

Computer Modeling of STC – Options and Accuracy

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The use of computer modeling to estimate sound transmission class (STC) ratings has become increasingly common within the acoustical consulting community. There are several factors to consider when using software to estimate the sound insulation of architectural elements and assemblies. One of the most important factors is the question of real-world accuracy. Others include the use of analytical vs. empirical models, the complexity of assemblies that can be modeled and the level of user experience and knowledge necessary to yield valid or useful results. Computational results can include octave or third-octave-band transmission loss values or might only provide an estimated single-number STC rating. A detailed comparison of available modeling programs is presented, and modeled results are compared to published laboratory test data for several representative assemblies.

Various types of modeling software have proven to be valuable design tools for many aspects of acoustical design and noise control. Software packages are available to model design parameters such as environmental noise, exterior noise propagation, reverberation time, absorption coefficients and ratings such as sound transmission class (STC) and impact insulation class (IIC). Many types of auralizations can also be digitally created.

This article examines three available software packages (programs) capable of estimating the isolation afforded by a partition or floor/ceiling assembly. The primary focus of this analysis is a comparison of modeled STC and transmission loss (TL) values for some common wall types for which ample laboratory test data are available. The specific capabilities and limitations of these programs also played a role in determining the types of assemblies to include in this study. There are many variables in such a study, and all of these programs have capabilities and features that are not a part of this evaluation. Although some of these features are described in the following section, this should not be considered to be a comprehensive presentation of the capabilities of any given program.

Modeling Programs

The modeling programs used for this study include two software packages available for purchase (*INSUL* and *SoundFlow*) and one freely available estimating tool (*Socrates*) that uses regressions of test data collected by Canada's National Research Council (NRC). The developers of all three programs, and the NRC, have kindly allowed the author to reference these products by name.

Socrates. The name *Socrates* is derived from the name Sound Classification RATing EStimator. *Socrates* was developed by Alf Warnock at NRC to estimate the STC rating for stud walls of various configurations as well as STC and IIC ratings for joist floors. Estimated ratings are derived from regressions developed for several large sets of NRC measurements. The gypsum board wall regressions were derived from data in NRC internal reports IR-693 and IR-832, both of which are currently available to the public on the Internet. The program itself is publically available for download from the NRC website (<http://archive.nrc-cnrc.gc.ca/eng/ibp/irc/software.html>) and also as a web program (<http://www.alfwarnock.info/sound/socindex.html>). Detailed analysis of the source data and the resulting regression equations are included online and in the help file that comes with the downloadable version.

Socrates presents results as a single STC or IIC value given a number of user-defined variables. These user-defined variables

are limited so that results will be consistent with the referenced data sets and do not allow for evaluation of nonstandard designs (designs not included within the referenced tests). Neither Warnock nor the NRC plan any future updates to *Socrates*, and there is no version number associated with this program.

INSUL. *INSUL* is a sound insulation prediction program developed by Marshall Day Acoustics in New Zealand and distributed in North America by Navcon Engineering. *INSUL* will allow a user to construct a virtual partition, glazing design or floor/ceiling assembly, one element at a time, and can predict STC and IIC ratings (as well as the European equivalents). Materials are highly customizable, and the ability to include user-defined materials is included. Output includes one-third-octave-band transmission loss or impact sound pressure level values. Later versions of the software also include multiple options for rain-impact noise calculations. The most current available version of the software, at the time of writing, was used for this study (Version 7.0.13). As previously noted, there are other features and calculation tools included in *INSUL* that are not presented here.

SoundFlow. AFMG *SoundFlow* (referred to in this article simply as *SoundFlow*) is a simulation program developed by Ahnert Feistel Media Group (AFMG) located in Berlin, Germany. AFMG is well known in the acoustical and audio-visual communities for other software packages such as *EASE*, *EASERA* and *SysTune*. *SoundFlow* allows the user to construct a virtual assembly from a variety of absorbers, perforated panels and plates (concrete, gypsum, plywood, etc.). Calculated parameters include absorption and reflection coefficients, transmission loss, input impedance, reflection factor and transmission factor. Many of these results can be exported for use in *EASE* models. As with *INSUL*, material variables are highly customizable, and the ability to include user-defined materials is included.

SoundFlow does not currently support the use of metal or wood studs within wall cavities. Also, from the user guide, "with respect to plates, the current software is also limited to the theory of thin plates that allows considering structures with a thickness of up to three to four wavelengths in practice." As a result of the limitation regarding studs, the *SoundFlow* models used for this study were limited to either double-stud partitions (completely decoupled panels) or homogeneous construction, such as a concrete slab. There are clearly many different types of calculations that *SoundFlow* can perform. Only the transmission loss calculation, and by extension STC, was evaluated in this study, and only for the relatively small number of assembly types mentioned. The most current available version of the software, at the time of writing, was used for this study (Version 1.0.10.158).

Laboratory Tests

Laboratory test data used for comparison were collected from three published collections of test results. These include publications from the NRC,¹ the California Department of Health Services,² and United States Gypsum.³ For simplicity, these sources are hereafter referred to as NRC, California and USG, respectively. A summary of the number and sources of tests referenced for each type of assembly is included in the assembly descriptions below.

Modeled Assemblies

Five general partition types and one monolithic concrete assembly were modeled. Modeled STC and transmission loss values were then compared to available laboratory test data. What follows is a description of each assembly modeled as well as a summary of laboratory tests used as reference for each type. A visual rep-

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resentation of each wall type is shown in Figure 1 for clarity. The images used in Figure 1 were created by *INSUL*.

Partition Type 1 – Single Steel-Stud Wall. The first partition type presented is a single steel stud wall with one layer of 16-mm (5/8-inch) gypsum on each side and insulation in the cavity. The studs are 90 mm (3-5/8 inches) wide and are spaced on 610-mm (24-inch) centers. The NRC tests specify the use of 25-gage steel studs. The California and USG tests for these wall types do not clearly state what stud gage was used, though it is assumed that they were also 25 gage. For reference, all models were based on the use of 25-gage studs (0.55 mm). The type and thickness of cavity insulation represented in the test data varies.

There were 22 representative tests referenced for this wall type: six from NRC, five from California and 11 from USG.

Partition Type 2 – Staggered Steel-Stud Wall. The second partition type presented is a staggered steel-stud wall with one layer of gypsum on each side with no insulation in the cavity. There were only two tests found for this wall type, both from California. Both tests used 40-mm (1-5/8-inch) metal studs spaced on 610-mm (24-in) centers and staggered 305 mm (12 inch) on center on 64-mm (2-1/2-inch) channels. One test used 16-mm (5/8-inch) gypsum, while the other used 13-mm (1/2-inch) gypsum. Because of this difference, transmission loss results were modeled and presented separately.

Partition Type 3 – Staggered Wood-Stud Wall. The third partition type presented is a staggered wood-stud wall with one layer of gypsum on each side and insulation in the cavity. Studs are 90 mm (3-5/8 in) wide and are spaced on 406-mm (16-inch) centers and staggered 203 mm (8 inches) on center on 150-mm (6-inch) plates. The type and thickness of cavity insulation represented in the test data varies.

There were 14 representative tests referenced for this wall type: eight from NRC and six from California.

Partition Type 4 – Double-Stud Wall. The fourth partition type presented is a double-stud wall with one layer of 16-mm (5/8-inch) gypsum on each side of the assembly and insulation in the cavity. Two rows of studs (either steel or wood) are each 90 mm (3-5/8 inches) wide, spaced on 406-mm (16-inch) centers in two separate (decoupled) rows with a 25-mm (1-inch) air gap between the separate rows of studs. The total air cavity is 209 mm (8-1/4 inches) wide. The type and thickness of cavity insulation represented in the test data varies.

There were 16 representative tests referenced for this wall type: 13 from NRC, two from California and one from USG.

Partition Type 5 – Wood-Stud Wall with Resilient Channel. The fifth partition type presented is a wood-stud wall with one layer of 16-mm (5/8-inch) gypsum on each side with resilient channel used on one side of the wall and insulation in the cavity. The studs are 90 mm (3-5/8 inches) wide and are spaced on 406-mm (16-inch) centers with resilient channels spaced 610 mm (24 inches) on center. The type and thickness of cavity insulation represented in the test data varies.

There were 18 representative tests referenced for this wall type: nine from NRC, five from California and four from USG.

Concrete Slab. Finally, a concrete slab 150 mm (6 inches) thick was also modeled in both *INSUL* and *SoundFlow* and compared to a single representative California test. The concrete's mass is approximately 2,339 kg/m³ (146 lb/ft³).

Comparison to Laboratory Data

Sound Transmission Class (STC) Comparison. The ranges of tested and modeled STC values for each assembly type are shown in Table 1. When a range is shown for any given model, it is the result of altering the thickness or type of insulation modeled in the cavity. A more detailed discussion of the results for each type of assembly is included in the following section.

Transmission Loss (TL) Data Comparison.

Partition Type 1 – Single Steel-Stud Wall. The shaded area in Figure 2 shows the range of transmission loss values in each third-octave band for the 22 representative lab tests. The dashed black line represents the average tested transmission loss values (equivalent to STC 48) and the red line shows the modeled results

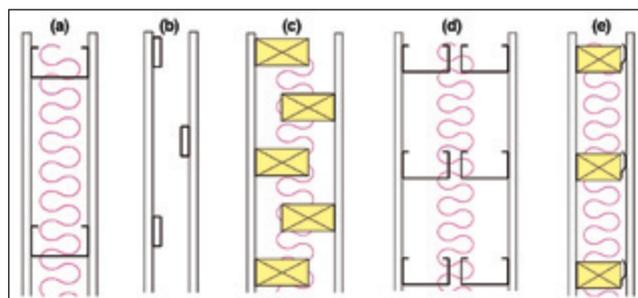


Figure 1. Modeled wall types include: (a) single-stud wall, (b) staggered steel-stud wall with no insulation, (c) staggered wood-stud wall, (d) double-stud wall and (e) wood-stud wall with resilient channel.

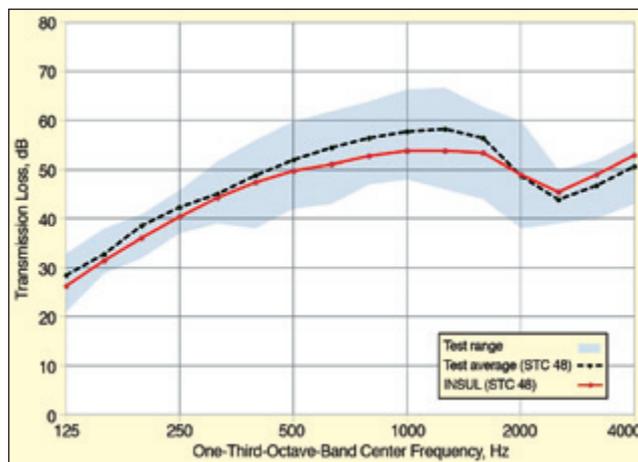


Figure 2. Transmission loss comparison for Partition Type 1.

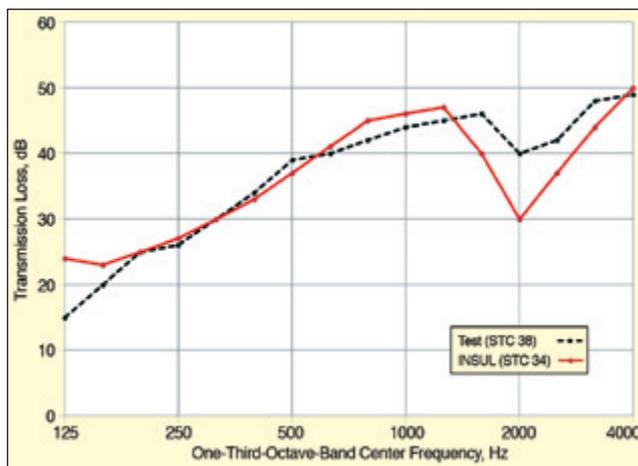


Figure 3. Transmission loss comparison for Partition Type 2 (5/8-inch GWB).

from *INSUL* (STC 48). Modeled results are well within the range of test data, albeit mid-frequency values are slightly below average and values beyond 2,000 Hz are slightly above average.

Partition Type 2 – Staggered Steel-Stud wall. The dashed black line in Figure 3 shows the referenced test data when using 5/8-inch GWB (STC 38). The red line shows the modeled results from *INSUL* (STC 34).

The dashed black line in Figure 4 shows the referenced test data when using 1/2-inch GWB (STC 34). The red line shows the modeled

Table 1. Tested and modeled STC values.

Partition	Tested Values	INSUL	SoundFlow	Socrates
Type 1	41 - 51	48	NA	49 - 50
Type 2, 5/8" GWB	38	34	NA	NA
Type 2, 1/2" GWB	34	35	NA	NA
Type 3	46 - 50	47 - 48	NA	48
Type 4	53 - 59	56 - 57	47 - 61	55 - 58
Type 5	42 - 52	47	NA	47
Concrete slab	55	55	54	NA

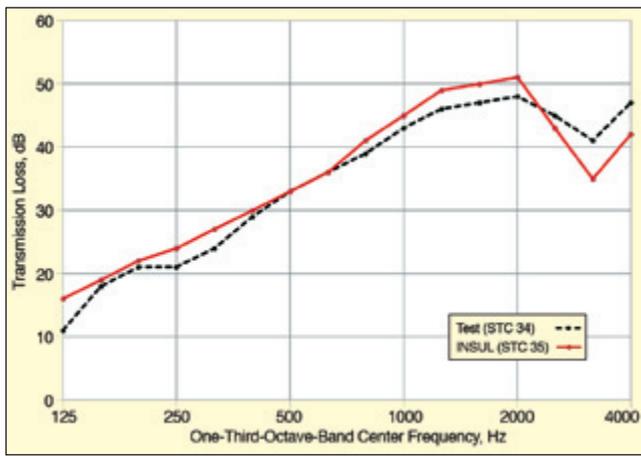


Figure 4. Transmission loss comparison for Partition Type 2 (1/2-inch GWB).

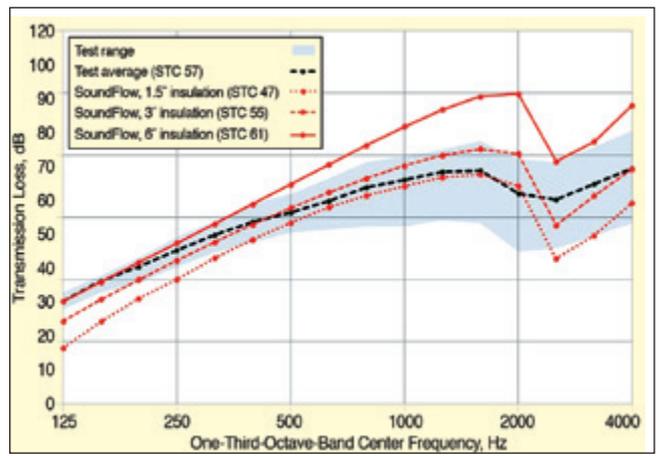


Figure 7. Transmission loss comparison for Partition Type 4 (SoundFlow).

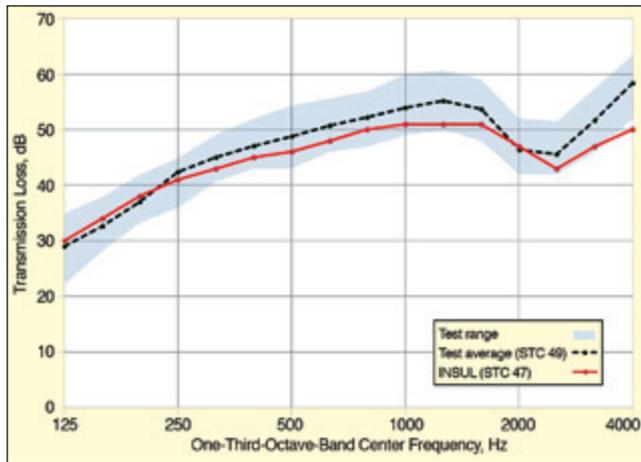


Figure 5. Transmission loss comparison for Partition Type 3.

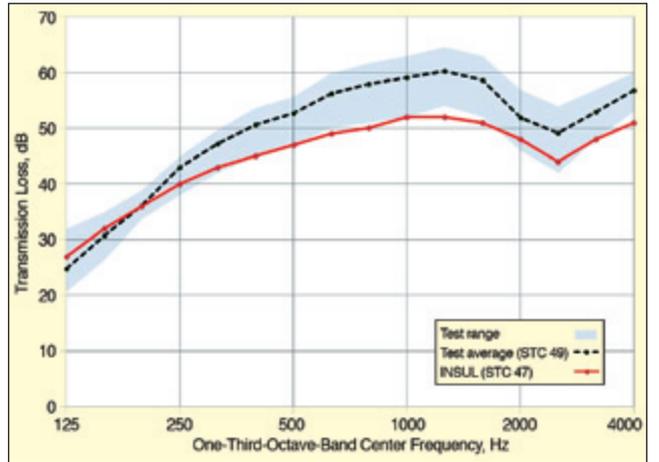


Figure 8. Transmission loss comparison for Partition Type 5.

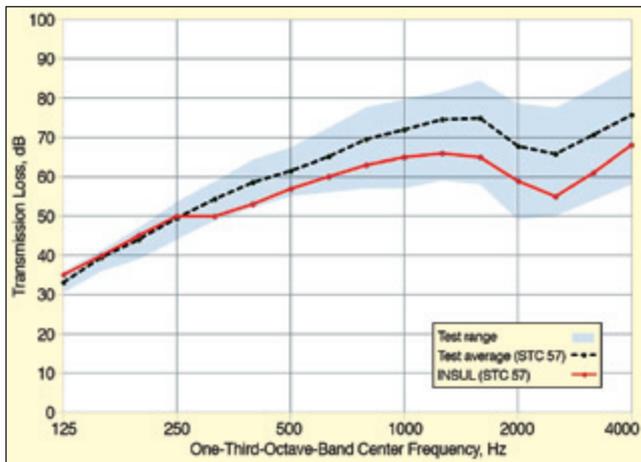


Figure 6. Transmission loss comparison for Partition Type 4 (INSUL).

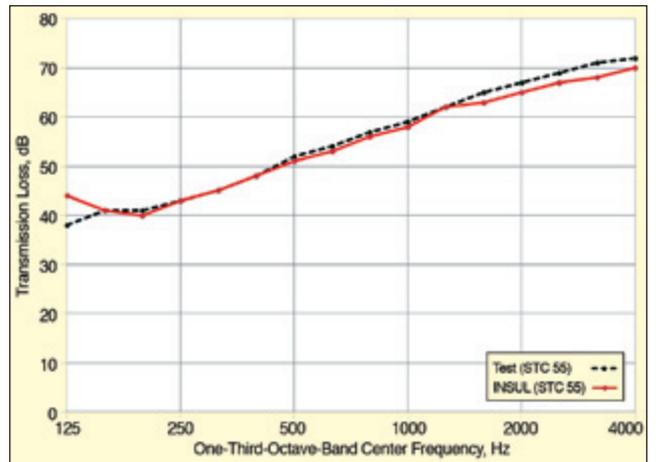


Figure 9. Transmission loss comparison for concrete slab (INSUL).

results from *INSUL* (STC 35).

Modeled values for partition type 2 (staggered steel studs) track relatively well with the representative tests. The coincidence dip is somewhat exaggerated in each case, however a larger set of test data would be needed to confirm if this is truly a pattern.

Partition Type 3 – Staggered Wood-Stud Wall. The shaded area in Figure 5 shows the range of transmission loss values in each third-octave band for the 14 representative lab tests. The dashed black line represents the average tested transmission loss values (equivalent to STC 49) and the red line shows the modeled results from *INSUL* (STC 47). Mid and high frequency TL values appear to be underestimated in the model when compared to this set of test data.

Partition Type 4 – Double Stud Wall. The shaded area in Figure 6 shows the range of transmission loss values in each third-octave

band for the 16 representative lab tests. The dashed black line represents the average tested transmission loss values (equivalent to STC 57) and the red line shows the modeled results from *INSUL* (STC 57). Mid and high frequency TL values again appear to be underestimated in the model when compared to the test data. The effects of varying the type and thickness of cavity absorption in *INSUL* is slight, altering the STC by no more than 1 point and any individual third-octave TL value by no more than 2 dB. When compared to test data it appears that the effects of this variable may be underestimated by *INSUL*.

The same test results are shown in Figure 7 compared to modeled results from *SoundFlow* for varying modeled thicknesses of fiberglass insulation in the wall cavity. If it is assumed that 3-inch insulation is most standard, then the modeled STC rating of 55 is well within the tested range. There is, however, a large swing in

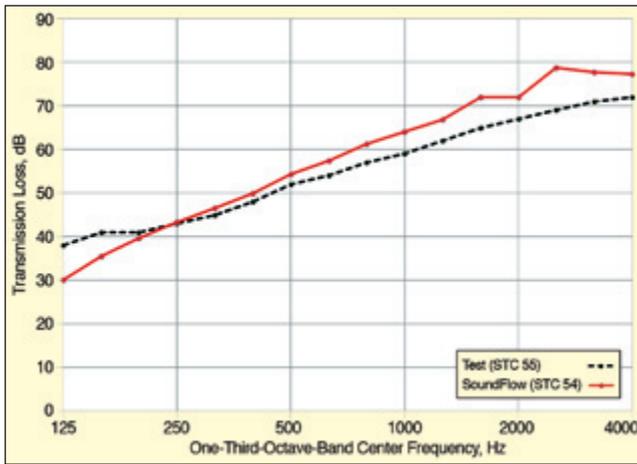


Figure 10. Transmission loss comparison for concrete slab (SoundFlow).

the modeled STC and TL values observed when changing the type or thickness of modeled cavity absorption. When compared to test data it appears that the effects of this variable may be overestimated by *SoundFlow*.

Partition Type 5 – Wood-Stud Wall With Resilient channel. The shaded area in Figure 8 shows the range of transmission loss values in each third-octave band for the 18 representative lab tests. The dashed black line represents the average tested transmission loss values (equivalent to STC 49) and the red line shows the modeled results from *INSUL* (STC 47). Mid and high frequency TL values appear to be underestimated in the model when compared to the test data.

Concrete Slab. The dashed black line in Figure 9 shows the referenced test data for a 6-inch concrete slab (STC 55). The red line shows the modeled results from *INSUL* (STC 55). It is clear that this model tracks the test very closely. However, a single laboratory test is insufficient to determine any sort of pattern.

The dashed black line in Figure 10 shows the same referenced test data compared to the modeled results from *SoundFlow* (STC 54). Again, the model tracks reasonably well to the single referenced test. Although some TL values appear to be overestimated, a single laboratory test is insufficient to determine if this is a pattern.

Conclusions

Using a collection or regression of actual laboratory test data provides the highest degree of confidence when estimating the STC and/or TL values of any given assembly. Often, however, test data are not readily available for a given assembly or may be limited. Given the number of variables when considering a planned or existing assembly, it can be helpful to use computer modeling. When using such models, it is important to understand how individual component variables such as mass, stiffness, damping and cavity absorption alter modeled results. Although these same real-world variables also affect both laboratory and field testing, the modeled effects may be exaggerated. The variability of data seen when comparing multiple test results for nominally equivalent assemblies adds yet another level of uncertainty.

Modeled transmission loss values have tended to underestimate average tested values in this study, though this often had very little or no effect on the modeled STC value when compared to tested STC ratings. Because the effects of altering specific design parameters may be exaggerated by either too much or too little deviation, it is necessary to closely examine these effects when considering the accuracy of any given model.

References

1. "Gypsum Board Walls: Transmission Loss Data," NRC-NCRC Internal Report IRC-IR-761, National Research Council Canada, 1998.
2. "Catalog of STC and IIC Rating for Wall and Floor/Ceiling Assemblies," Office of Noise Control, California Department of Health Services, 1981.
3. "Design Data for Acousticians," Architectural and Construction Services, United States Gypsum, 1985. 

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