NCMA TEK

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SOUND TRANSMISSION CLASS RATINGS FOR CONCRETE MASONRY WALLS

TEK 13-1B
Sound (2007)

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INTRODUCTION

Unwanted noise can be a major distraction, whether in the school, work or home environment. Concrete masonry walls are often used for their ability to isolate and dissipate noise. Concrete masonry offers excellent noise control in two ways. First, masonry walls effectively block airborne sound transmission over a wide range of frequencies. Second, concrete masonry effectively absorbs noise, thereby diminishing noise intensity. Because of these abilities, concrete masonry has been used successfully in applications ranging from party walls to hotel separation walls, and even highway sound barriers.

Sound is caused by vibrations transmitted through air or other mediums, and is characterized by its frequency and intensity. Frequency is a measure of the number of vibrations or cycles per second. One cycle per second is defined as a hertz (Hz). Intensity is measured in decibels (dB), a relative logarithmic intensity scale. For each 20 dB increase in sound there is a corresponding tenfold increase in pressure.

This logarithmic scale is particularly appropriate for sound because the perception of sound by the human ear is also logarithmic. For example, a 10 dB sound level increase is perceived by the ear as a doubling of the loudness. The human ear can perceive sounds as low as 16 Hz to as high as 20,000 Hz, although it is most sensitive to sounds between 500 and 5,000 Hz. Human voices speaking in conversational tones have a frequency of approximately 500 Hz.

The speed of sound through a particular medium, such as a party wall, depends on both the density and stiffness of the medium. All solid materials have a natural frequency of vibration. If the natural frequency of a solid is at or near the frequency of the sound which strikes it, the solid will vibrate in sympathy with the sound, which will be regenerated on the opposite side. The effect is especially noticeable in walls or partitions that are light, thin or flexible. Conversely, the vibration is effectively stopped if the partition is heavy and rigid, as is the case with concrete masonry walls. In this case, the natural frequency of vibration is relatively low, so only sounds of low frequency will cause sympathetic vibration. Because of its mass (and resulting inertia) and rigidity, concrete masonry is especially effective at reducing the transmission of unwanted sound.

SOUND TRANSMISSION CLASS

Sound transmission class (STC) provides an estimate of the acoustic performance of a wall in certain common airborne sound insulation applications.

The STC of a wall is determined by comparing sound transmission loss (STL) values at various frequencies to a standard contour. STL is the decrease or attenuation in sound energy, in dB, of airborne sound as it passes through a wall. In general, the STL of a concrete masonry wall increases with increasing frequency of the sound.

To determine STC, a standard curve is superimposed over a plot of STL values obtained by test (Figure 1) and shifted upward or downward relative to the test curve until some of the measured transmission loss values fall below the standard STC contour and the following conditions are fulfilled:

1. the sum of the deficiencies (deviations below the standard contour) does not exceed 32 dB, and
2. the maximum deficiency at any single test point is not greater than 8 dB.

When the contour is adjusted to the highest value that meets the above criteria, the sound transmission class is taken as the transmission loss value read from the standard contour at the 500 Hz frequency line. For example, the STC for the data plotted in Figure 1 is 25.

Note that the STC rating was developed to be representative of STL at the frequency content of speech, which is important because at these frequencies, higher mass systems tend to perform better than lighter ones.

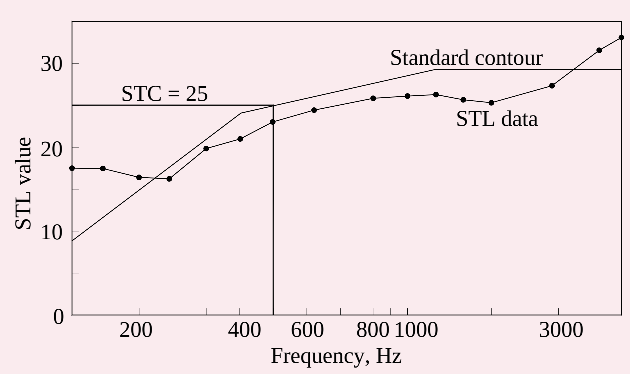


Figure 1—Determining STC: Standard Contour Fitted to Transmission Loss Data

Although STC is a convenient index of transmission loss, it may be necessary in some cases to study the sound transmission loss data at specific frequencies, such as when the main noise source is of one known frequency. In this case, the STL value at the frequency of interest is checked to ensure there is not a "hole," or low STL value, at that particular frequency.

DETERMINING STC FOR CONCRETE MASONRY

Many sound transmission loss tests have been performed on various concrete masonry walls. These tests have indicated a direct relationship between wall weight and the resulting sound transmission class—heavier concrete masonry walls have higher STC ratings. A wide variety of STC ratings is available with concrete masonry construction, depending on wall weight, wall construction and finishes.

In the absence of test data, standard calculation methods exist, although these tend to be conservative. *Standard Method for Determining the Sound Transmission Class Rating for Masonry Walls*, TMS 0302 (ref. 1), contains procedures for determining STC values of concrete masonry walls. According to the standard, STC can be determined by field or laboratory testing in accordance with standard test methods or by calculation. The calculation in TMS 0302 is based on a best-fit relationship between concrete masonry wall weight and STC based on a wide range of test results, as follows:

$$STC = 21.5W^{0.223} \quad \text{Eqn. 1}$$

$$[\text{SI: } STC = 15.1W^{0.223}]$$

where W = the average wall weight based on the weight of the masonry units; the weight of mortar, grout and loose fill material in voids within the wall; and the weight of surface treatments (excluding drywall) and other components of the wall, psf (kg/m^2)

Equation 1 is applicable to uncoated fine- or medium-textured concrete masonry and to coated coarse-textured concrete masonry. Because coarse-textured units may allow airborne sound to enter the wall, they require a surface treatment to seal at least one side of the wall. At least one coat of acrylic latex, alkyd or cement-based paint, or plaster are specifically called out in TMS 0302, although other coatings that effectively seal the surface are also acceptable. One example is a layer of drywall with sealed penetrations, as shown in Figure 4. Note that architectural concrete masonry units are also considered to be sealed for the purposes of using Equation 1.

Equation 1 also assumes the following:

1. walls have a thickness of 3 in. (76 mm) or greater,
2. hollow units are laid with face shell mortar bedding, with mortar joints the full thickness of the face shell,
3. solid units are fully mortar bedded, and
4. all holes, cracks and voids in the masonry that are intended to be filled with mortar are solidly filled with mortar.

Calculated values of STC based on Equation 1 are listed in Table 1.

Because the best-fit equation is based solely on wall weight, the calculation tends to underestimate the STC of masonry walls that incorporate dead air spaces, which contribute to sound attenuation. Figure 2 illustrates some examples and compares calculated STC ratings with those determined by test.

For multi-wythe walls where both wythes are concrete masonry, the weight of both wythes is used in Equation 1 to determine STC. For multi-wythe walls having both concrete masonry and clay brick wythes, however, a different procedure must be used, because concrete and clay masonry have different acoustical properties. In this case, Equation 2, representing a best-fit

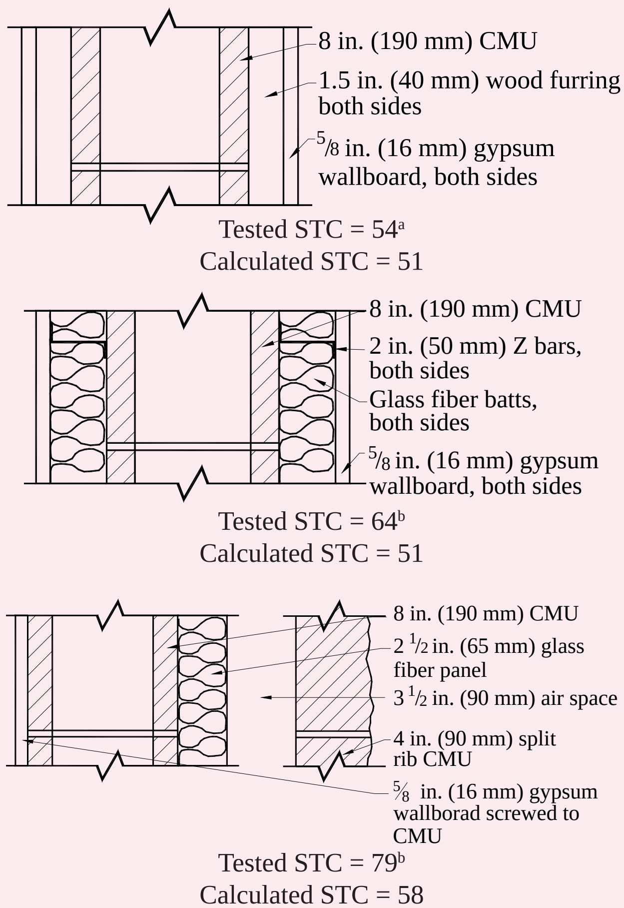
Table 1—Calculated STC Ratings for Concrete Masonry Walls (ref. 1)

Nominal unit thickness, in. (mm)[b]	Density, pcf (kg/m^3)	STC[a] Hollow unit	Grout-filled unit	Sand-filled unit	Solid unit
4 (100)	85 (1,362)	43	46[c]	45	45
	95 (1,522)	44	46[c]	45	45
	105 (1,682)	44	46[c]	46	46
	115 (1,842)	44	47[c]	46	46
	125 (2,002)	45	47[c]	46	47
	135 (2,162)	45	47[c]	47	47
6 (150)	85 (1,362)	44	49	47	47
	95 (1,522)	44	50	48	48
	105 (1,682)	45	50	48	49
	115 (1,842)	45	51	49	50
	125 (2,002)	46	51	49	51
	135 (2,162)	46	52	50	51
8 (200)	85 (1,362)	45	53	50	50
	95 (1,522)	46	53	51	51
	105 (1,682)	46	54	51	52
	115 (1,842)	47	55	52	53
	125 (2,002)	47	55	52	54
	135 (2,162)	48	56	53	55
10 (250)	85 (1,362)	46	56	53	53
	95 (1,522)	47	57	53	54
	105 (1,682)	48	58	54	55
	115 (1,842)	48	58	55	57
	125 (2,002)	49	59	56	58
	135 (2,162)	50	60	56	59
12 (300)	85 (1,362)	47	60	55	55
	95 (1,522)	48	61	56	57
	105 (1,682)	49	62	57	59
	115 (1,842)	49	62	58	60
	125 (2,002)	50	63	59	62
	135 (2,162)	51	64	59	63

[a] Based on: grout density of 140 lb/ft^3 (2,243 kg/m^3); sand density of 90 lb/ft^3 (1,442 kg/m^3); unit percentage solid from mold manufacturer's literature for typical units (4-in. (100-mm) 73.8% solid, 6-in. (150-mm) 55.0% solid, 8-in. (200-mm) 53.0% solid, 10-in. (250-mm) 51.7% solid, 12-in. (300-mm) 48.7% solid). STC values for grout-filled and sand-filled units assume the fill materials completely occupy all voids in and around the units. STC values for solid units are based on all mortar joints solidly filled with mortar.

[b] Metric dimensions reflect equivalent metric unit sizes as opposed to direct SI conversions. Therefore, STC ratings of these hard metric units may be slightly different from the ratings listed here.

[c] Because of small core size and the resulting difficulty consolidating grout, these units are rarely grouted.



[a] 48.2 psf (236 kg/m2) wall weight of CMU only, test designation TL-88-361

[b] 48.2 psf (236 kg/m2) wall weight of CMU only, test designation TL-88-384

[c] 85.4 psf (417 kg/m2) wall weight of masonry only, test designation TL-88-431

Figure 2—Concrete Masonry STC Test Results (ref. 2)

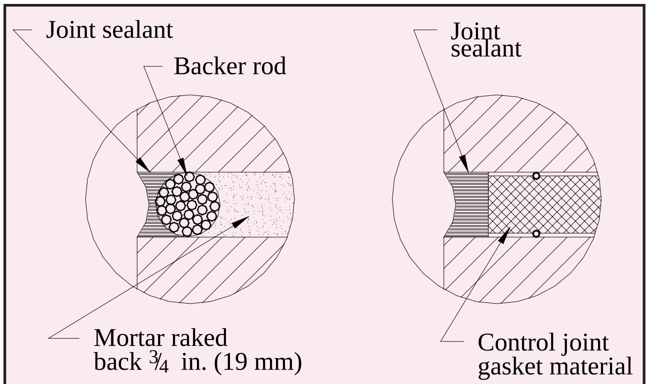


Figure 3—Sealing Wall Intersections and Control Joints

relationship for clay masonry, must also be used. To determine a single STC for the wall system, first calculate the STC using both Equations 1 and 2, based on the combined weight of both wythes, then linearly interpolate between the two resulting STC ratings based on the relative weights of the wythes. Equation 2 is the STC equation for clay masonry (ref. 1):

$$STC = 19.6W^{0.230} \quad \text{Eqn. 2}$$

$$[\text{SI: } STC = 13.6W^{0.230}]$$

For example, consider a masonry cavity wall with an 8-in. (203-mm) concrete masonry backup wythe (W = 33 psf, 161 kg/m^2) and a 4-in. (102-mm) clay brick veneer (W = 38 psf, 186 kg/m^2).

$$STC\ (\text{Eqn. 1}) = 21.5(33 + 38)^{0.223} = 55$$

$$STC\ (\text{Eqn. 2}) = 19.6(33 + 38)^{0.230} = 52$$

Interpolating:

$$STC = \frac{33}{71}(55) + \frac{38}{71}(52) = 53$$

When STC tests are performed, the TMS 0302 requires the testing to be in accordance with ASTM E 90, *Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements* (ref. 3) for laboratory testing or ASTM E 413, *Standard Classification for Rating Sound Insulation* (ref. 4) for field testing.

BUILDING CODE REQUIREMENTS

The *International Building Code* (refs. 5, 6) contains requirements to regulate sound transmission through interior partitions separating adjacent dwelling units and for those separating dwelling units from adjacent public areas, such as hallways, corridors, stairs or service areas. Partitions serving the above purposes must have a sound transmission class of at least 50 dB for airborne noise when tested in accordance with ASTM E 90. If field tested, an STC of 45 must be achieved. In addition, penetrations and openings in these partitions must be sealed, lined or otherwise treated to maintain the STC. Guidance on achieving this for masonry walls is contained below in *Design and Construction*.

The *International Residential* Code (refs. 7, 8) contains similar requirements, but with a minimum required STC rating of 45 dB when tested in accordance with ASTM E 90 for walls and floor/ceiling assemblies separating dwelling units.

DESIGN AND CONSTRUCTION

In addition to STC values for walls, other factors also affect the acoustical environment of a building. For example, a higher STC may be warranted between a noisy room and a quiet one than between two noisy rooms. This is because there is less background noise in the quiet room to mask the noise transmitted through the common wall.

Seemingly minor construction details can also impact the acoustic performance of a wall. For example, screws used to attach gypsum wallboard to steel furring or resilient channels should not be so long that they contact the face of the concrete masonry substrate, as this contact area becomes an effective path for sound vibration transmission.

Standard Method for Determining the Sound Transmission Class Rating for Masonry Walls (ref. 1) includes requirements for sealing openings and joints to ensure these gaps do not undermine the sound transmission characteristics of the wall. These requirements are described below and illustrated in Figures 3 and 4.

Through-wall openings should be completely sealed, After first filling gaps with foam, cellulose fiber, glass fiber, ceramic fiber or mineral wool. Similarly, partial wall penetration openings and inserts, such as electrical boxes, should be completely sealed with joint sealant.

Control joints should also be sealed with joint sealants to minimize sound transmission. The joint space behind the sealant backing can be filled with mortar, grout, foam, cellulose fiber, glass fiber or mineral wool (see Figure 4).

To maintain the sound barrier effectiveness, partitions should be carried to the underside of the structural slab, and the joint between the two should be sealed against sound transmission in a way that allows for slab deflection. If the roof or floor is metal deck rather than concrete, joint sealants alone will not be effective due to the shape of the deck flutes. In this case, specially shaped foam filler strips should be used. For fire and smoke containment walls, safing insulation should be used instead of foam filler strips.

Additional design and building layout considerations, not covered in TMS 0302, will also help minimize sound transmission. These are covered in detail in *Noise Control with Concrete Masonry*, TEK 13-2A (ref. 9).

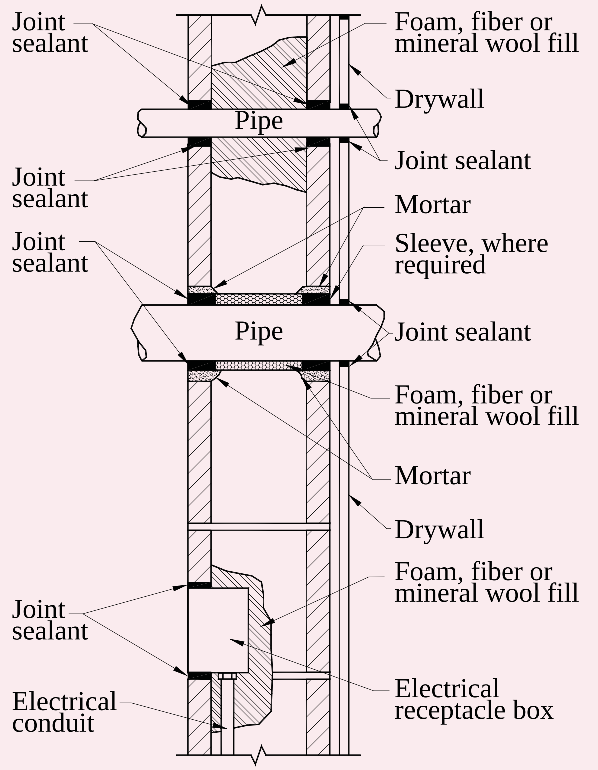


Figure 4—Sealing Around Penetrations and Fixtures

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