CTA NOISE ABATEMENT

IPRO 597 – 029
CTA Noise Abatement
Dec. 10, 1999

Group Members

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...one of the Interprofessional Projects@IIT

IPRO 597-029

CTA Noise Abatement at the Illinois Institute of Technology

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Statement of Objectives

- Determine noise generation sources and parameters affecting noise production.
- Produce samples of noise absorbing and noise barrier materials and evaluate them for effectiveness.
- Develop skill in assessing the effect of barriers and buildings on noise propagation.
- Develop designs for barriers of a variety of types: in building walls, free standing, and attached to something.

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Problems:

- The Tracks
  - Old Reverberant Steel Structure
  - We cannot touch it

- The Noise
  - Sound Pressure Levels
    - SPL = $20\log_{10}(P_{sound}/P_0)$ (100-110 dB)
  - Problem Frequencies

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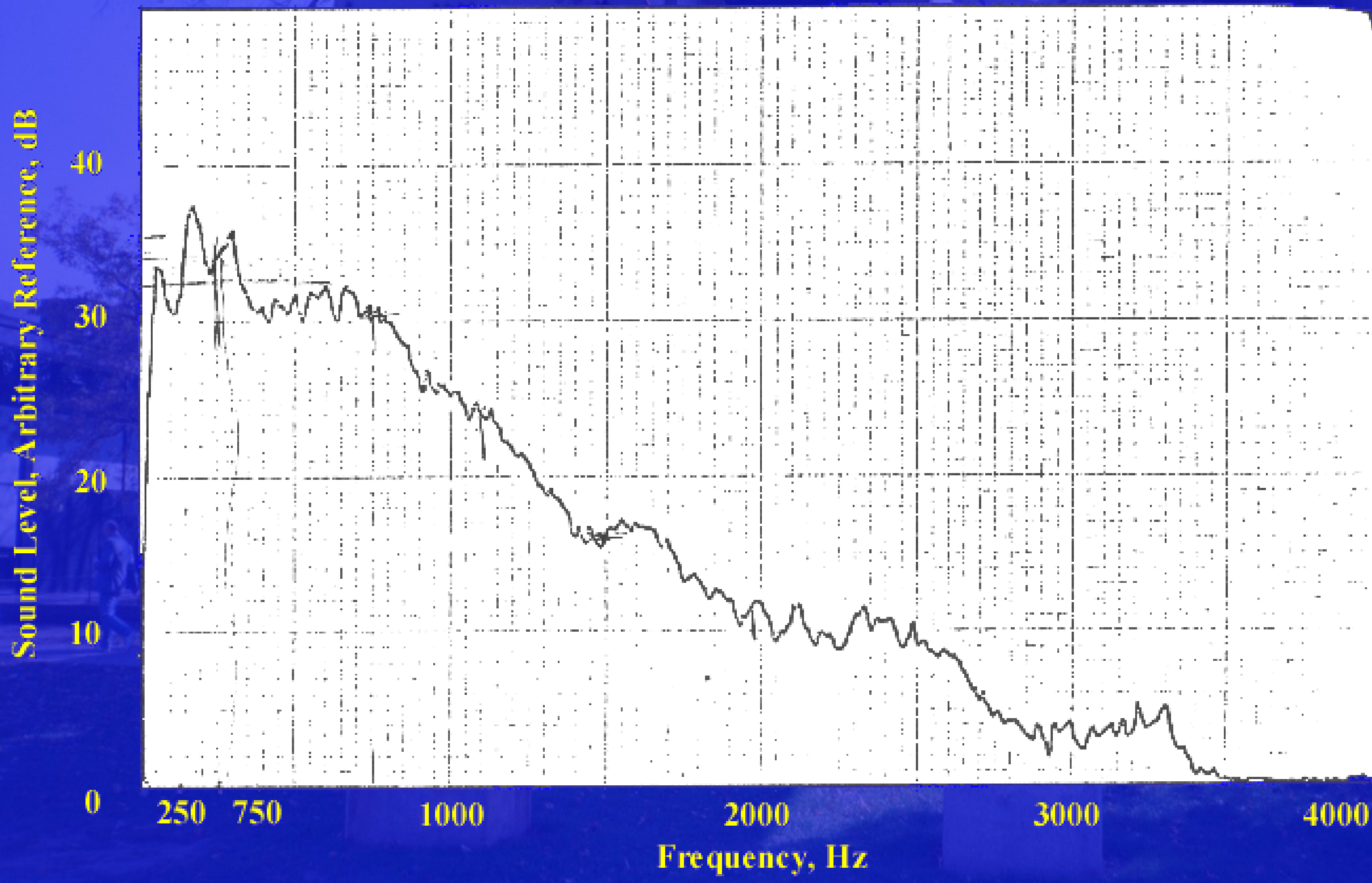

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Approaches:

- The Study of Materials
  - The Impedance Tube
  - Recycled Rubber
  - Pyrok
- Study of Methods
  - Active Sound Suppression (why it won’t work)
  - Sound Barriers

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Development of Sound Absorbing Material:

- Recycling of Tire Crumb
- Sound Absorbing Characteristics
  - Theoretical
    - Porosity
    - Tortuosity
    - Flow Resistivity
  - Fabrication
    - Grain Size
    - Binder Quantity
    - Pressure Loading

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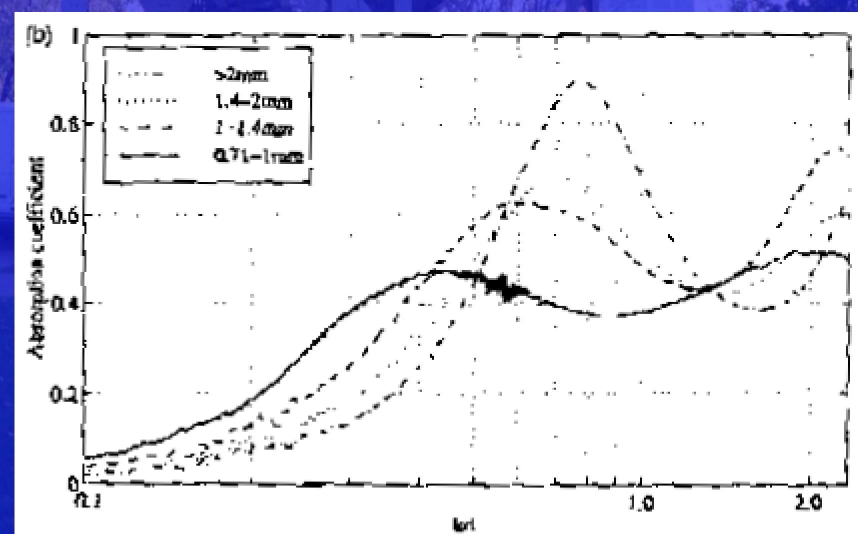
$$V_b = \int_V dV_b = x \int_S dS$$

$$= \frac{4}{3}\pi\left[\left(r_n + x\right)^3 - r_n{}^3\right]$$

$$m_b = m_s \frac{\rho_b}{\rho_s}\left[\left(1 + \frac{x}{r_n}\right)^3 - 1\right]$$



Fabrication of Sound Absorption Samples

- Design of Die
  - **Ram Plate**:
    - 8” diameter aluminum circle, ½” thick with 1/10” lip around the edge
    - 7/8” diameter hole placed in the center of the plate
  - **Mold Cylinder**:
    - 7 15/16” inner diameter, ½” thick aluminum cylinder
    - 7/8” diameter rod which will slide through the mold
  - **Bottom Plate**:
    - 8” diameter aluminum circle, ½” thick with a 1/10” lip around the edge to provide support to the die cylinder
    - 7/8” diameter hole placed in the center of the plate

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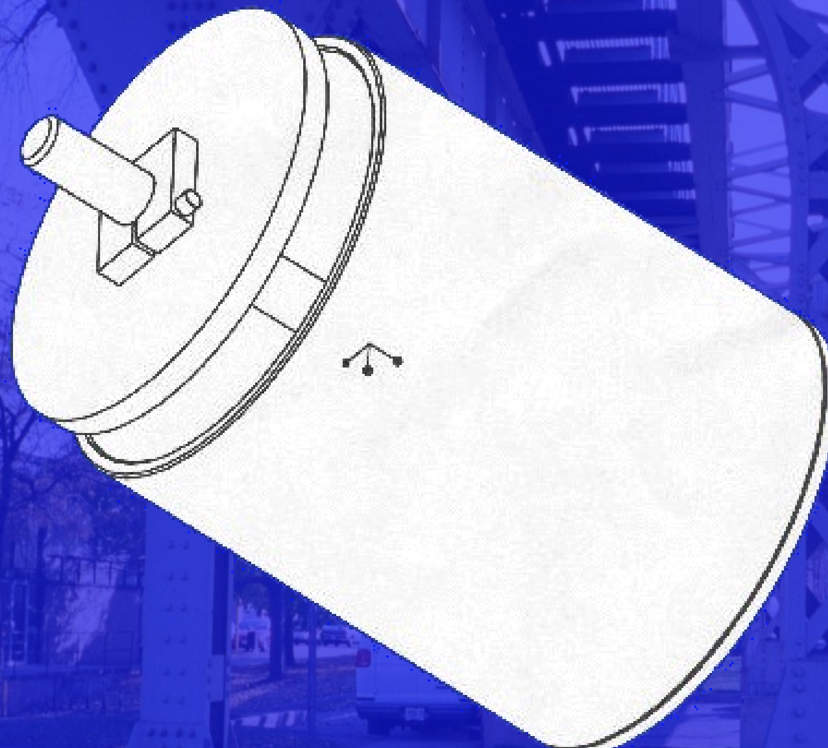

- Visual image of the die generated on the ProEngineer Drawing Package

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Fabrication of Sound Absorption Samples, *(cntd.)*

- Mixture of Sample Components
  - Latex/asphalt
  - Rubber tire shreds
    - Separation of different particle size
- Compression
- Curing Time
- Mixture of Sample Components
  - Refer to the examples of our finished product of varying grain size and composition

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Assembly of the Impedance Tube for Tests

- **Equipment Used for Impedance Tube Tests**
  - Function Generator
  - Oscilloscope
  - Amplifier
  - Voltmeter
  - Loudspeaker
  - Schedule 40, 8” nominal OD PVC tube
  - Aluminum Backing Disk
  - Radio Shack Sound Level Meter
  - 1” OD Steel Tube

- **The next slide contains a picture of the assembled impedance tube and a diagram of the connection between these components on it.**

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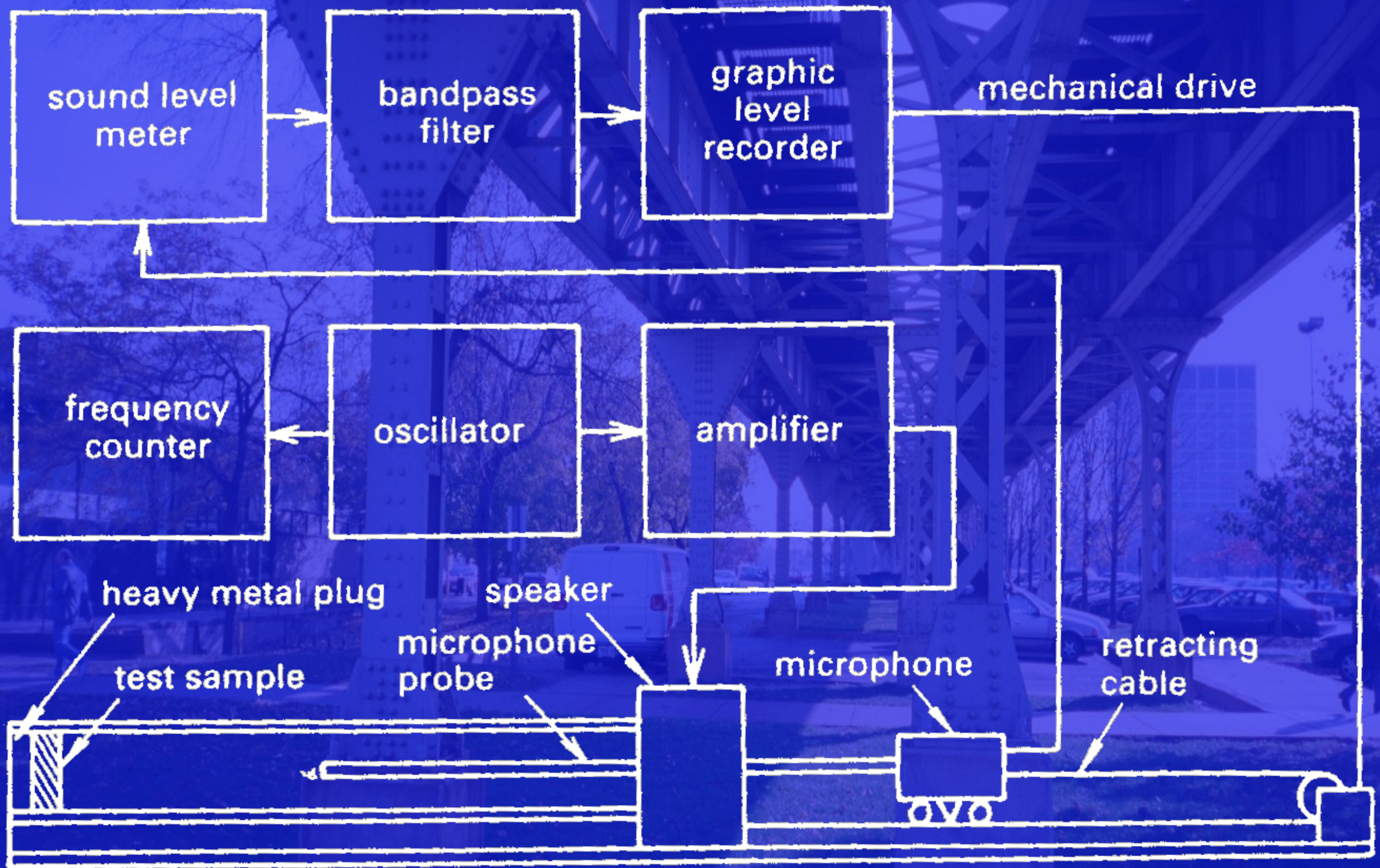

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Collection of the data from the impedance tube

- **Process of data collection**
- **Calculation of the sound absorption coefficient from the maximum and minimum dB values on the A-scale can be done with the following equation:**

$$\alpha = 1 - \left[\frac{10^{\frac{\Delta L}{20}} - 1}{10^{\frac{\Delta L}{20}} + 1} \right]^2$$

Equation 1. Sound absorption coefficient

Where α is the sound absorption coefficient and ΔL is the difference between the maximum and minimum dB values.

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Analysis of the data from the impedance tube

- Noise data collected from several samples at different frequencies and their calculated sound absorption coefficients:

	ω (hz)	Max	Min	α
Test #1	550	103	79	0.223
Test #2	550	101	85	0.472
Test #3	500	101	79	0.273
Test #4	500	106	88	0.397
Test #5	500	106	88	0.397

Table 1. Maximum and minimum dB readings (a-scale) and calculated absorptivity constants

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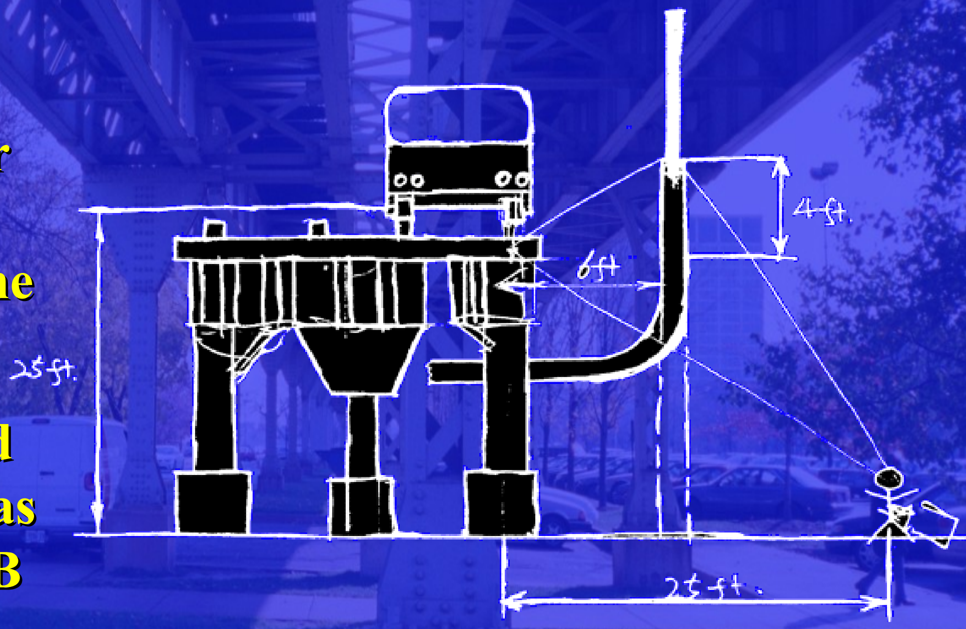
Conclusions and Recommendations

- Noise barriers have been shown to reduce the Sound Pressure Level (SPL), or noise.
- Study conducted by Professor Rollin Dix on the effect a noise barrier has on an observer some distance away.
- Results of this study indicated that the SPL at the observer was reduced to 75.1 dB from 100 dB due to through and around transmission losses.



- Proved the idea of sound barriers was useful and feasible.

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Conclusions and Recommendations, (*cntd.)*

- Exploration of other noise mitigation techniques besides sound barriers.
  - Not useful according to Professor David William's research
- Lead and spring technique presented by Professor Koutkowski (formerly University of Chicago, Fermi Lab)
  - Does not apply to the CTA problem because it involves direct interaction with the tracks, something that the CTA will not allow.
- Mainly these other methods were not feasible for the CTA noise abatement problem, so attention was focused on development of materials and design for sound barriers.

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Conclusions and Recommendations, (*cntd.)*

- Selection of materials for sound barriers
  - Shredded tire crumbs with a latex binder
    - Cheap, easy to obtain, environmentally friendly
    - Samples demonstrated fairly good absorptivity
    - Untested problems include durability and flammability – future
  - PYROK material
    - Already implemented in transportation systems in other major cities
    - In limited tests, samples showed good absorptivity, although lower than that of rubber tire samples
    - Very durable, corrosion resistant, inflammable
  - Other materials
    - Polyurea – possible subject of future work

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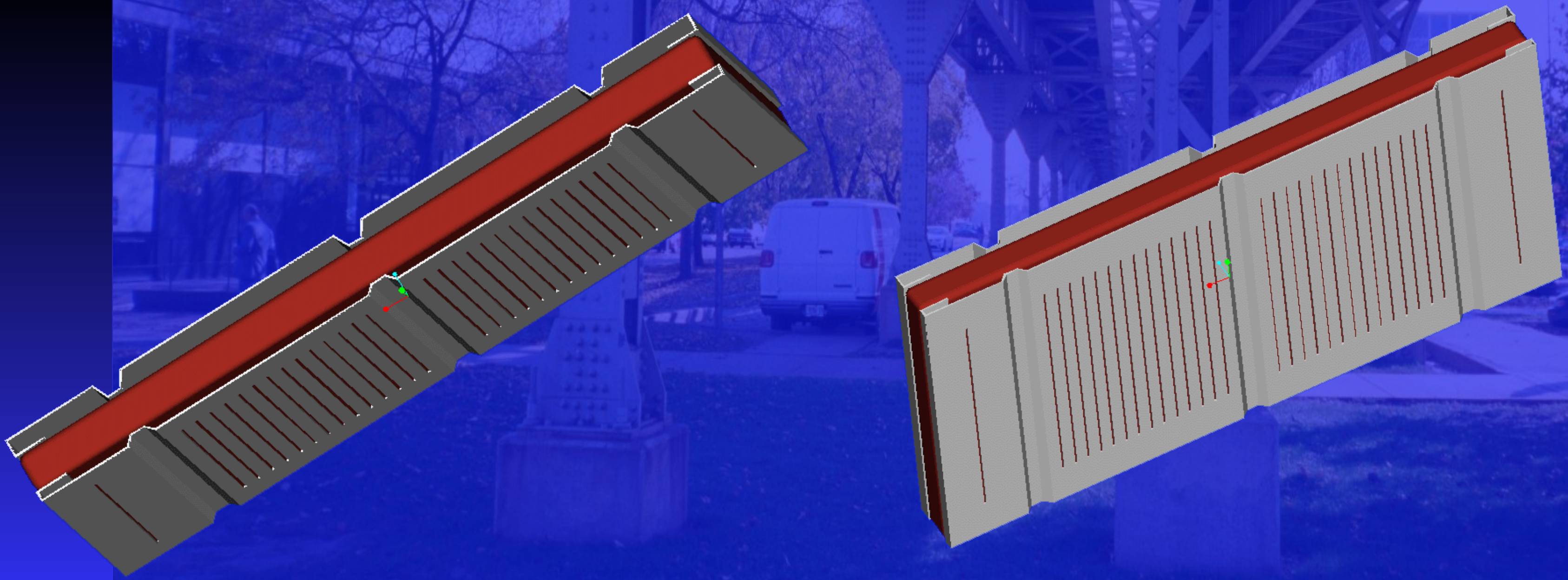
Conclusions and Recommendations, (*cntd.)*

- Design of sound barriers
  - Designs created
  - No designs assembled or tested – subject of future experimentation



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Conclusions and Recommendations, (*cntd.)*

- Additional outcomes
  - Bibliography of noise control methods applicable to land near elevated tracks
    - Noise Control in Buildings written by S. Harris in 1994 -- Avery technical book about the topic, lots of equations
    - Concepts in Architectural Acoustics written by David Egan in 1972 -- a very non-technical book, lots of visual images
    - Environmental Acoustics written by Leslie Doelle in 1972 -- technical nature of the book is somewhere between that of the other two
    - Gypsum Construction Handbook written by USG, a company located in the Chicagoland area