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**Subject: Ann Arbor Public Schools (AAPS) - Logan Elementary School
Ambient Sound Level Measurement and Building Shell Design**

Dear Lindsay,

Soundscape Engineering has measured the pre-construction ambient sound level at the site of the future Logan Elementary School in Ann Arbor. The results of the measurements were used to predict the sound transmission through the building envelope. The transmitted level was within 10 dB of the CHPS limit for learning studio, so the predicted interior mechanical sound level was added for a total level. The building shell as designed will reduce the exterior sound level sufficiently and therefore no redesign was needed for the envelope design.

Project Background

A new elementary school, Logan Elementary, will be built adjacent to Clague Middle School on Nixon Road and Clague Street. The Ann Arbor Public Schools has set a project goal to achieve Collaborative for High-Performance Schools (CHPS) verified leader certification. The acoustics prerequisites must be met to obtain this certification. Beyond this, Ann Arbor Public Schools has directed the project team to apply best practices where practical.

The new school is cited on the property as shown in Figure 1. Nixon Road is a busy road to the west and is approximately 80 feet from the nearest classroom, which is highlighted in orange in Figure 2. An enlarged plan of Learning Studio is provided in **Error! Reference source not found.** This classroom is the basis for the exterior-to-interior building shell analysis and recommendations.

Acoustics Terminology

A glossary of acoustical terminology is provided in Appendix A in case you wish to refer to it while reading the report.

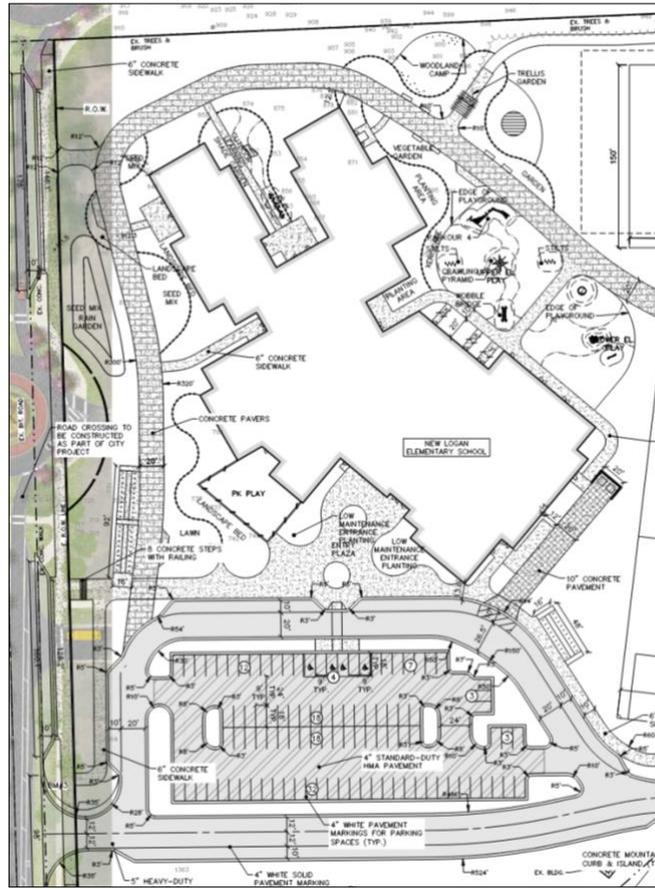


Figure 1: Logan Site Plan



Figure 2: Level 1 Floor Plan Core with Selected Learning Studio in Orange

Instrumentation

An NTi Audio model XL2-TA acoustic analyzer with model MC230 microphone and model MA220 preamp was used for all measurements. This system is Class 1 Type Approved, meeting the requirements of IEC 61672 and ANSI S1.4. This equipment has been calibrated within the past two years to a reference traceable to the National Institute of Standards and Technology (NIST) by the equipment manufacturer or a laboratory in the business of providing calibration services. The sensitivity of the sound level meter was checked using a handheld sound level calibrator conforming to the Class 1 requirements of IEC 60942 and ANSI S1.40 both before and after the measurements.

Acoustics Criteria

The CHPS prerequisite for interior sound level from exterior noise is listed in *Section EQ P15.0.2 Background Noise Requirements* of the *2020 US-CHPS Criteria 2.0* document as follows:

In Core Learning Spaces and in spaces designated as ICWS and SER, the total background noise from the combination of building HVAC systems and exterior noise shall not exceed 40 dBA.

- The metric for HVAC and exterior noise shall be the Equivalent Sound Level (L_{eq}).
- For exterior noise sources, the maximum hourly L_{eq} during instructional hours shall be used.

Measurement Procedure and Results

Soundscape Engineering visited the future site of Logan Elementary to install a sound level meter on the evening of November 3, 2023. The information captured on November 4, a school day, was used to determine the maximum hourly L_{eq} during instructional hours.

The balance of the measurement was used to assess the neighborhood ambient levels to estimate the audibility of radiated sound from the rooftop mechanical equipment. A separate report presents this environmental sound propagation analysis.

The meter was located at approximately the same distance from Nixon Road that the nearest learning studio will be. Figure 3 shows the meter location at the blue pin, and Figure 4 shows the microphone on a tripod as installed on site.

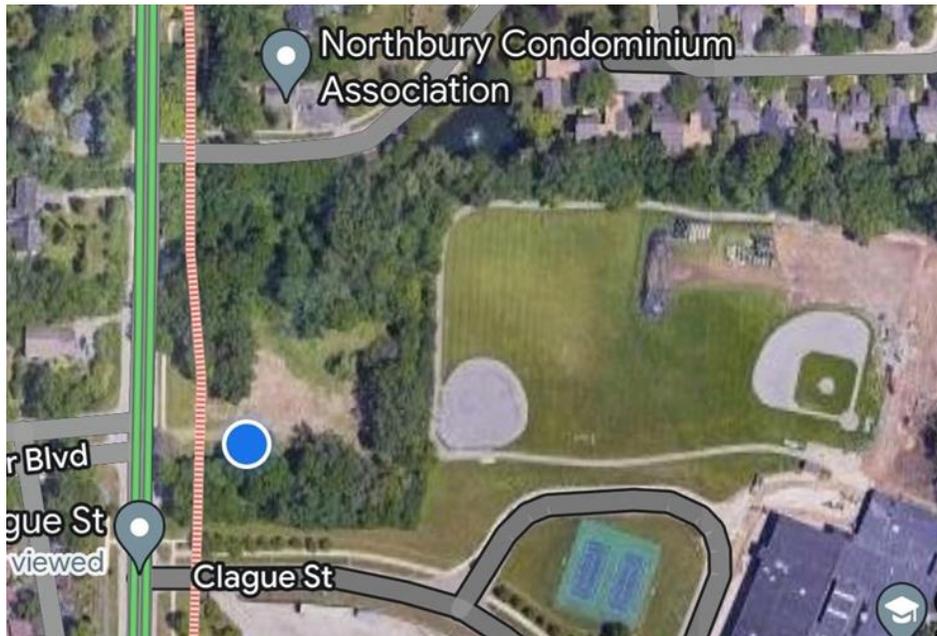


Figure 3: Meter Installation Location (Blue dot)

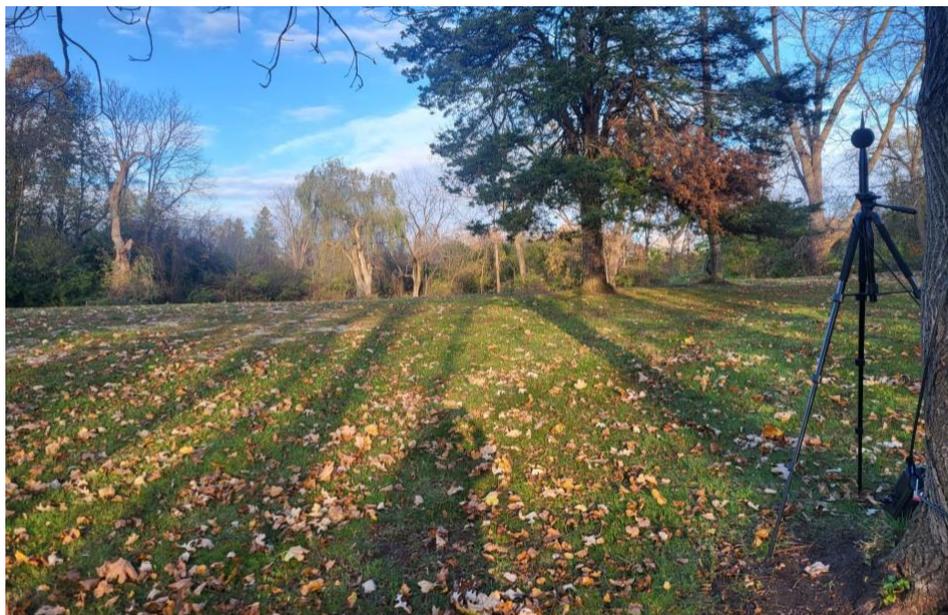


Figure 4: Installed Meter Placement

Figure 5 presents the A-weighted energy averaged sound level (L_{eq}) during school hours on November 4. The loudest hour was recorded from 1-2PM at 61 dBA, and per CHPS, this was the hour chosen as the basis of design. The octave band frequency spectrum for this hour is provided in Table 1 in Appendix B.

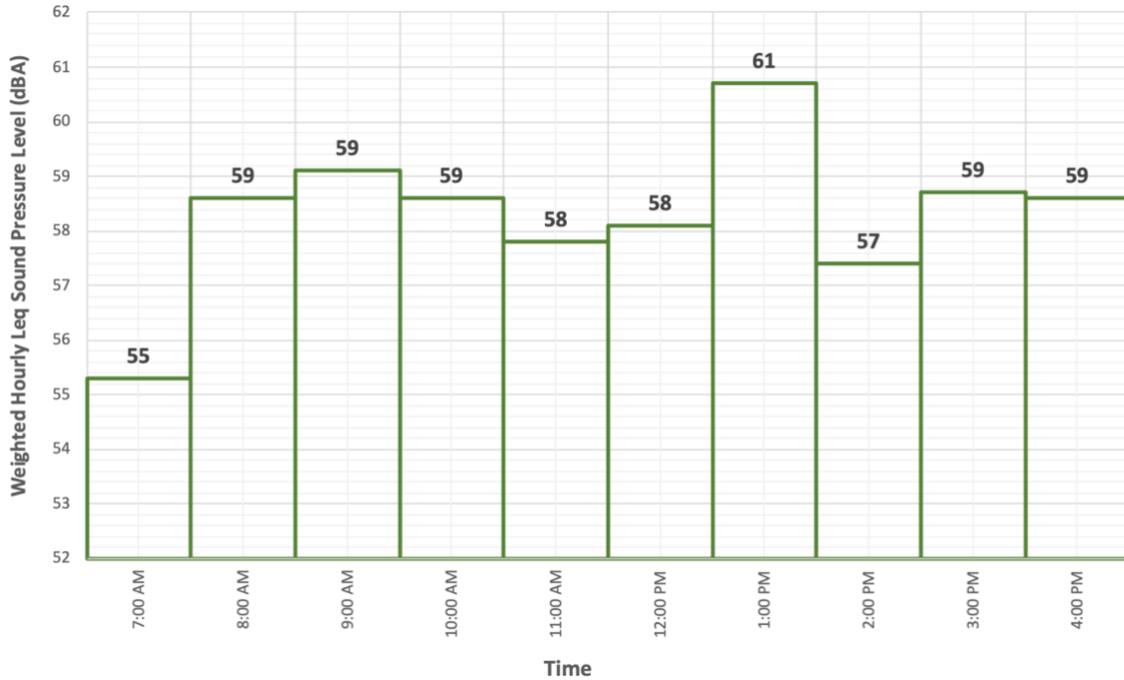


Figure 5: Hourly L_{eq} during Measured School Day

Building Shell Analysis

For the learning studio closest to Nixon Road, the following exterior finishes are shown on drawing A314, Exterior Elevations – Area C, Detail A2 in the bid set. A partial elevation is shown in Figure 6.

- Brick or High Pressure Laminate
- 1” IGU windows with one panel operable



Figure 6: Exterior of Learning Studios 144 and 244

We calculated the sound transmitted into the learning studio based on a composite sound transmission class (STC_c) for the exterior façade on an octave band basis. See Table 2 in Appendix B for the calculation spreadsheet and Figure 7 in the same appendix for the sound transmission of each façade component. The predicted interior sound level in the second-floor learning studio is 30 dBA from exterior sources. The second level was selected for analysis because it has more metal panel on the façade and is therefore acoustically weaker than the first floor.

While this level is below the required 40 dBA, it is within 10 decibels of the HVAC contribution and therefore influences the overall predicted level in the Learning Studio. Consequently, it must be added to the interior HVAC sound level for an overall level.

Total Predicted Interior Sound Level

The predicted HVAC sound level for a typical Learning Studio is 35 dBA. When added to the 30 dBA from the exterior sound transmission, the overall level from both sources is 36 dBA. This is less than the 40 dBA limit and meets the CHPS requirement. We performed this calculation on an octave band basis as shown in Table 3 in Appendix B, and converted the result to an overall dBA level.

Final Note

Please note that our recommendations and comments are exclusive to acoustics. We cannot comment on such things as local codes, life-safety requirements, or any other non-acoustic issues. Our recommendations should be reviewed by an appropriate design professional for code compliance and constructability before they are implemented.

This concludes our measurement and recommendations report. We will be happy to elaborate on anything contained within this report.

Sincerely,

Soundscape Engineering

Per:



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Appendix A: Acoustics Terminology
Appendix B: Data Tables and Supporting Calculations

Appendix A: Acoustics Terminology

Sound level is measured in units called decibels (abbreviated dB). Decibels are logarithmic rather than linear quantities and thus a doubling of the sound level does not translate to a mathematical doubling of decibels. Also, the human ear does not interpret a doubling of sound energy (two sources instead of one) as a doubling of loudness. The logarithmic nature of dB and the human subjective perception of relative sound levels result in the following approximate rules for judging increases in sound.

- 3 dB sound level increase or decrease - just noticeable
(the addition of one identical sound source to an existing source)
- 5 dB sound level increase or decrease - clearly perceptible and is often considered significant
(the addition of two identical sound sources to an existing source)
- 10 dB sound level increase or decrease - perceived as twice as loud/half as loud
(the addition of nine identical sound sources to an existing source)

These perceived changes in the sound level are mostly independent of the absolute sound level. That is, a 35 dB sound will be perceived as twice as loud as a 25 dB sound, and a 60 dB sound will be perceived as twice as loud as a 50 dB sound.

Audible sound occurs over a wide frequency range, from low pitched sounds at approximately 20 hertz (Hz) to high pitched sounds at 20,000 Hz. These frequencies are commonly grouped into octave bands or 1/3 octave bands. Building mechanical systems generally produce noise in the 63 Hz to 1000 Hz octave bands, with the lower frequency noise generated by large fans. Human speech is predominantly contained in the 250 Hz to 2000 Hz octave bands.

A-weighted sound level - Humans do not hear equally well at all frequencies. We are especially poor at hearing low frequency sound and are best at hearing sound in the frequency range of speech. A microphone does not have these same characteristics. Therefore, when sound is being measured to determine how well people will be able to hear it, a “weighting” or microphone-to-human correction factor is applied to the sound level measured using a microphone. The most common weighting is the “A-weighting”, and the resulting sound level is expressed in A-weighted decibels (dBA). This weighting reduces the low frequency energy contribution to the overall sound level, slightly increases the contribution at the dominant frequencies of speech, and slightly reduces the contribution at high frequencies.

Equivalent Sound Level (L_{eq}) is essentially the average sound level in an environment. However, the L_{eq} is a logarithmic average over a period of time and not a simple arithmetic average which means that louder sounds have more influence on the level. L_{eq} can be measured for any time period. It is typically measured for the time increments of 10 minutes, 15 minutes, 1 hour, or 24 hours. Steady sounds, such as fan or pump noise, can be accurately measured for much shorter periods of time, such as 30 to 60 seconds if the equipment is the dominant sound. An A-weighted equivalent sound level is sometimes designated as LA_{eq} though the unit dBA after the decibel level also indicates an A-weighted level.

The **ambient or background sound level** often refers to the indoor or outdoor sound level without the sound source of interest but with other sounds that contribute to the level. For example, if the sound level of an outdoor condensing unit is being assessed, the extraneous sound of traffic and other mechanical equipment should also be measured to determine if it affects the measurement of the condensing unit. Indoor background/ambient sound often originates with the air ventilation system. If the background

sound does interfere with the measurement of the sound of interest, then most of the time a correction factor can be applied.

Sound Transmission Class (STC) is a single number rating of the amount of sound blocked by a material or assembly (a window glazing unit, door, wall, floor-ceiling assembly). This metric is measured in a laboratory under ideal conditions. STC is a single number reduction calculated from the measured one-third octave band spectrum. This metric is mathematically normalized and can be compared other partitions or test data. STC is most appropriately used to assess the ability of a material or partition to block sound in the frequency range of speech. The original sound transmission test reports should be consulted when the sound source contains low frequencies, such as music or mechanical noise. A higher number indicates better sound isolating performance.

Composite Sound Transmission Class (STC_c) is the combined sound transmission class rating of all elements in a partition. The rating is often controlled by the weakest element of the partition, though its influence is dependent on the relative size of the weak element. For example, a window in a concrete block wall will reduce the STC_c rating. Another example is an undercut in a door. A higher number indicates better sound isolating performance.

Decibel addition is not on an arithmetic basis but on a logarithmic basis. This means that the level produced from two sound sources of 60 dBA is 63 dBA and not 120 dBA. While acoustics consultants use the mathematical formulas for this calculation, this table provides a shorthand method of estimation. To add up a spectrum of multiple bands, the logarithmic process must be repeated multiple times.

When two dB values differ by...	...add the following dB to the higher value.
0 or 1	3
2 or 3	2
4 to 9	1
10 or more	0

Examples:

43 dB + 44 dB = 47 dB (difference between numbers is 1, so add 3 to the highest value)

43 dB + 48 dB = 49 dB (difference between numbers is 5, so add 1 to the highest value)

43 dB + 53 dB = 53 dB (difference between numbers is 10 dB, so add 0 to the highest value)

Appendix B: Data Tables and Supporting Calculations

Table 1: Measured Loudest Hour During School Day- Octave Band

Time	Octave Band Center Frequencies (Hz)									Overall dBA
	31.5	63	125	250	500	1000	2000	4000	8000	
11/07/2023 13:00	61	66	67	56	54	57	54	44	36	61

Table 2: Exterior to Interior Calculation for Learning Studio Sound Level

Octave Band Center Frequency	63	125	250	500	1000	2000	4000	dBA	
Level at Exterior, dB	66	67	56	54	57	54	44	61	
Room RT, sec	0.7	0.7	0.6	0.6	0.5	0.5	0.5		
Room Volume, ft ³	10292								
Room Effect, dB	29	29	29	29	30	30	30		
	Element Area, ft ²	Transmission Loss of Building Shell Element at Octave Band Center Frequencies							
Exterior brick wall - based on INSUL calculation	370	34	38	44	48	58	63	69	
Exterior wall with metal panel - based on INSUL calculation	76	17	28	50	62	70	71	73	
1" IGU - based on INSUL calculation	167	24	25	22	35	42	38	40	
Total Area, ft ²	612.6075								
Composite TL	24	29	28	40	47	44	46		
Interior Sound Level	47	43	33	19	13	14	2	30	

Table 3: Learning Studio Calculated Sound Level Summation

Sources	Overall Sound Level	Octave Band Centre Frequency, Hz							
	dB(A)	63	125	250	500	1k	2k	4k	8k
Calculated interior sound level in Learning Studio due to exterior sources	30	47	43	33	19	13	14	2	1
Calculated mechanical sound level in Learning Studio	35	39	44	37	29	26	27	22	16
Summation	36	48	47	38	29	26	27	22	16

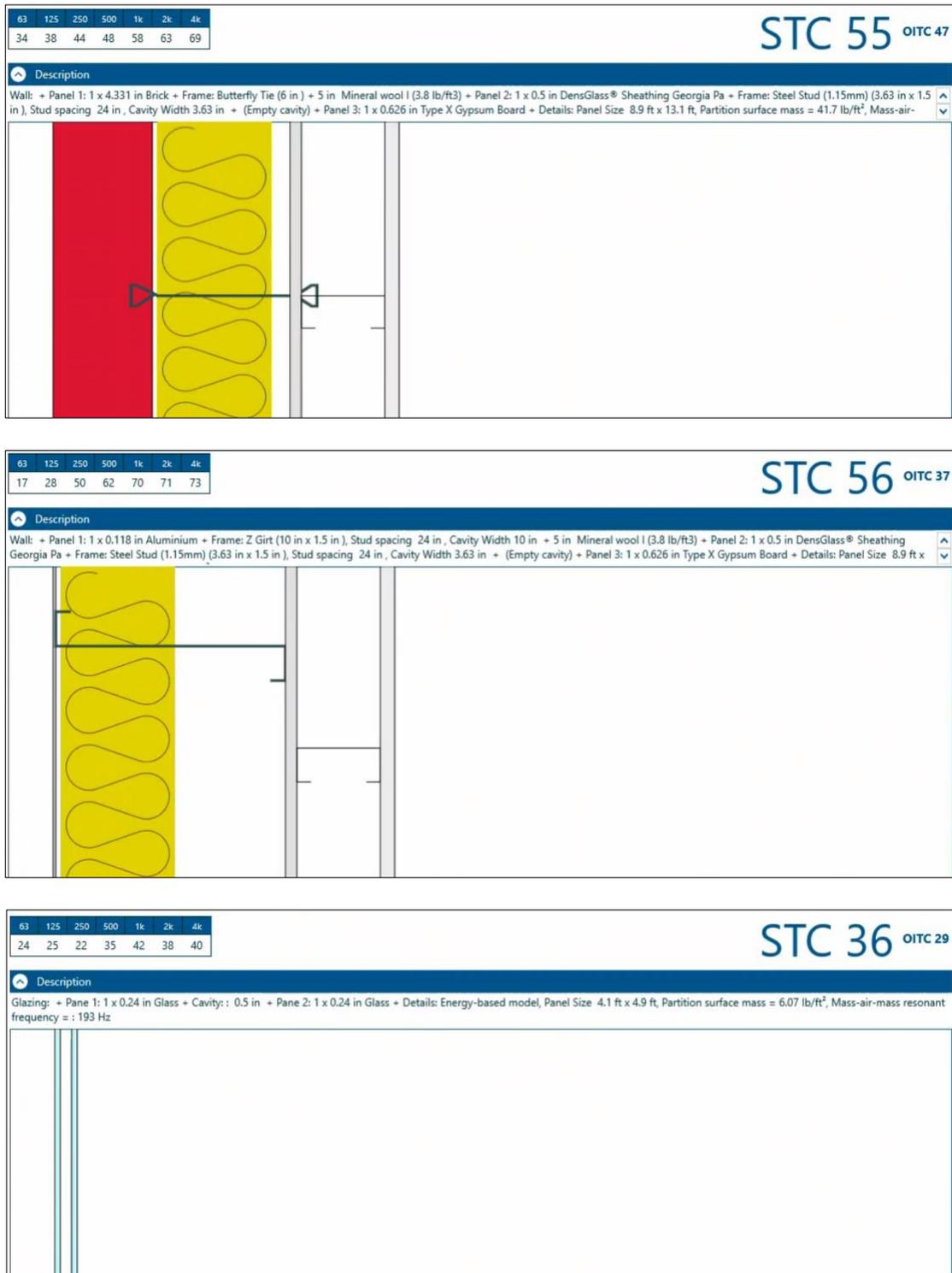


Figure 7: Exterior construction elements - sound transmission loss calculations