Integrity Reliability Innovation Service

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Prediction Methods for the Sound Transmission Loss of Building Structures

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Outline

- Background
- Study requirements
- Test facility design
- Development and validation of theories
- Prototype results
- Summary

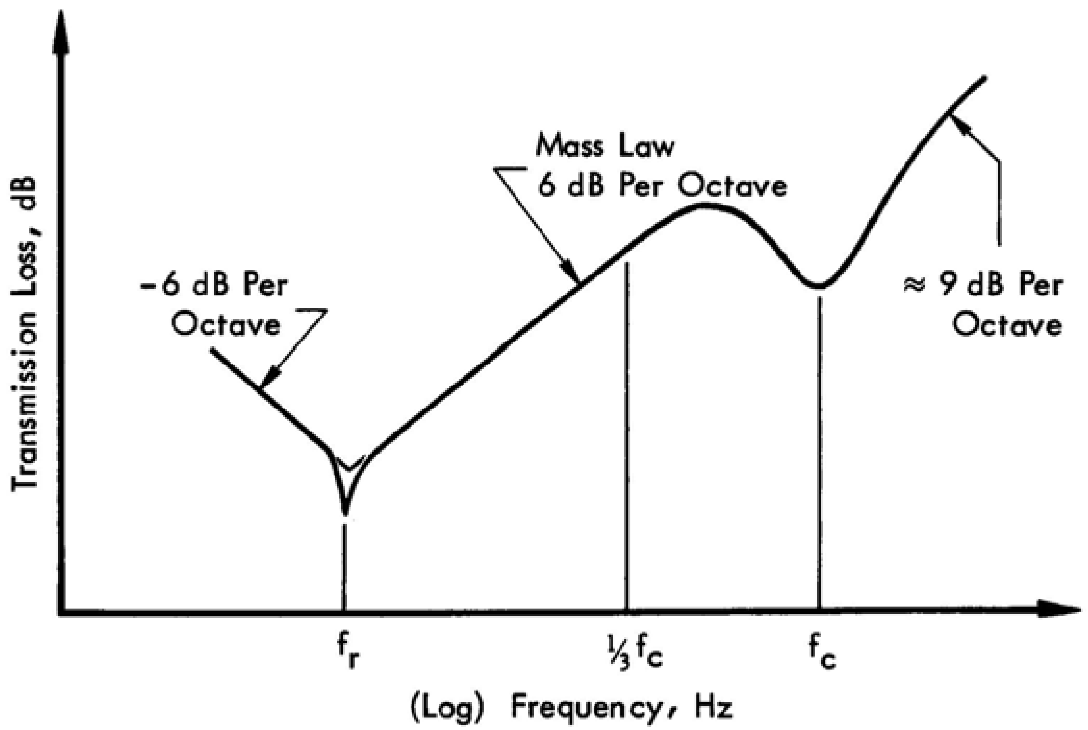
Program Requirements

Design and test prototypes that exhibit:

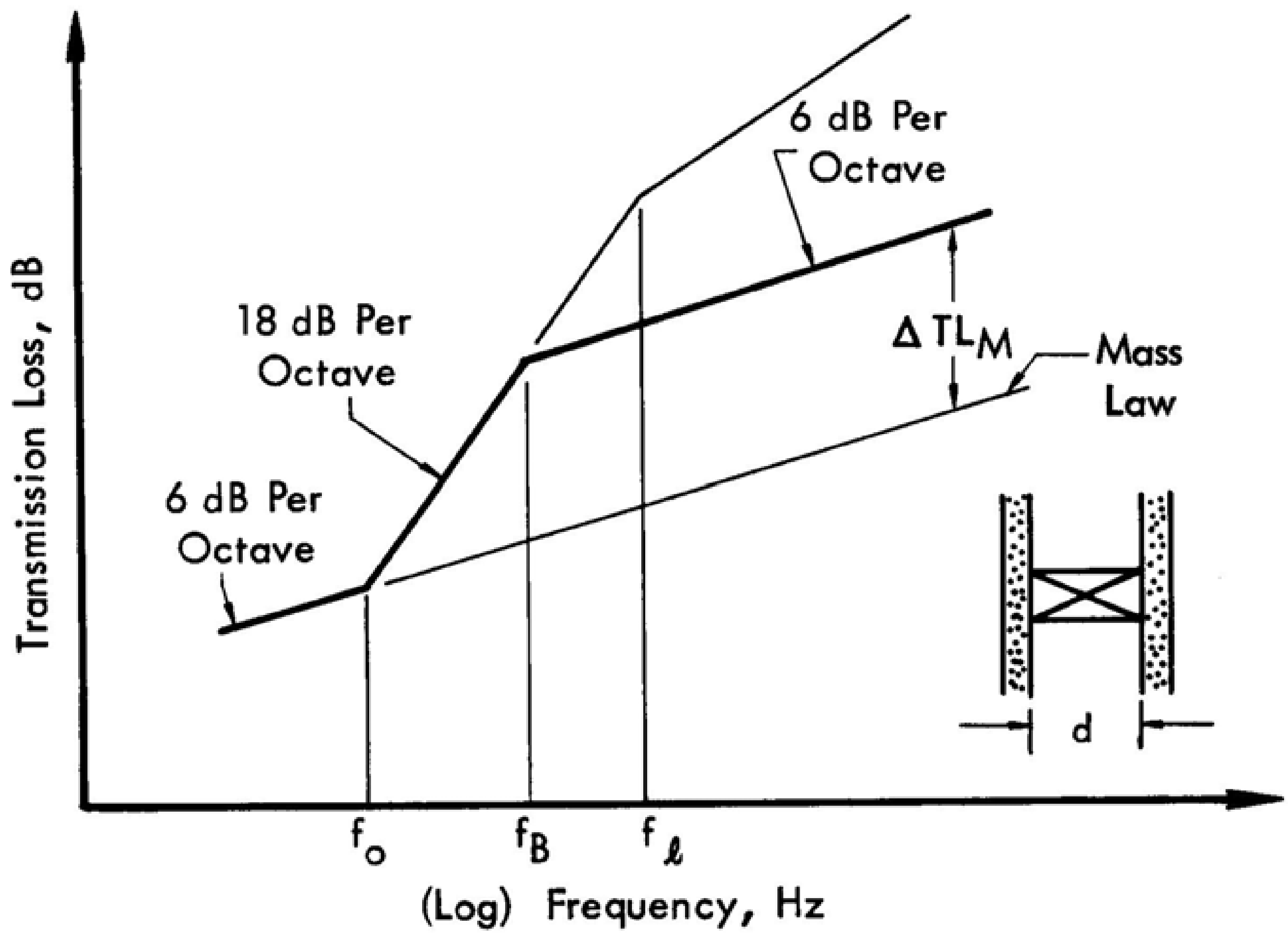
- Transmission Loss 20 dB in excess of Mass Law from 125 Hz to 4000 Hz
- Low weight
- Low cost
- Minimum thickness
- Amenable to prefabrication

Transmission Loss for a Single Panel

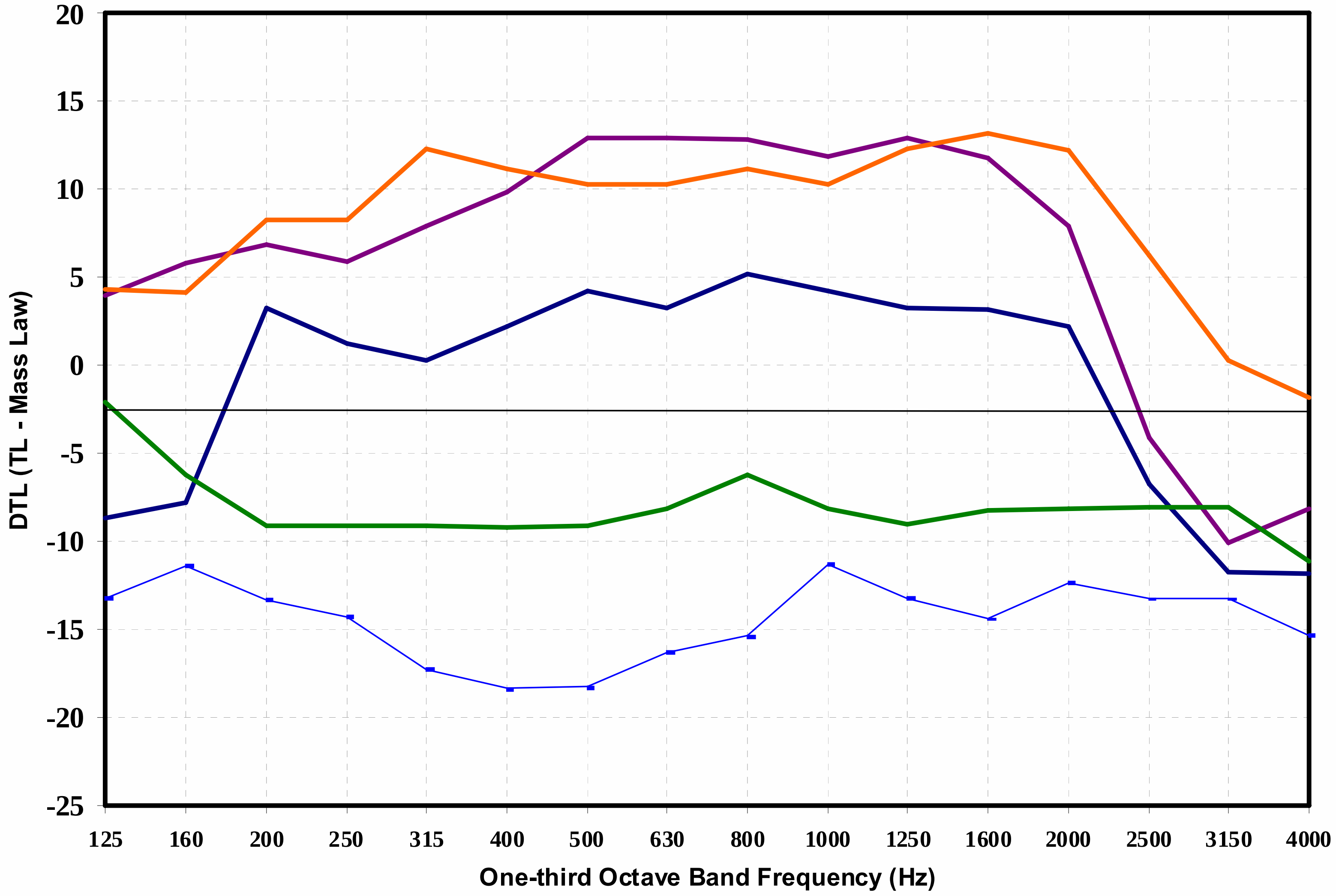
Mass Law: $TL_M = 20\log(mf) - 33.5$, dB



Transmission Loss for a Double Panel

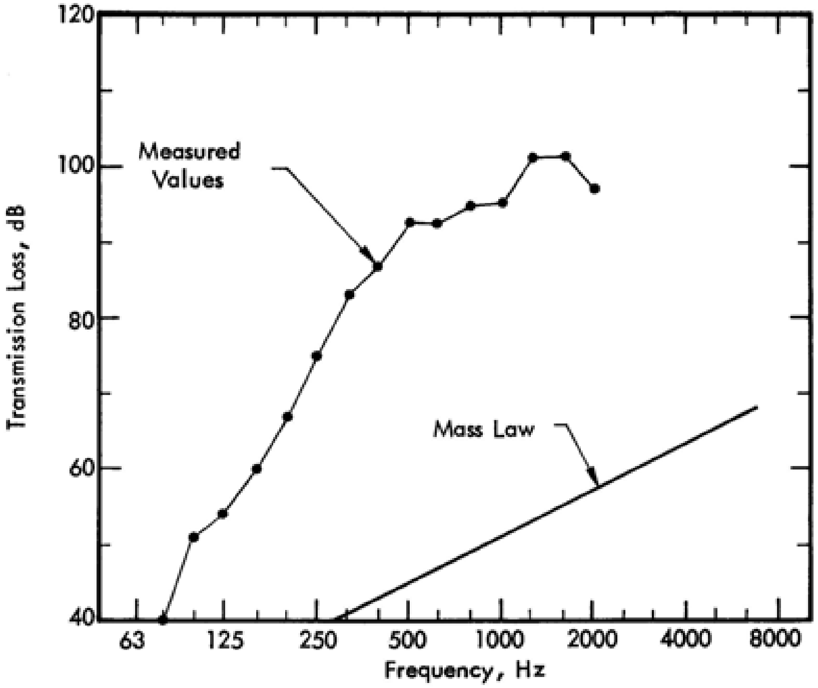


Typical Construction Performance



Test Facility Design

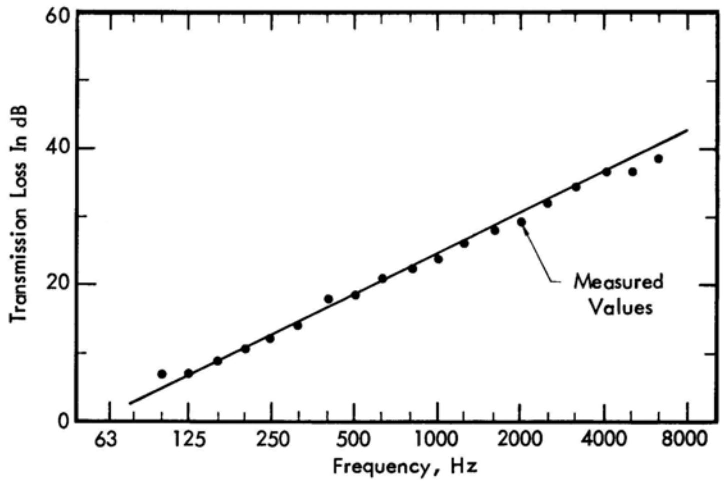
- Development of theory required extensive testing in a 2-room reverberant facility
- Source room – steel plates on steel beams, on concrete base
- Receiving room – multiple layers of gypsumboard on wood frame, mounted on inflatable rubber tires.



Test Room Design

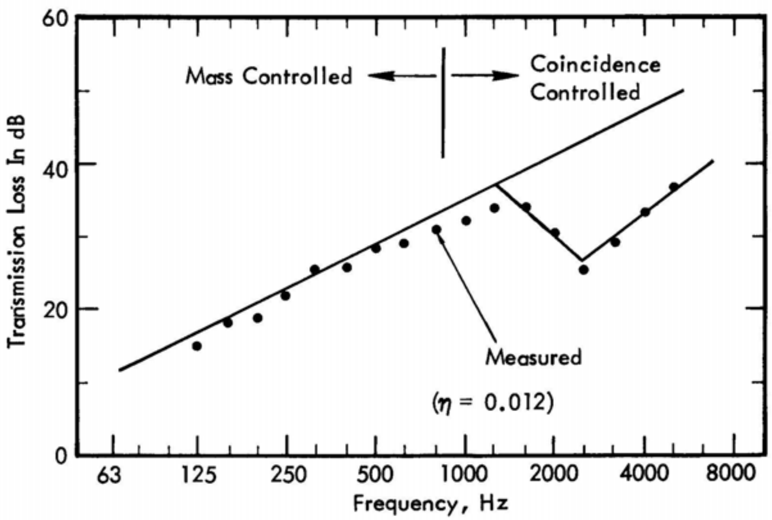
- Important to minimize room effects
- Difficult to achieve at low frequencies where modal density is low
- Typical testing room designs show 3 to 5 dB increase in TL at low frequencies, even with diffusing reflectors
- Wyle rooms are identical in size to remove room effect

Single-Panel Measurements

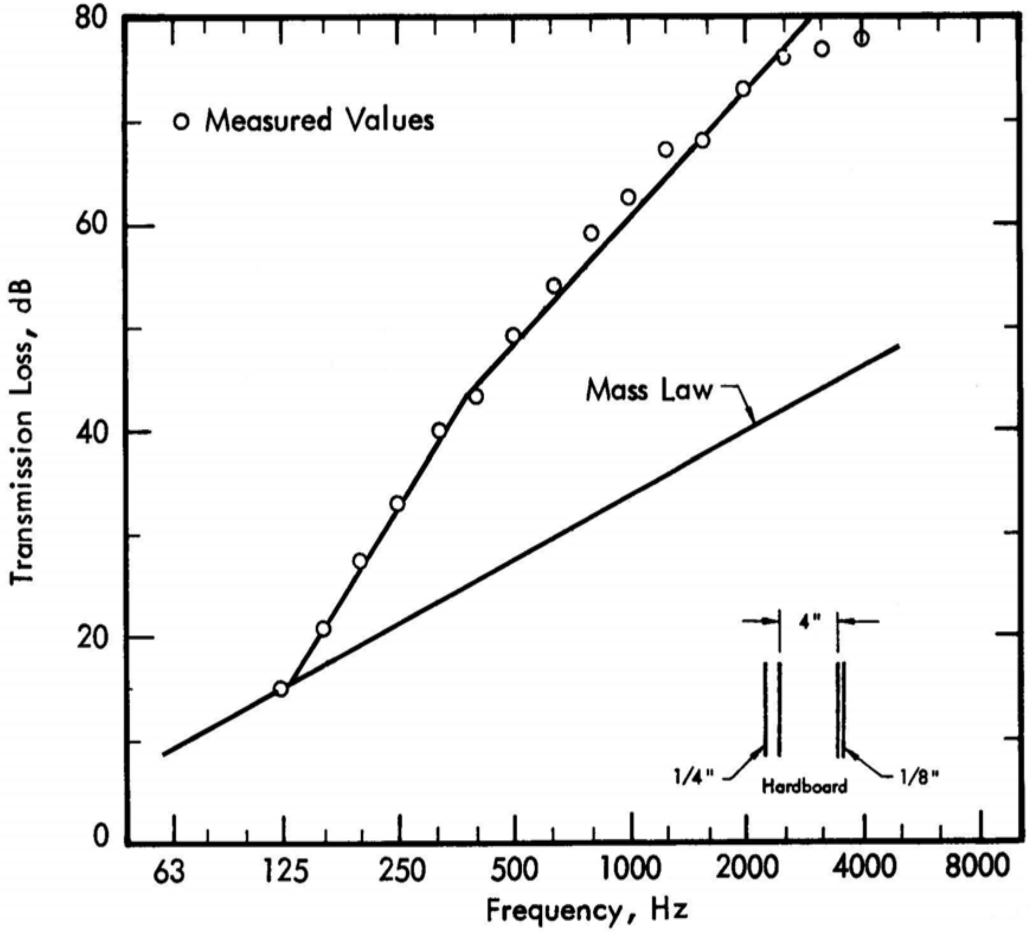


1/8-inch Hardboard

5/8-inch Gypsumboard



Double-Panel Measurements



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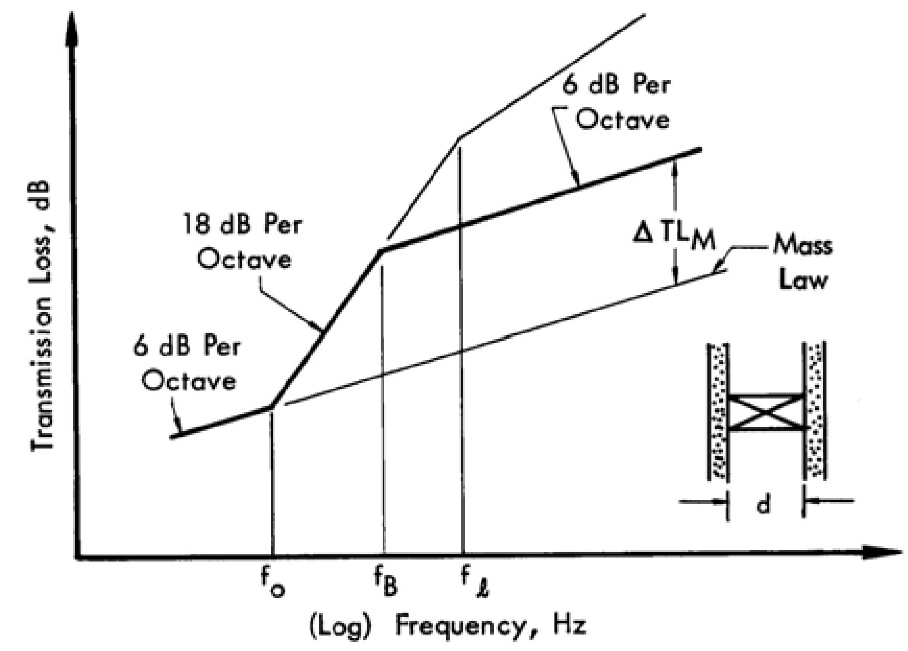
"20 dB" Design Considerations



Design Objectives:

1. $\Delta TL_M \geq 20$ dB

Determined by number and type of panel connections

2. $f_c > 4000$ Hz

Determined by panel stiffness

3. fo < 125 Hz
Determined by panel mass and spacing

Line and Point Connections

For a line (e.g. stud) connections with spacing ‘b’:

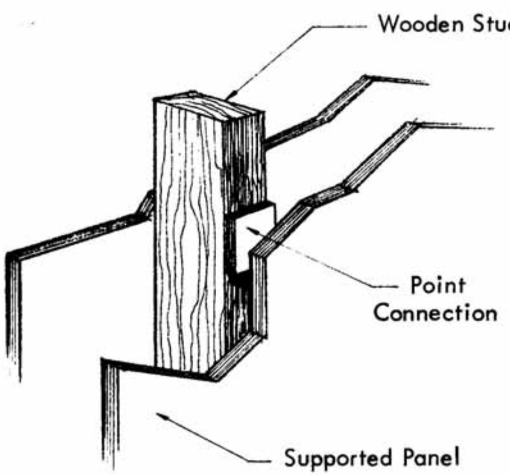
$$\Delta TL_M = 10\log(bf_c) - 31, \text{ dB}$$

For b = 2 ft., required value of f_c = 62,000 Hz to meet “20 dB” requirement

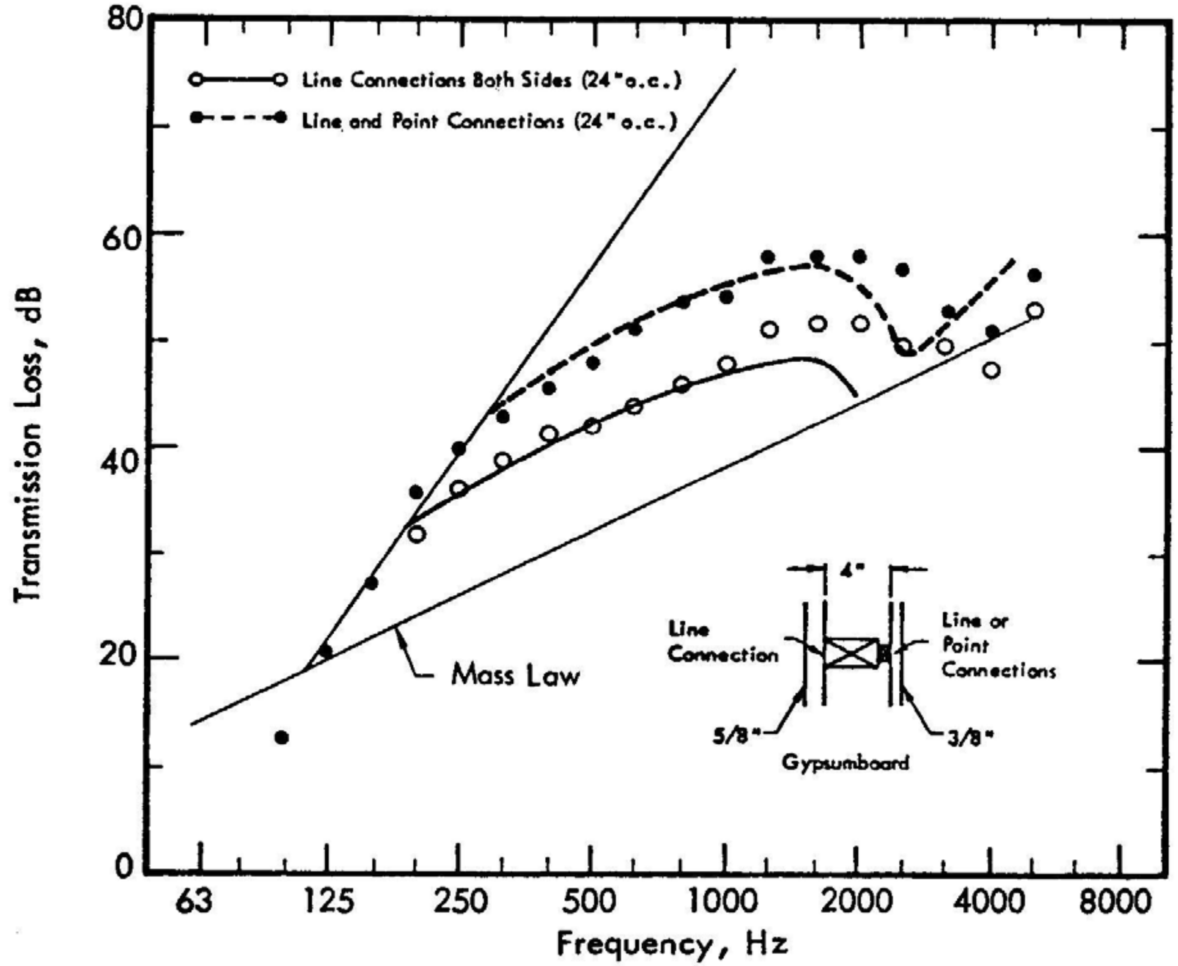
For point connections on a square lattice ‘e’:

$$\Delta TL_M = 20\log(efc) - 61, \text{ dB}$$

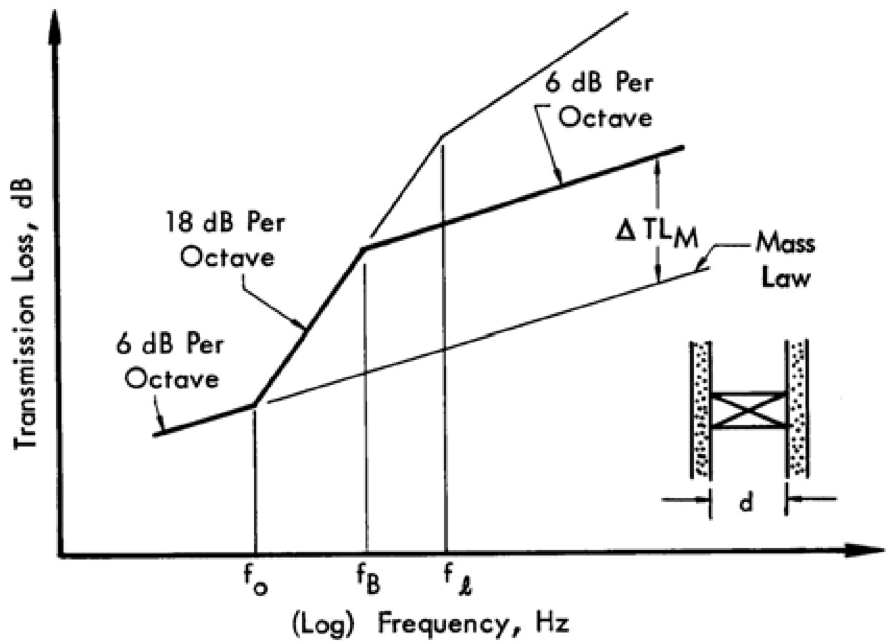
For e = 2 ft., required value of f_c = 5,600 Hz to meet “20 dB” requirement



Line vs Point Connections



“20 dB” Design Considerations



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Critical Frequency Design Options

- A high value for f_c requires a panel with low stiffness-to-mass ratio. This can achieved by:
  - Low stiffness
  - High mass (with low stiffness)
- But high static stiffness is required for structural integrity
- Laminated panels provide a high stiffness at low-frequencies, with transition to lower stiffness at medium frequencies due to shearing of adhesive layer.
- Spot laminated panels remove the dependence on the lamination layer

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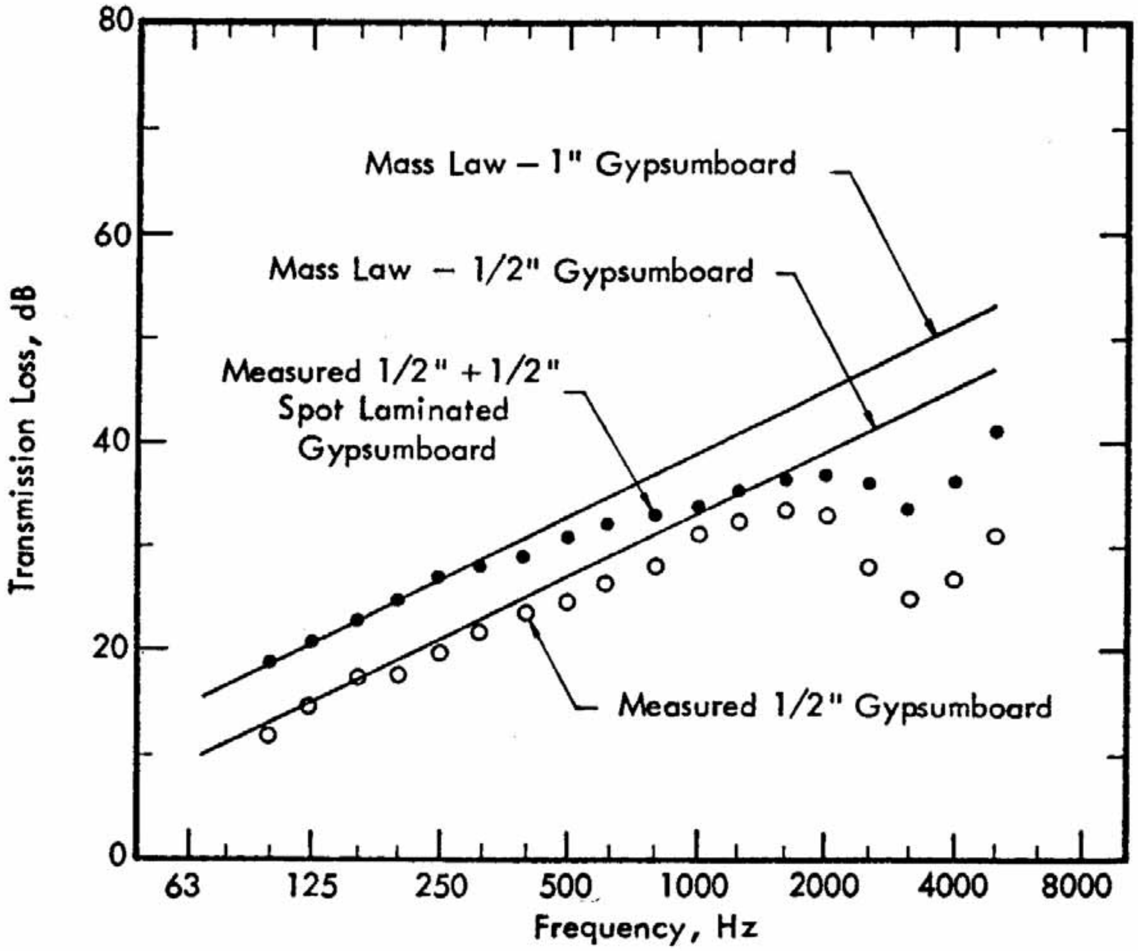
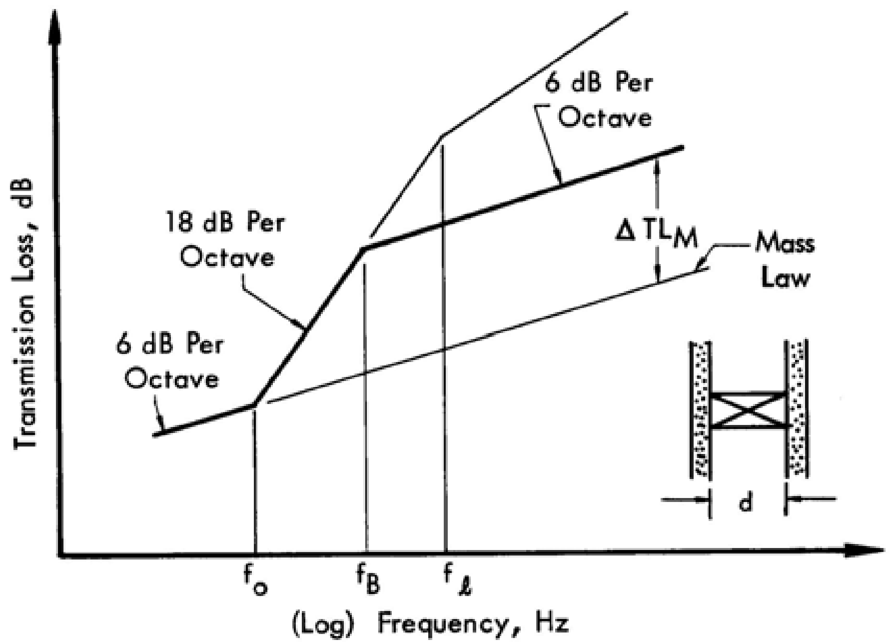
Laminated Panels



Spot lamination applied on a 2' square lattice

"20 dB" Design Considerations



Design Objectives:

1. $\Delta TL_M \geq 20$ dB

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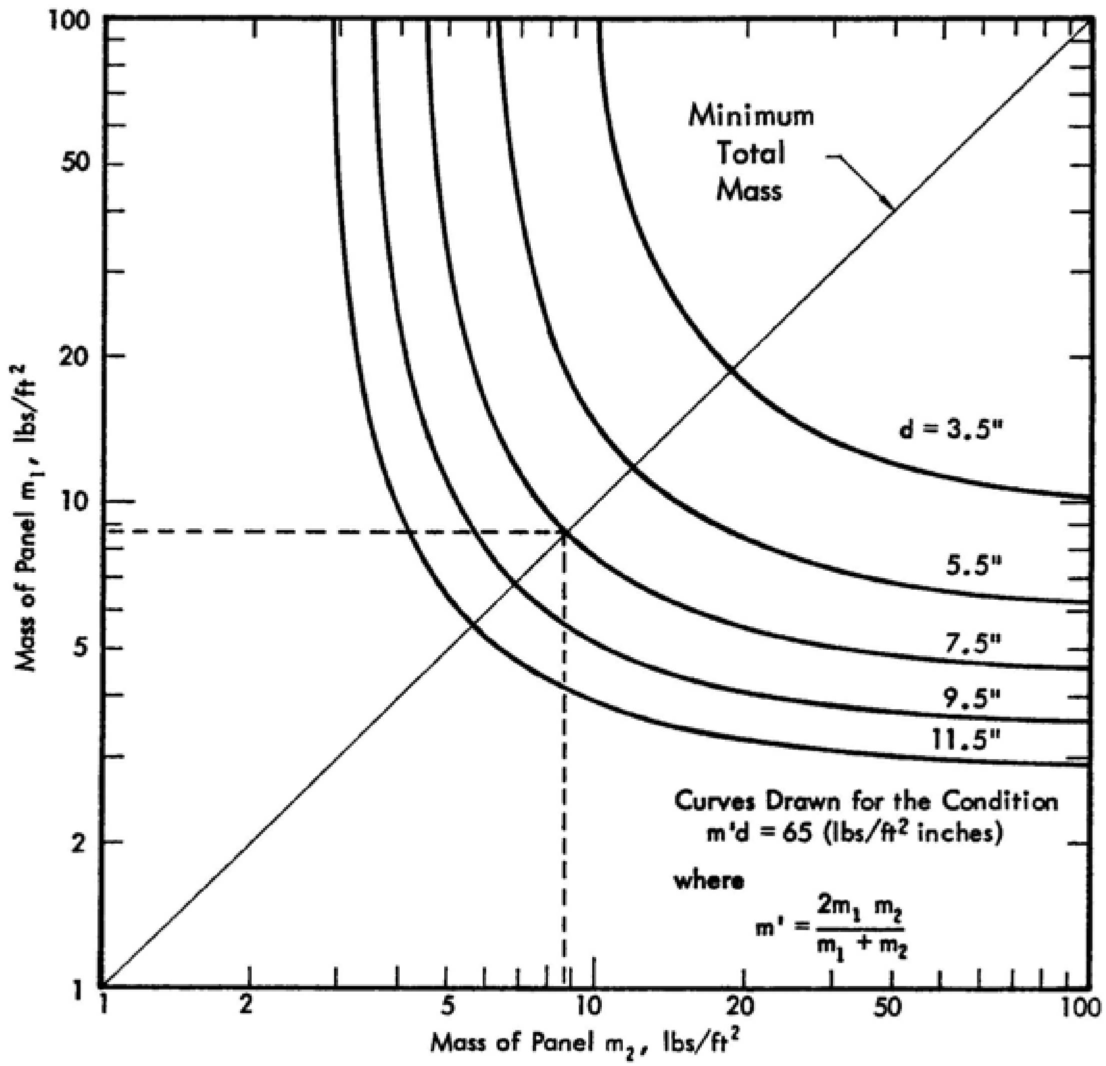
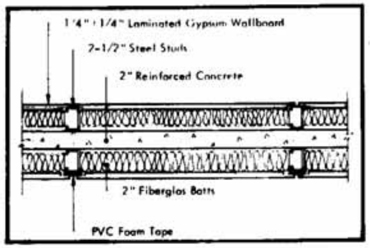
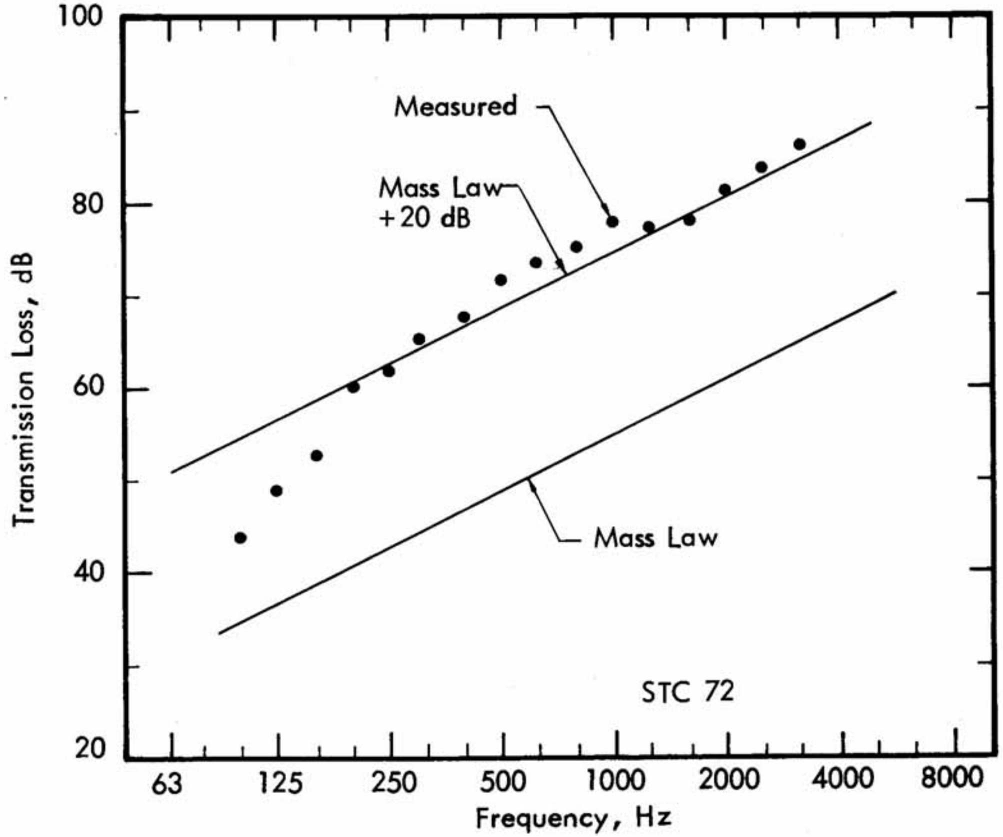
Optimization of F_0



Example Prototype A

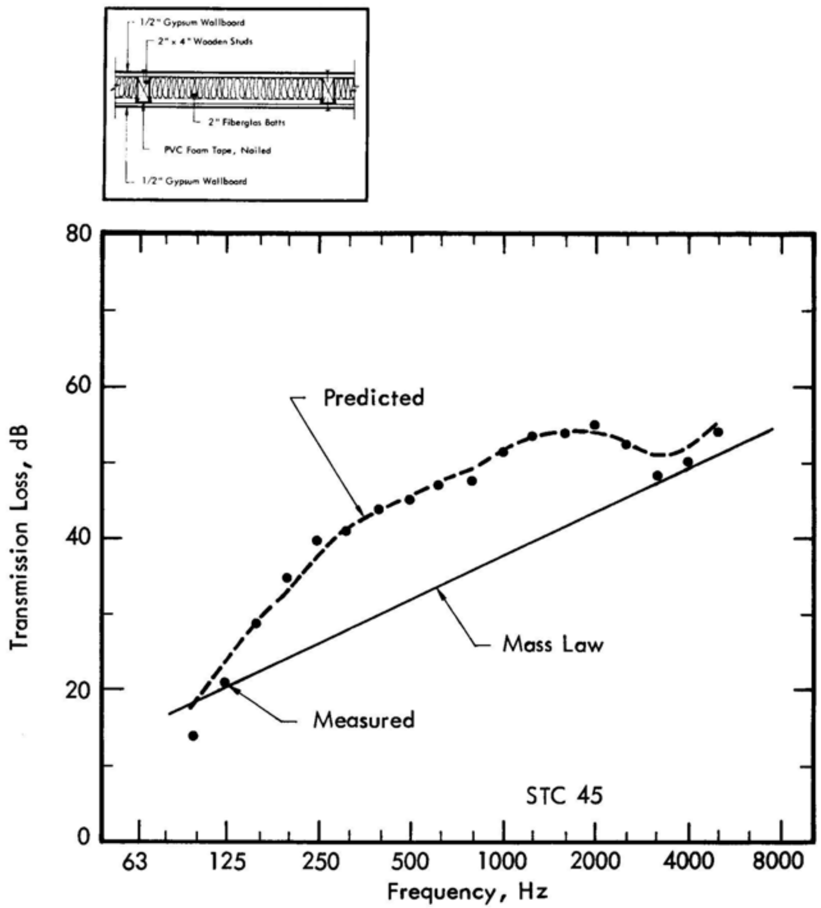




M = 27 lbs/ft^2

D = 8”

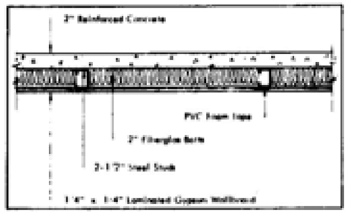
Example Prototype B

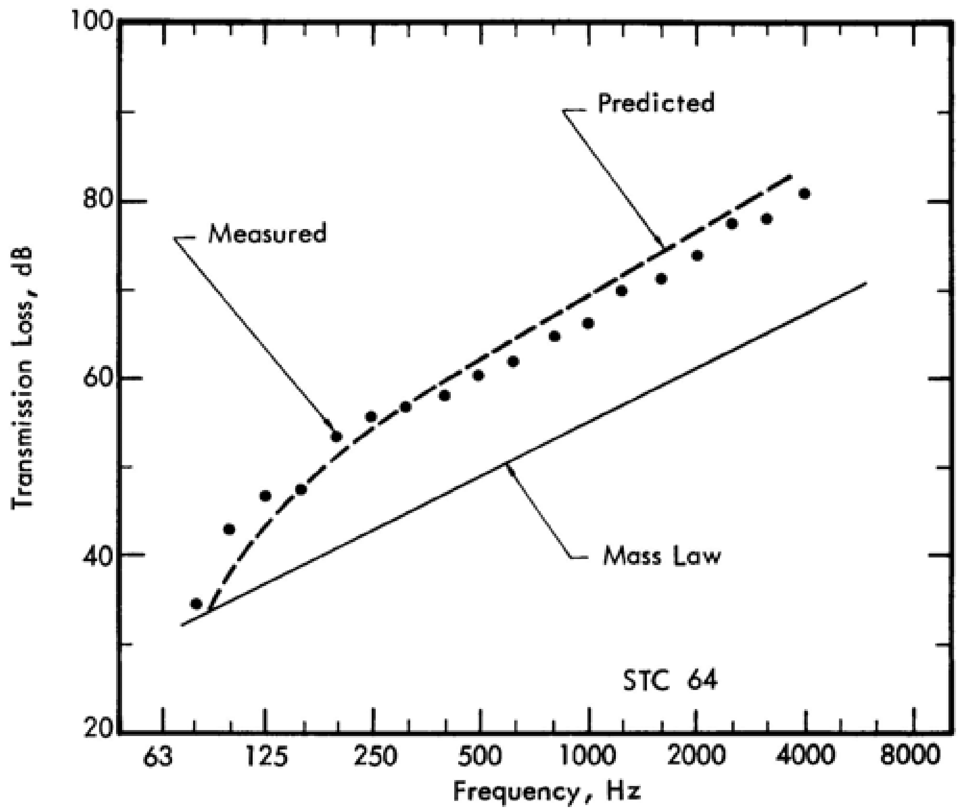


M = 4.2 lbs/ft^2

D = 5”

Example Prototype C

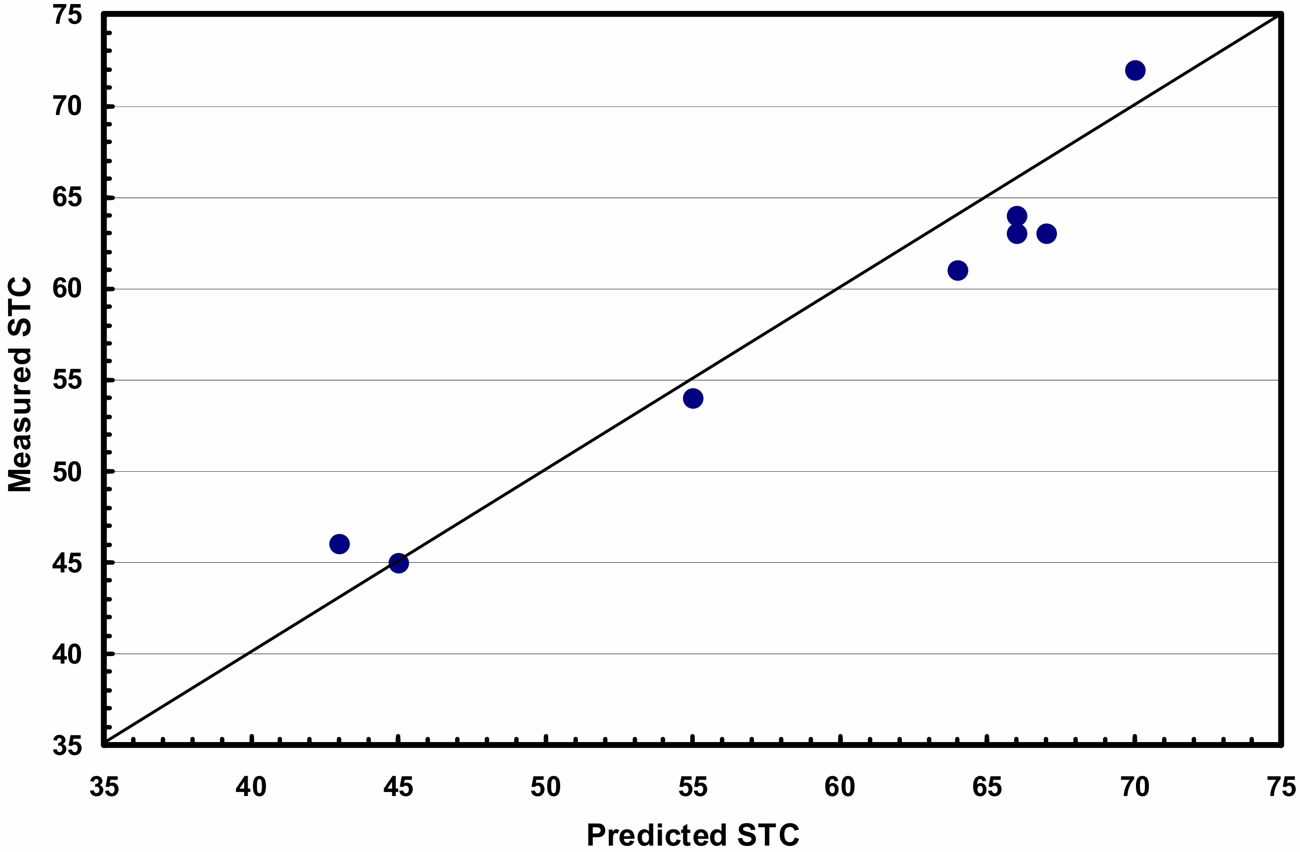




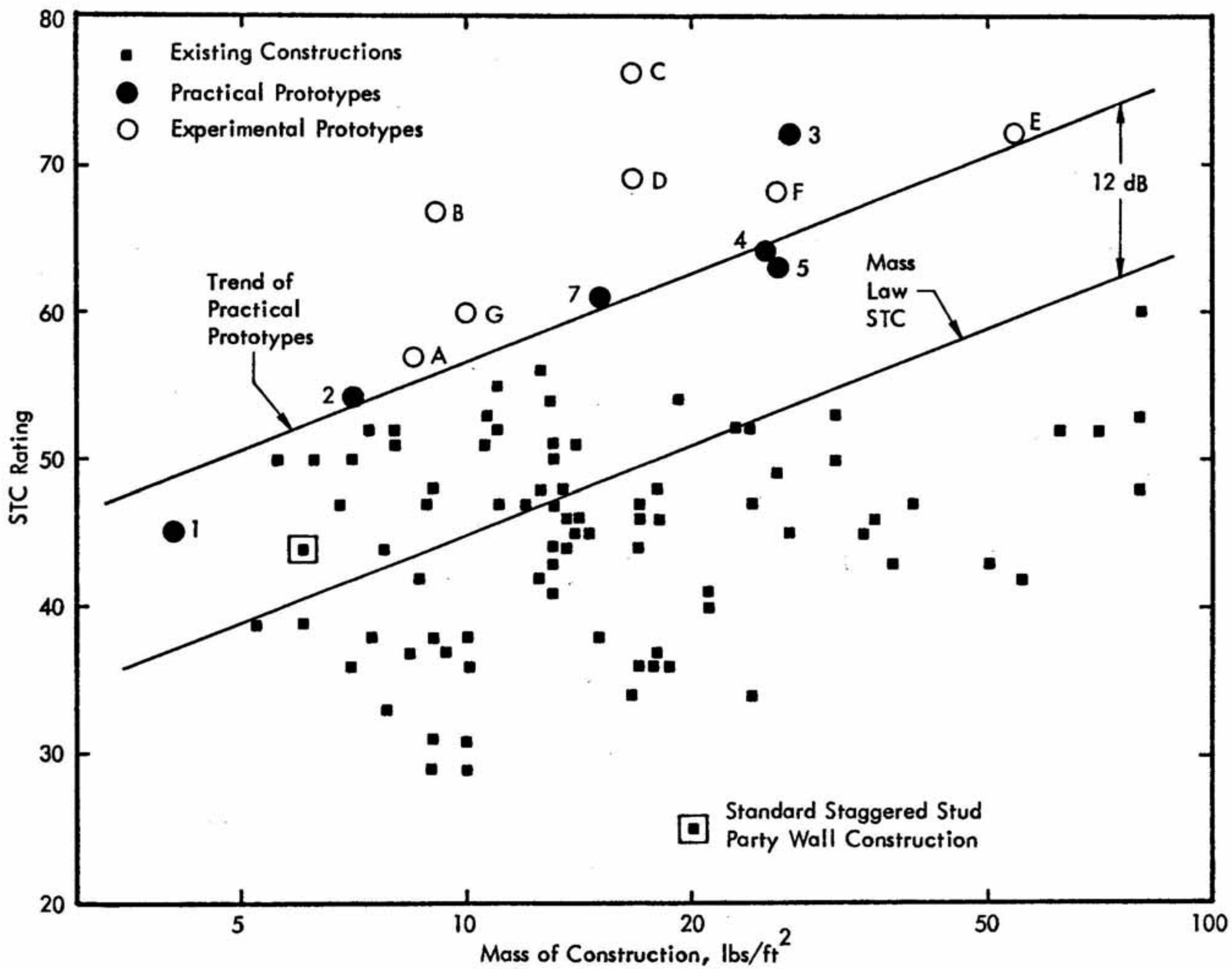
M = 26 lbs/ft^2

D = 5”

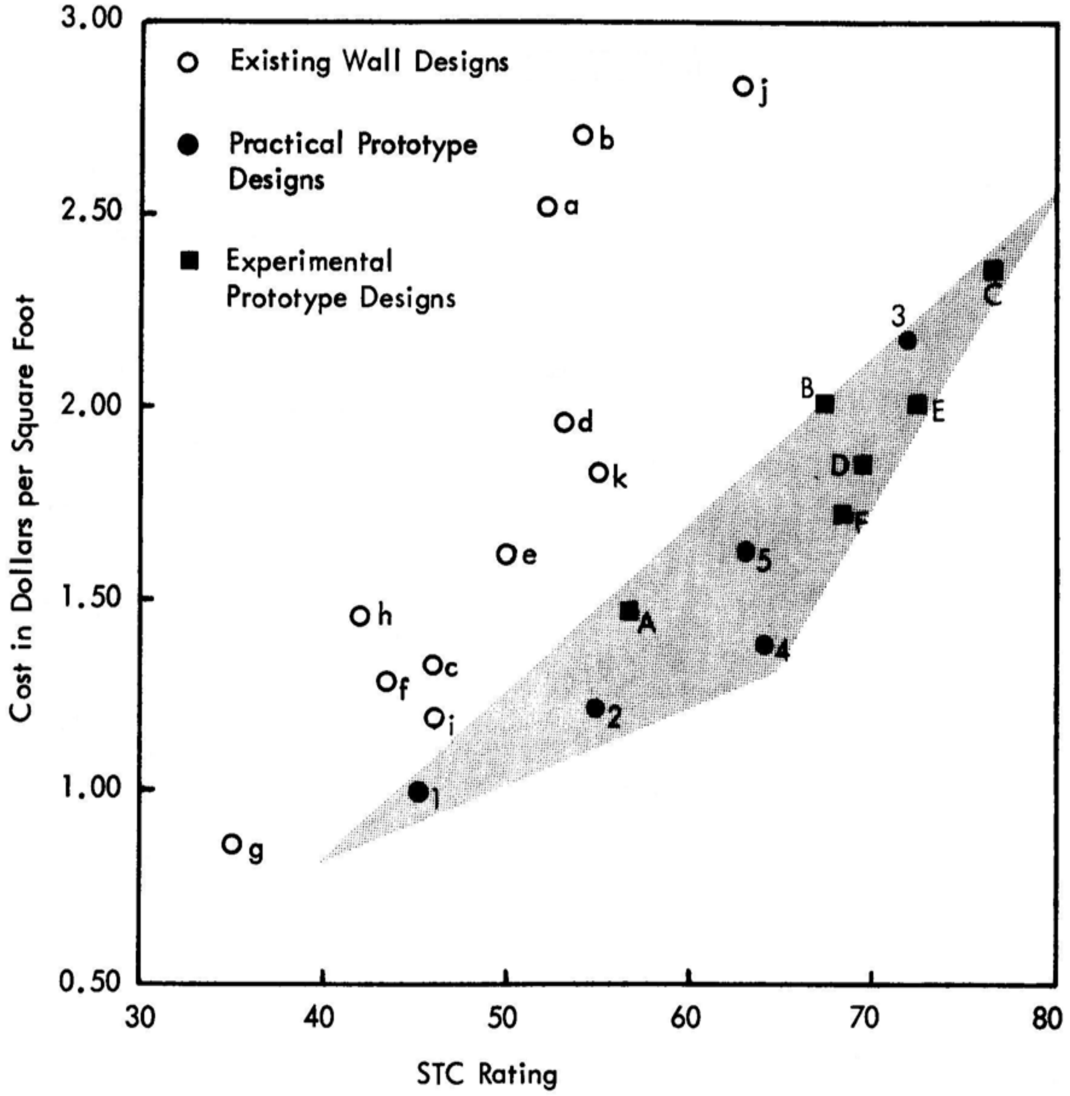
Prediction Accuracy



Prototype Performance



Prototype Costs



Summary

- The “20 dB” program goal provided the impetus to reevaluate and further develop current TL theory

- Developed validated theoretical basis for designs, including design procedures for optimally and accurately achieving any required TL

- Constructions can be designed to provide significantly higher TL at lower weight and cost

- Sadly, there has been little application of results in the building industry