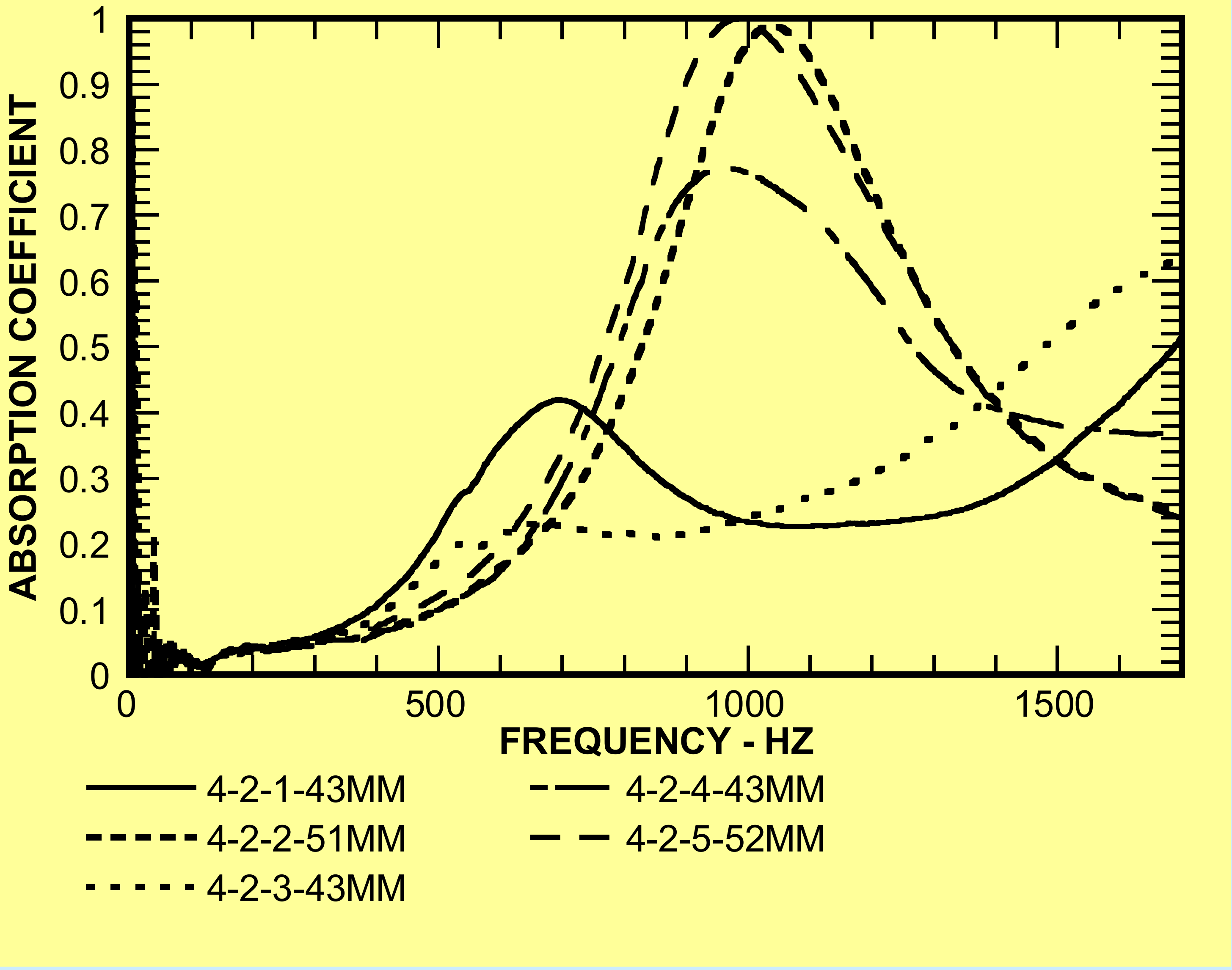
48MM LAYER 3MM GLASS BEADS



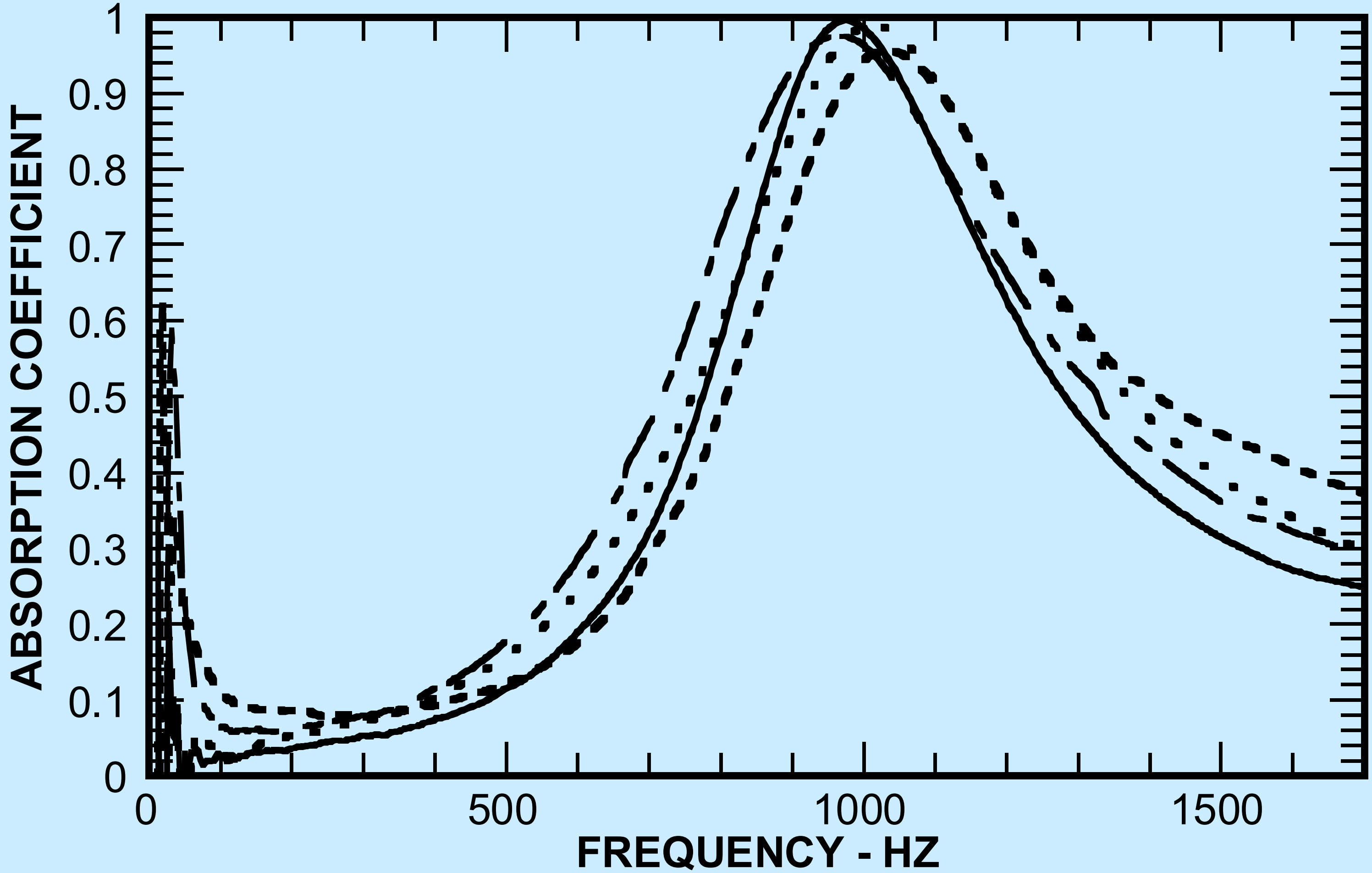
LABORATORY ASPHALT

- Thicknesses
  - 50MM
  - 100MM
- Rock Size
  - #4
  - #8
- Type
  - Rounded
  - Angled

50MM LAYER #4 ANGLED ROCK

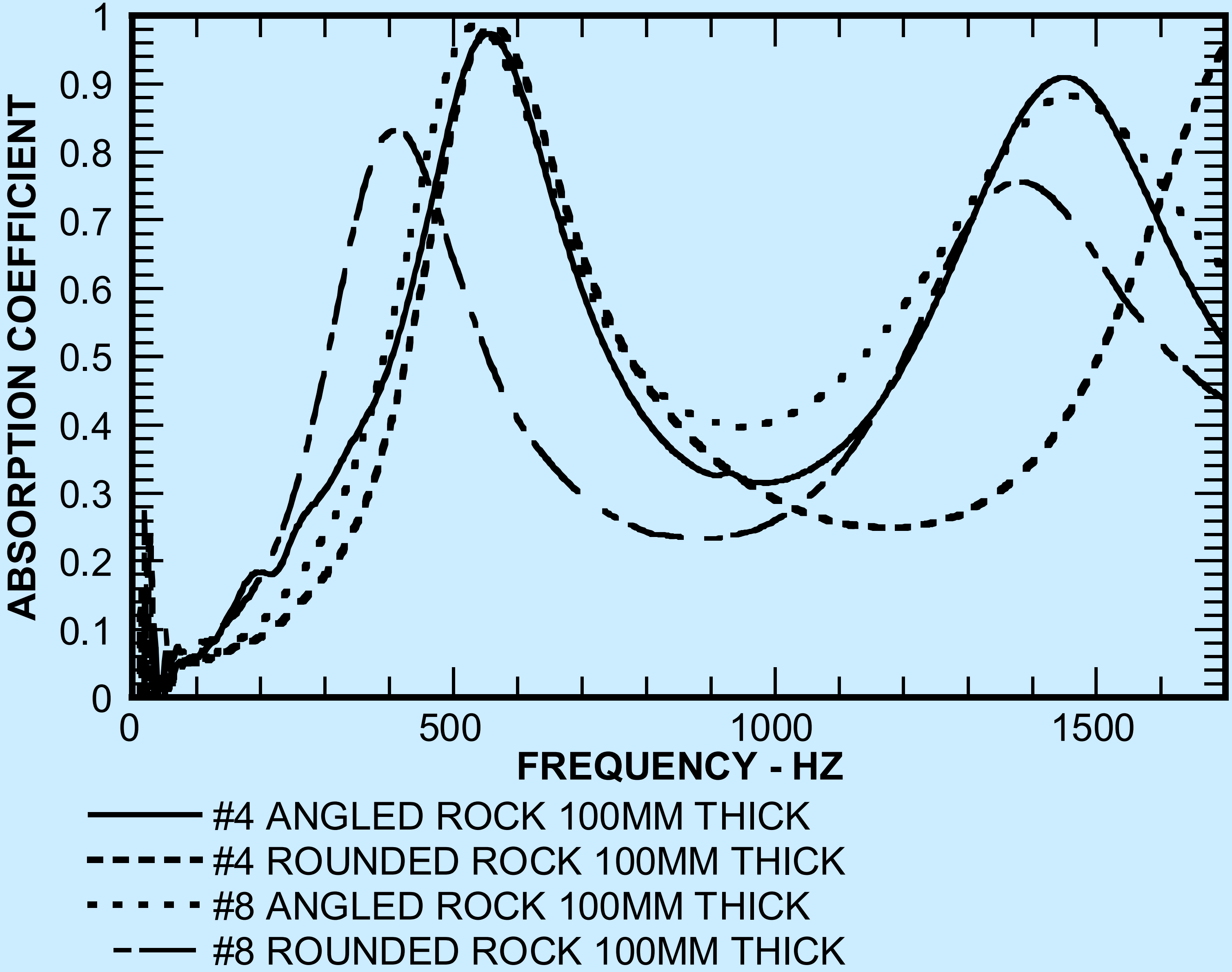


50MM LAYER



#4 ANGLED ROCK 50MM THICK
#4 ROUNDED ROCK 50MM THICK
#8 ANGLED ROCK 50MM THICK
#8 ROUNDED ROCK 50MM THICK

100MM ASPHALT



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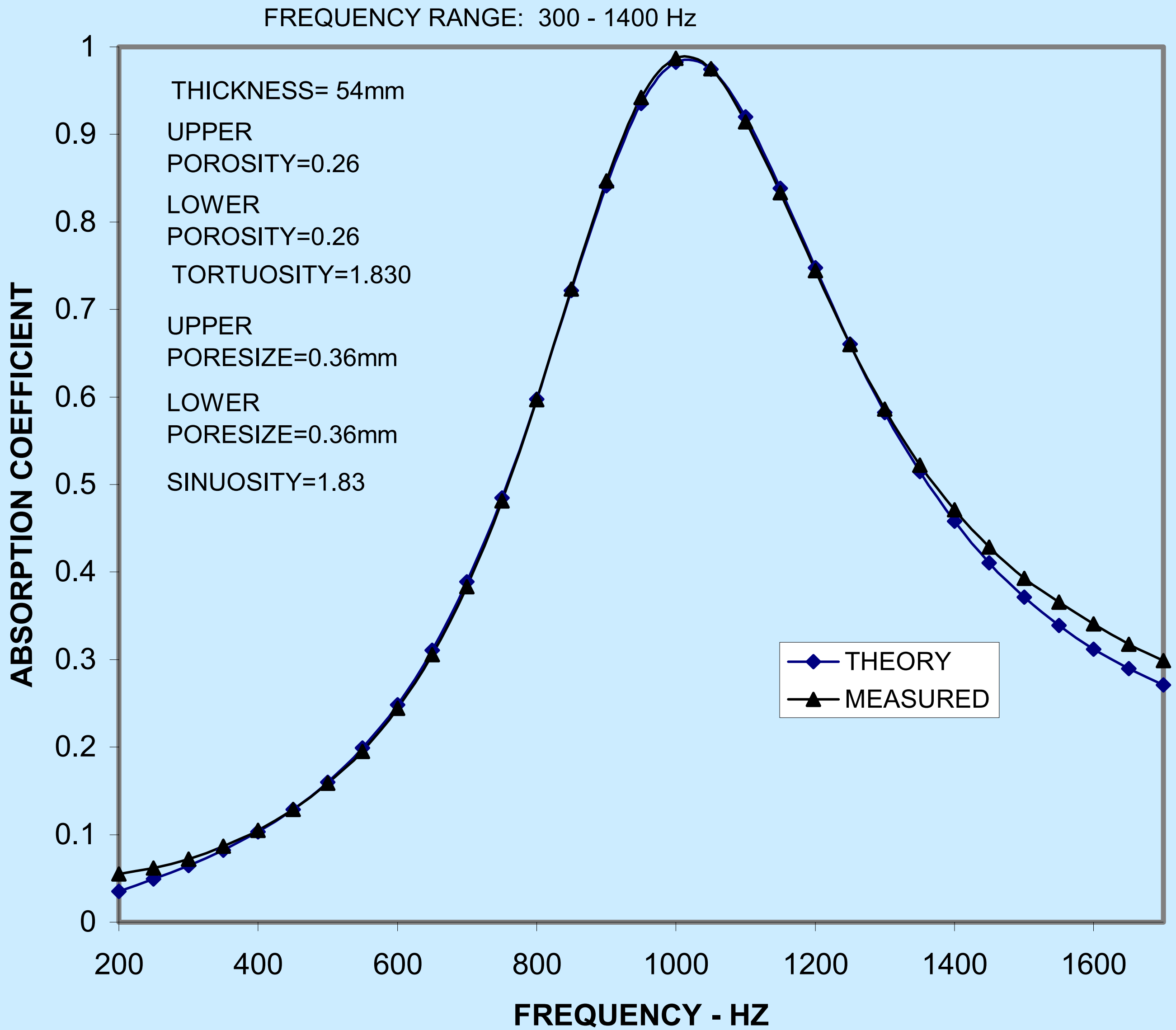
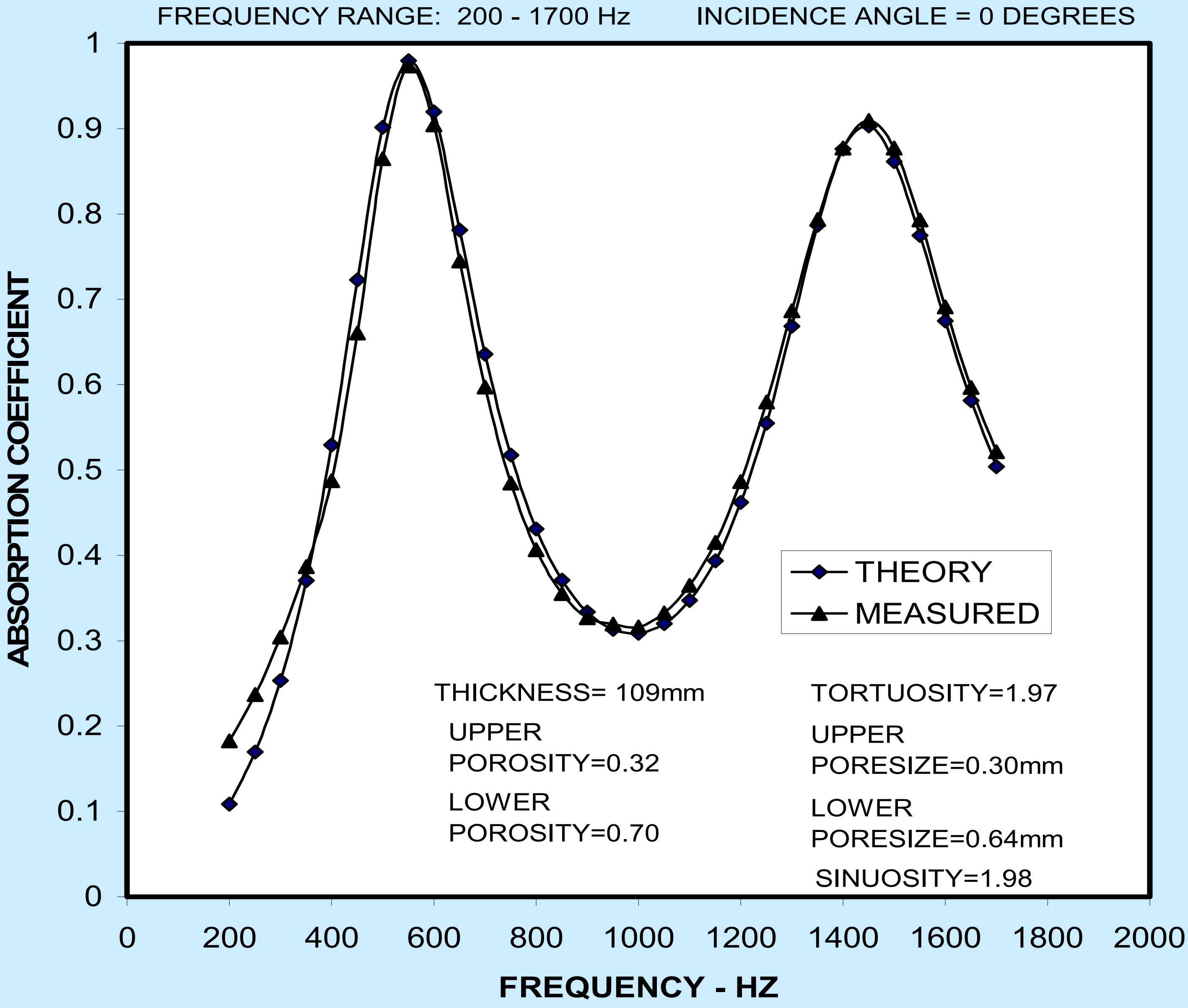
FIT – 50MM #8 ANGLED ROCK



UCDAVIS WILSON IHRIG & ASSOCIATES CALTRANS

100MM #4 ANGLED ROCK



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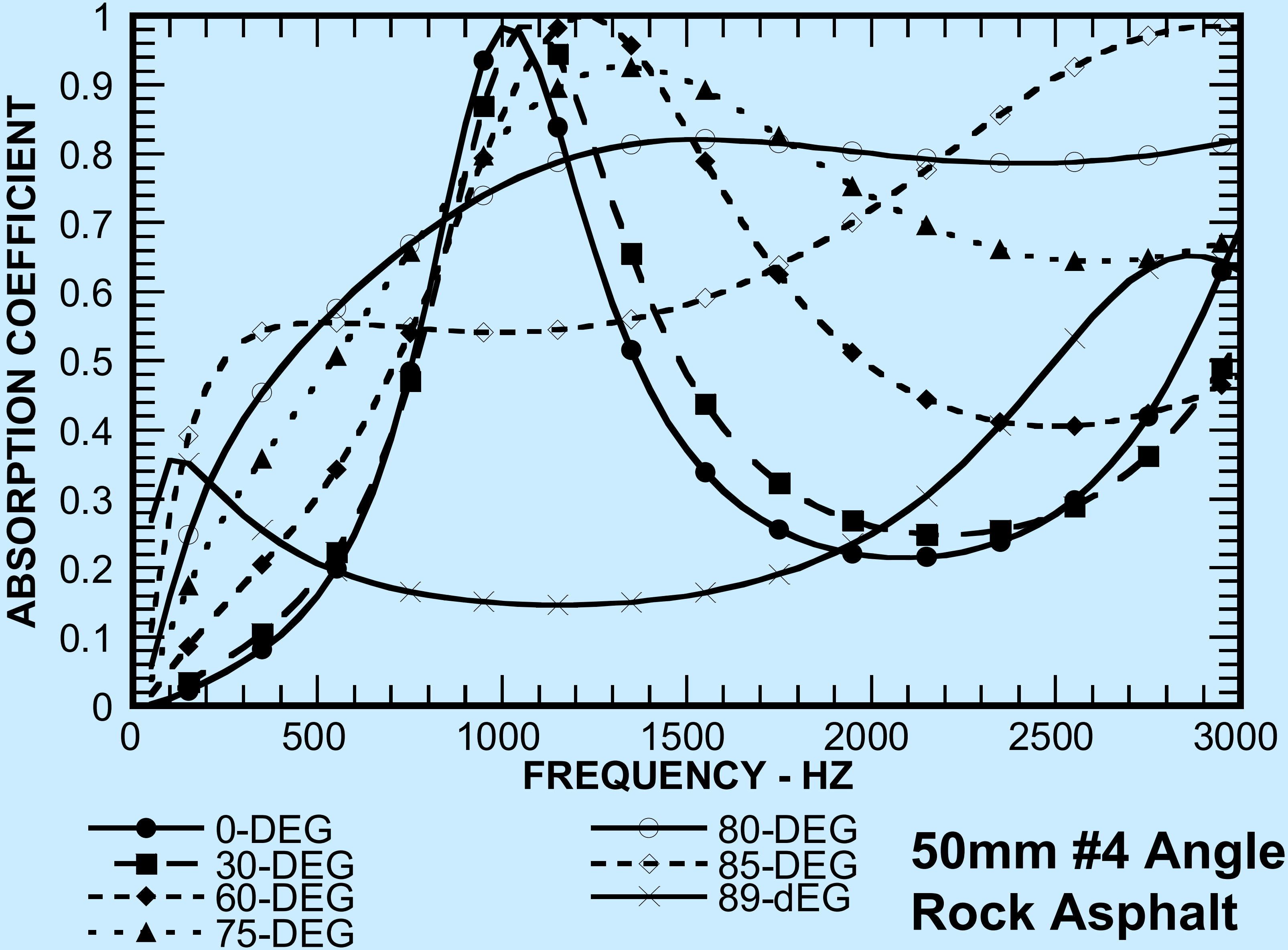
INFERED PARAMETERS

Sample	Porosity	Tortuosity	Pore Size mm
50mm #4 ANGLE	0.27	2.27	0.47
50mm #4 ROUND	0.33	2.11	0.56
100mm #4 ANGLE	0.37	1.88	0.32
100mm #4 ROUND	0.35	1.90	0.57
50mm #8 ANGLE	0.26	1.83	0.36
50mm #8 ROUND	0.29	2.33	0.32
100mm #8 ANGLE	0.37	2.15	0.27
100mm #8 ROUND	0.28	2.72	0.37
OVERALL AVERAGE	0.32	2.15	0.4
#4 ANGLED MEAN	0.32	2.08	0.4
#4 ROUNDED MEAN	0.34	2.01	0.57
#8 ANGLED MEAN	0.32	1.99	0.32
#8 ROUNDED MEAN	0.29	2.53	0.35
#4 MEAN	0.33	2.04	0.48
#8 MEAN	0.30	2.26	0.33

ABSORPTION VS INCIDENCE ANGLE



50mm #4 Angled Rock Asphalt

CONCLUSIONS

- Pavement Absorption vs OBSI
- Existing Theories Adequate
  - Lateral Homogeneous Materials
  - Isotropic
  - Vertical Heterogeneous
- Numerical Model
  - Infer Material Parameters
  - Predict Absorption for Non-Zero Angle of Incidence
- Material Parameters Difficult to Control