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## SOUND TRANSMISSION CLASS RATINGS FOR CONCRETE MASONRY WALLS

### INTRODUCTION

Unwanted noise can be a major distraction, whether at school, work or home. Concrete masonry walls are often used for their ability to isolate and dissipate noise. Concrete masonry offers excellent noise control in two ways. First, it effectively blocks 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 (the number of vibrations or cycles per second) is measured in 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 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 sound transmission.

### DETERMINING SOUND TRANSMISSION CLASS (STC) FOR CONCRETE MASONRY

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.

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 STC—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, which tend to be conservative. *Standard Method for Determining Sound Transmission Ratings 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 in accordance with the following:

$$STC = 20.5W^{0.234} \quad \text{Eqn. 1}$$
$$[\text{SI: } STC = 14.1W^{0.234}]$$

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 2. Architectural concrete masonry units are considered sealed without surface treatment 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.

Calculated values of *STC* 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. See the following section for the effect of drywall with furring spaces on *STC*.

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 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):

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

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

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

$$STC \text{ (Eqn. 1)} = 20.5(33 + 38)^{0.234} = 55$$

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

Interpolating:

$$STC = 55(33/71) + 52(38/71) = 53$$

The installed weight of concrete masonry assemblies can be determined in accordance with CMU-TEC-002-23 (ref. 10). When *STC* tests are performed, the TMS 0302 requires the testing to be in accordance with ASTM E90, *Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements* (ref. 2) for laboratory testing or ASTM E413, *Standard Classification for Rating Sound Insulation* (ref. 3) for field testing.

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

Nominal unit thickness, in. (mm)	Density, pcf (kg/m <sup>3</sup> )	<i>STC</i> <sup>A</sup>			
		Hollow unit	Grout-filled unit	Sand-filled unit	Solid unit
4 (102)	85 (1,362)	40	45 <sup>B</sup>	44	44
	95 (1,522)	41	46 <sup>B</sup>	44	45
	105 (1,682)	42	46 <sup>B</sup>	45	46
	115 (1,842)	43	47 <sup>B</sup>	46	46
	125 (2,002)	44	48 <sup>B</sup>	46	47
	135 (2,162)	45	48 <sup>B</sup>	47	48
6 (152)	85 (1,362)	42	51	48	48
	95 (1,522)	43	51	49	49
	105 (1,682)	44	52	50	50
	115 (1,842)	45	52	50	51
	125 (2,002)	45	53	51	52
	135 (2,162)	46	53	51	53
8 (203)	85 (1,362)	44	55	52	52
	95 (1,522)	45	55	52	53
	105 (1,682)	46	56	53	54
	115 (1,842)	47	56	54	55
	125 (2,002)	48	57	54	56
	135 (2,162)	49	57	55	57
10 (254)	85 (1,362)	46	58	55	55
	95 (1,522)	48	58	55	56
	105 (1,682)	49	59	56	57
	115 (1,842)	50	59	57	58
	125 (2,002)	50	60	57	59
	135 (2,162)	51	60	58	60
12 (305)	85 (1,362)	48	61	57	57
	95 (1,522)	49	61	58	58
	105 (1,682)	50	62	58	60
	115 (1,842)	51	62	59	61
	125 (2,002)	52	63	60	62
	135 (2,162)	53	63	60	63

<sup>A</sup> Based on: grout density of 140 lb/ft<sup>3</sup> (2,243 kg/m<sup>3</sup>); mortar density of 130 lb/ft<sup>3</sup> (2,082 kg/m<sup>3</sup>) sand density of 90 lb/ft<sup>3</sup> (1,442 kg/m<sup>3</sup>); 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). Other unit configurations may have different *STC* values. *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.

<sup>B</sup> Because of small core size and the resulting difficulty consolidating grout, these units are rarely grouted.

## CONTRIBUTION OF DRYWALL

Drywall attached directly to the surface of a concrete masonry wall has very little effect on sound attenuation other than the same benefit as sealing the surface. Adding 1/2 or 5/8 in. (13 or 16 mm) gypsum wall board to one side of the wall with an unfilled furring space will generally result in a slight increase in *STC*. However, when placed on both sides of the wall with a furring space of less than 0.8 in. (19 mm) a reduction in *STC* is realized due to mass-air-mass resonance similar to the action of drum. Better results are realized when the furring space is filled with sound insulation. Sound insulation consists of fibrous materials, such as cellulose fiber, glass fiber or rock wool insulation, are good materials for absorbing sound; closed-cell materials, such as expanded polystyrene, are not, as they do not significantly absorb sound (refs. 1, 7). Note that most of these materials are susceptible to moisture so care must be taken when applying these types of insulation to exterior walls.

Equations to determine the change in *STC* when adding drywall are as follows (Table 2 lists calculated values of  $\Delta STC$  based on Equations 3 through 6):

- For drywall on one side of the wall with no sound absorbing material in the furring space:
 
$$\Delta STC = 2.8d - 1.22 \quad \text{Eqn. 3}$$

$$[SI: \Delta STC = 0.11d - 1.22]$$
- For drywall on both sides of the wall and no sound absorbing material in the furring spaces:
 
$$\Delta STC = 3.6d - 2.78 \quad \text{Eqn. 4}$$

$$[SI: \Delta STC = 0.14d - 2.78]$$
- For drywall on one side of the wall with sound absorbing material in the furring space:
 
$$\Delta STC = 3.0d + 1.87 \quad \text{Eqn. 5}$$

$$[SI: \Delta STC = 0.12d + 1.87]$$
- For drywall on both sides of the wall and sound absorbing material in the furring spaces:
 
$$\Delta STC = 11.2d - 7.37 \quad \text{Eqn. 6}$$

$$[SI: \Delta STC = 0.44d - 7.37]$$

In addition to this TEK, CMHA has generated a calculator for determining the sound transmission class (*STC*) of a user-defined assembly. See CMU-XLS-003-19, *CMU Sound and Assemblies Properties Calculator* (ref. 8).

## BUILDING CODE REQUIREMENTS

The *International Building Code* (ref. 4) contains requirements to regulate sound transmission through interior partitions separating adjacent dwelling units and 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 E90. 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* (ref. 5) contains similar requirements, but with a minimum *STC* rating of 45 dB when tested in accordance with ASTM E90 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.

TMS 0302 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 1 and 2.

**Table 2—Increase in *STC* Ratings Due to Furring Space and Drywall (ref. 1)**

Furring space condition:	Drywall on:	$\Delta STC$ for furring space thickness <sup>A</sup> (in., (mm)) of:							
		0.5 (13)	0.8 (19)	1 (25)	1.5 (38)	2 (51)	2.5 (64)	3 (76)	3.5 (89)
No sound-absorbing material in the furring space	one side	0.2	0.9	1.6	3.0	4.4	5.8	7.2	8.6
	both sides <sup>A</sup>	-1.0	-0.1	0.8	2.6	4.4	6.2	8.0	9.8
Furring space filled with sound-absorbing material <sup>B</sup>	one side	3.4	4.1	4.9	6.4	7.9	9.4	10.9	12.4
	both sides <sup>A</sup>	-1.8	1.0	3.8	9.4	15.0	20.6	26.2	31.8

<sup>A</sup> When drywall is used on both sides of the masonry, use the thickness of the furring space on one side of the wall to determine  $\Delta STC$ . The furring space and insulation condition must be the same on both sides to use this provision.

<sup>B</sup> Fibrous materials, such as cellulose fiber, glass fiber or rock wool insulation, are good materials for absorbing sound; closed-cell materials, such as expanded polystyrene, are not, as they do not significantly absorb sound.

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.

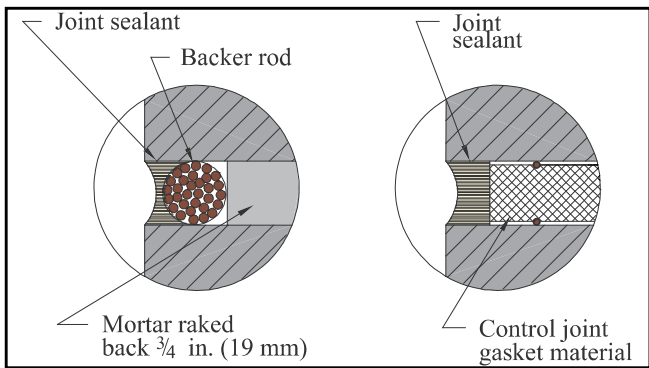
Control joints should also be sealed with joint sealants to minimize sound transmission. The joint space behind the sealant backing can be filled with mortar, grout, foam, cellulose fiber, glass fiber or mineral wool (see Figure 2).

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.

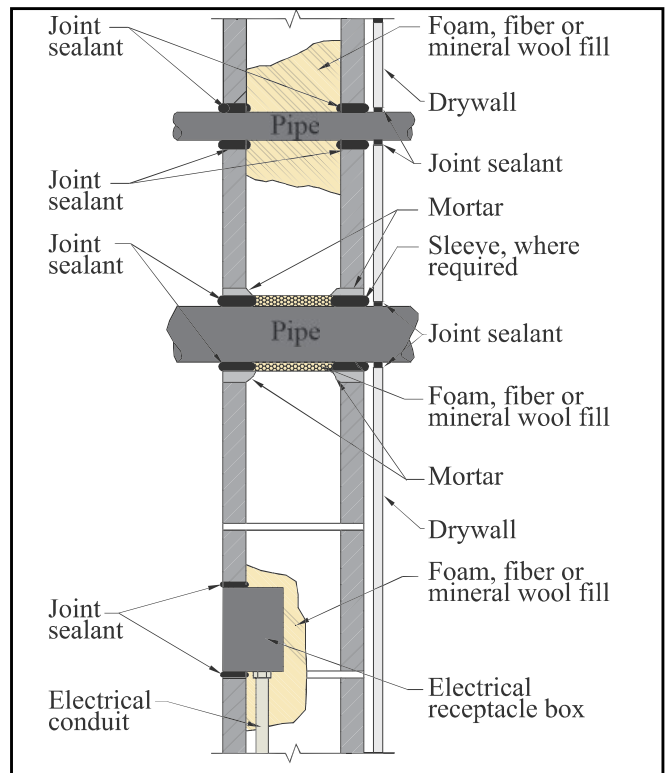
Additional nonmandatory design and building layout considerations will also help minimize sound transmission. These are covered in detail in TEK 13-02A (ref. 6). The design of exterior walls for the mitigation of outdoor-indoor sound transmission is covered under TEK 13-04B (ref. 9).

**NOTATIONS**

- $\Delta STC$  = the change in *STC* rating compared to a bare concrete masonry wall
- d* = the thickness of the furring space (when drywall is used on both sides of the masonry, *d* is the thickness of the furring space on one side of the wall only), in. (mm)
- STC* = Sound Transmission Class
- STL* = Sound Transmission Loss
- 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<sup>2</sup>)



**Figure 1—Sealing Wall Intersections & Control Joints**



**Figure 2—Sealing Around Penetrations & Fixtures**

## REFERENCES

1. *Standard Method for Determining Sound Transmission Ratings for Masonry Walls*, TMS 0302-12. The Masonry Society, 2012.
2. *Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements*, ASTM E90-09. ASTM International, 2009.
3. *Standard Classification for Rating Sound Insulation*, ASTM E413-10. ASTM International, 2010.
4. 2003, 2006, 2009, and 2012 *International Building Code*. International Code Council, 2003, 2006, 2009, 2012.
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6. *Noise Control with Concrete Masonry*, [TEK 13-02A](#). Concrete Masonry & Hardscapes Association, 2007.
7. *Controlling Sound Transmission Through Concrete Block Walls*, Construction Technology Update No. 13. National Research Council of Canada, 1998.
8. *CMU Sound and Assemblies Properties Calculator*, CMU XLS-003-19, Concrete & Hardscapes Association, 2019.
9. *Outdoor-Indoor Transmission Class of Concrete Masonry Walls*, TEK 13-04A, Concrete & Masonry Hardscapes, 2012.

## ABOUT CMHA

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