



TECHNICAL NOTES on Brick Construction

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Technical Notes 5A - Sound Insulation - Clay Masonry Walls (Reissued August 2000)

INTRODUCTION

The sound insulation or sound transmission loss of a wall is that property which enables it to resist the passage of noise or sound from one side to the other. This should not be confused with sound absorption which is that property of a material which permits sound waves to be absorbed, thus reducing the noise level within a given space and eliminating echoes or reverberations. Only sound insulation will be discussed in this *Technical Notes*.

MEASUREMENT OF SOUND

The sound insulation of a building assembly is expressed as a reduction factor in decibels (dB). The decibel is approximately the smallest change in energy the human ear can detect, and the decibel scale is used for measuring ratios of sound intensities. The reference sound intensity used to measure absolute noise levels is that corresponding to the faintest sound a human ear can hear (0 dB). However, a difference of 3 or less dB is not especially significant, because the human ear cannot detect a change in sounds of less than 3 dB.

Figure 1 shows the intensity level of common sounds on the decibel scale. These data are reproduced from "How Loud is Loud? Noise, Acoustics and Health", by Lee E. Farr, M.D., published in the February 1970 issue of *Architectural & Engineering News*.

SOUND TRANSMISSION LOSS

It is desirable to have a single number rating as a means for describing the performance of building elements when exposed to an "average" noise. In the past it was customary to use the numerical average of the transmission loss values at nine frequencies. This rating, termed the *nine-frequency average transmission loss*, is often quite inaccurate in comparing an assembly of materials having widely differing TL-frequency characteristics. One single number rating method which has been recently proposed is the *sound transmission class* (STC). This rating is based on the requirements that the value of transmission loss at any of the eleven measuring frequencies does not fall below a specified TL-frequency contour. The shape of this contour is drawn to represent the more common types of noise, and generally covers the requirements for speech privacy.

	dB	SOURCE	COMMENT
Deafening	150		Short exposure can cause hearing loss
	140	Jet plane takeoff	
	130	Artillery fire	Threshold of pain
		Machine gun	
	120	Riveting	
		Siren at 100 ft	
Jet plane (passenger ramp)			
110	Thunder - Sonic boom	Threshold of discomfort	
	Woodworking shop		
	Accelerating motorcycle		
Very Loud	100	Hard rock band	Intolerable for phone use
		Subway (steel wheels)	
		Loud street noise	
		Power lawnmower	
	90	Outboard motor	
		Truck unmuffled	
Loud	80	Train whistle	
		Kitchen blender	
		Pneumatic jackhammer	
		Printing press	
	70	Subway (rubber wheels)	
Noisy office			
Average factory			
Moderate	60	Average street noise	
		Quiet typewriter	
		Freight train at 100 ft	
	50	Average radio	
		Noisy home	
Faint	40	Average office	
		Normal conversation	
	30	General office	
Quiet radio			
Very Faint	20	Average home	
		Quiet street	
	10	Private office	
		Quiet home	
0	Empty auditorium	Threshold of audibility	
		Whisper	
		Rustling leaves	
		Sound proof room	
		Human breathing	

FIG. 1

The following are conclusions in a report entitled, "Measurements of Sound Transmission Loss in Masonry", by William Siekman of Riverbank Acoustical Laboratories, June 1969.

"In conclusion, changes in results of transmission loss measurements have been studied. They indicate that deficiencies in earlier test methods and environments have apparently been corrected. Although data reported today are lower than ever before, they agree very well with data taken in field situations, and consequently

provide assurance that laboratory tests can be relied upon to achieve the desired noise reductions. The performance of walls near the coincidence frequency cannot be predicted yet on a theoretical basis, nor can the performance of walls having a compound structure, but test specimen sizes are now large enough to be representative of typical walls and to provide data over the present frequency range of interest.

"Since the principal deviation due to specimen size is apt to occur at the lower frequencies, users of transmission loss data are urged to avoid dependence upon single figure ratings, even such a relatively good one as is recommended by the Proposed Classification for Determination of Sound Transmission Class, ASTM RM 14-2 (1966). The decision to use a particular construction should always be based upon the total curve and the requirements at individual frequencies."

DESCRIPTION OF SPECIMENS

The specimens discussed in this issue of *Technical Notes* were constructed at the Riverbank Acoustical Laboratories in a testing frame having inside dimensions of 14 ft 4 in. wide by 9 ft 4 in. high. The joints were of typical thickness and were staggered. Mortar was mixed in a ratio by volume of 1 part cement, 2 parts lime and 9 parts sand. All specimens were constructed by a professional mason. The curing time was 28 days or more. The transmission area, *S*, used in the computations was generally 126 sq ft.

Following are the descriptions of tests, performed at the Riverbank Acoustical Laboratories starting with the lowest Sound Transmission Class (STC):

STC 39. 4-in. Structural Clay Tile Wall

Tile dimensions: 3-9/16 by 4-7/8 by 11-3/4 in

Wall thickness: 3-9/16 in.

Average weight: 22.3 psf

Test: TL 67-59

STC 41. 4 in. Structural Clay Tile Wall, with 5/8-in. plaster one face

Tile dimensions: 3-9/16 by 4-7/8 by 11-3/4 in.

Wall thickness: 4-3/16 in.

Average weight: 25.3 psf

Test: TL 67-82

STC 45. 8-in. Structural Clay Tile Wall

Tile dimensions: 7-5/8 by 4-7/8 by 11-3/4 in.

Wall thickness: 7-5/8 in.

Average weight: 40.6 psf

Test: TL 67-69

STC 45. 4-in. Face Brick Wall

Brick dimensions: 2-1/4 by 3-3/4 by 8-1/4 in.

Wall thickness: 3-3/4 in.

Average weight: 38.7 psf

Test: TL 67-70

STC 49. 6-in. "SCR brick" (Reg. U.S. Pat. Off., SCPI) Wall, with 3/8-in. gypsum board over 1-in. styrofoam insulation one face

Brick dimensions: 2-1/4 by 5-1/2 by 11-1/2.

Wall thickness: 6-7/8 in.

Average weight: 57.7 psf

Test: TL 70-39

NOTE: The styrofoam was placed with adhesive, spot applied 12 in. o.c. both vertically and horizontally, to the brick wall on one side. A single layer of 3/8 in. gypsum board was applied vertically over the foam with adhesive, spot applied 12 in. o.c. vertically and horizontally in the field and 6 in. o.c. at the joints. The external joints were finished with a typical drywall joint system.

STC 50. 8-in. Face Brick and Structural Clay Tile Composite Wall

Brick dimensions: 2-1/4 by 3-3/4 by 8-1/4 in.

Tile dimensions: 4 in. nominal thickness

Wall thickness: 8 in.

Average weight: 63.8 psf

Test: TL 67-65

STC 50. 10-in. Face Brick Cavity Wall, with 2-in. air space

Brick dimensions: 2-1/4 by 3-3/4 by 8-1/4 in.

Wall thickness: 10 in.

Average weight: 81.0 psf

Test: TL 68-31

NOTE: The 2 wythes of masonry were tied together with metal wall ties.

STC 50. 4-in. Brick Wall, with 1/2-in. sanded plaster, two-coat one face

Brick dimensions: 2-1/4 by 3-5/8 by 7-5/8 in.

Wall thickness: 4-1/8 in.

Average weight: 42.4 psf

Test: TL 69-283

STC 51. 6-in. "SCR brick" (Reg. U.S. Pat. Off., SCPI) Wall

Brick dimensions: 2-1/4 by 5-1/2 by 11-1/2 in.

Wall thickness: 5-1/2 in.

Average weight: 55.8 psf

Test: TL 69-286

STC 52. 8-in. Solid Face Brick Wall

Brick dimensions: 2-1/4 by 3-3/4 by 8-1/4 in.

Wall thickness: 8 in.

Average weight: 83.3 psf

Test: TL 67-68

STC 53. 8-in. Solid Brick Wall, with 1/2-in. gypsum board on furring strips one face

Brick dimensions: 2-1/4 by 3-5/8 by 7-5/8 in.

Wall thickness: 9-1/4 in.

Average weight: 86.7 psf

Test: TL 69-287

NOTE: The 3/4-in. collar joint was filled with mortar. Metal Z ties were used between wythes spaced at 24 in. o.c. both vertically and horizontally. The 1 by 3 wood vertical furring strips were spaced at 16 in. o.c. and nailed at the mortar joints approximately 12 in. o.c. The gypsum board was applied vertically and attached with nails spaced 12 in. o.c. in the field and 8 in. o.c. along the edges. The joints and nail heads were finished with standard drywall system.

STC 53. 6-in. "SCR brick" (Reg. U.S. Pat. Off., SCPI) Wall, with 1/2-in. plaster one face

Brick dimensions: 2-1/4 by 5-1/2 by 11-1/2 in.

Wall thickness: 6 in.

Average weight: 60.8 psf

Test: TL 70-70

STC 55. 12-in. Face Brick and Structural Clay Tile Composite Wall

Brick dimensions: 2-1/4 by 3-3/4 by 8-1/4 in.

Tile dimensions: 7-5/8 by 4-7/8 by 11-3/4 in.

Wall thickness: 12 in.

Average weight: 84.1 psf

Test: TL 67-62

STC 59. 12-in. Solid Brick Wall

Brick dimensions:

Face: 2-1/4 by 3-3/4 by 8-1/4 in.

Building: 2-1/4 by 3-5/8 by 8 in.

Wall thickness: 12 in.

Average weight: 116.7 psf

Test: TL 67-32

NOTE: The outside wythes were of face brick. The interior wythe was of common brick.

STC 59. 10-in. Reinforced Brick Masonry Wall (RBM)

Brick dimensions: 2-1/4 by 3-5/8 by 7-5/8 in

Wall thickness: 9-1/2 in.

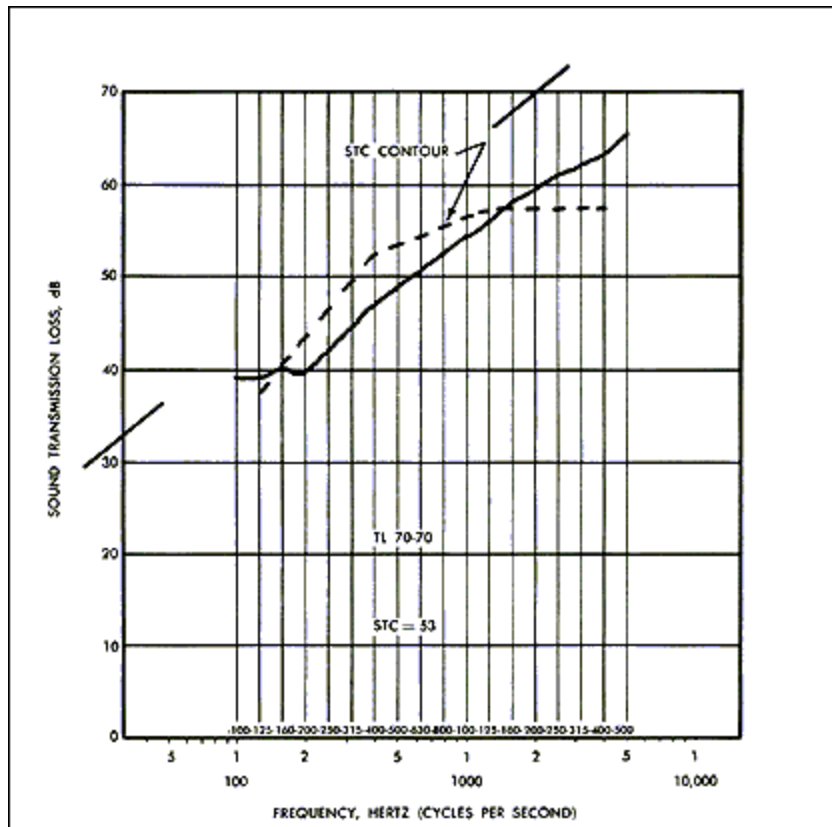
Average weight: 94.2 psf

Test: TL 70-6

NOTE: The 2-1/4-in. grouted cavity contained No. 6 bars at 48 in. o.c. vertically and No. 5 bars at 30 in. o.c. horizontally.

SOUND TRANSMISSION CLASS

Sound transmission class contours (see Fig. 2) may be constructed in accordance with ASTM RM 14-2 on conventional semi-logarithmic paper as follows: a horizontal line segment from 1250 to 4000 Hz (cycles per second); a middle line segment decreasing 5 dB in the interval 1250 to 400 Hz; and a low frequency segment decreasing 15 dB in the interval 400 to 125 Hz.



The sound transmission loss of the tested specimen is shown by the curved line in the above graph. The broken line is the limiting sound transmission class contour.

The theoretical transmission loss of that limp mass having the same weight per square foot as the specimen can be located by drawing a straight line between the two slash marks on the edges of the grid. This was derived from the equation: $TL = 20 \log W + 20 \log F - 33$, where W is weight in pounds per square foot, and F is frequency in Hertz (cycles per second).

FIG. 2

The STC contour is shifted vertically relative to the test curve until some of the measured TL values for the test specimen fall below those of the STC contour and the following conditions are fulfilled: The sum of the deficiencies (that is; the deficiencies of test points below the contour) shall not be greater than 32 dB, and the maximum deficiency of any single test point shall not exceed 8 dB. The sound transmission class for the specimen is the TL (transmission loss) value corresponding to the intersection of the sound transmission class contour and the 500-Hz ordinate.

Table 1 shows the decibel losses for 18 frequencies of test specimens listed above. Deficiencies or deviations from the contour (see graph) are tabulated to correspond with the proper frequencies.

These measurements were made using a one-third octave bank of pink noise, swept in 13 min from 100 to 5000 Hz. Runs were made before and after a system interchange, during which the ratio of sound pressure levels in the two rooms was directly recorded graphically. The final results were obtained by averaging the runs, with a resultant precision within a 90 per cent confidence limit of ± 1 dB.

The sound transmission class is computed in accordance with the Tentative Recommended Practice for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions, ASTM E 90-66T, and ASTM RM 14-2. The STC number is intended to be used as a preliminary estimate of the acoustical properties of the specimen. Final decisions for design use should be based upon the entire TL curve for the values at all the test frequencies.

TABLE 1
Test Measurements for 13 Minutes from 100 to 5000 Hertz

STC Rating	Test No.		Frequency, Hertz (cps)																	
			100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000
39	TL67-59	TL, dB ¹	28	27	28	30	31	31	31	34	36	38	39	40	43	48	51	53	52	50
		Def, db ²					1	4	7	5	4	3	3	3						
41	TL67-82	TL, dB	30	31	30	32	32	33	34	36	38	41	42	43	45	49	52	54	53	51
		Def					2	4	6	5	4	2	2	2						
45	TL67-69	TL, dB	33	33	32	33	37	36	38	39	43	44	45	47	49	52	55	53	50	55
		Def				2	1	5	6	6	3	3	3	2						
45	TL67-70	TL, dB	32	32	31	32	34	35	37	40	43	45	47	49	53	55	57	59	61	63
		Def			1	3	4	6	7	5	3	2	1							
49	TL70-39	TL, dB	39	37	37	36	35	37	43	49	55	60	62	63	65	67	68	70	72	73
		Def				3	7	8	5											
50	TL67-65	TL, dB	38	38	37	38	40	42	44	45	47	50	50	52	54	56	59	61	63	65
		Def				2	3	4	5	5	4	2	3	2						
50	TL68-31	TL, dB	40	37	34	34	37	40	44	47	49	52	55	58	60	62	63	65	66	64
		Def			3	6	6	6	6	5	3	2								
50	TL69-283	TL, dB	33	37	39	38	40	42	44	46	48	50	51	54	55	56	57	59	60	62
		Def				2	3	4	5	4	3	2	2							
51	TL69-286	TL, dB	35	38	38	39	40	43	45	47	49	50	52	54	55	58	59	61	63	65
		Def				2	4	4	5	4	3	3	2	1						
52	TL67-68	TL, dB	37	37	38	37	42	45	46	47	51	52	52	54	58	61	61	63	65	69
		Def			1	5	3	3	5	5	2	2	3	2						
53	TL69-287	TL, dB	41	37	35	35	41	49	54	56	59	61	63	64	66	70	71	69	70	73
		Def			5	8	5													
53	TL70-70	TL, dB	39	39	40	40	41	45	47	48	50	52	54	56	57	59	60	61	63	65
		Def				3	5	4	5	5	4	3	2	1						
55	TL67-62	TL, dB	41	39	41	41	45	48	49	51	52	56	58	60	62	62	63	63	64	68
		Def			1	4	3	3	5	4	4	1								
59	TL67-32	TL, dB	44	44	44	46	47	52	52	55	57	59	61	63	65	66	66	67	69	71
		Def			2	3	5	3	6	4	3	2	1							
59	TL70-6	TL, dB	43	42	43	46	47	51	54	56	59	60	63	63	64	67	68	69	71	72
		Def		1	3	3	5	4	4	3	1	1								

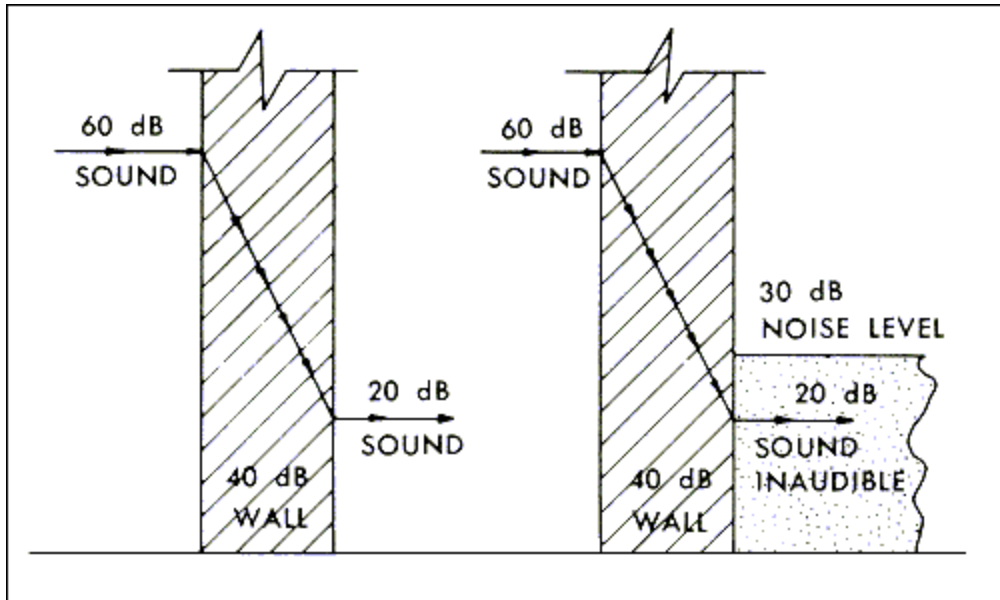
¹Transmission Loss, decibels

²Deficiencies, decibels

MASKING EFFECT

The sound insulation required in a structure to give satisfactory results depends not only upon the noise level outside of the building or in adjoining rooms, but also upon the noise level within the room under consideration.

If it is to be assumed that there is no noise within the room to be insulated against sound transmission and the noise level in the adjoining room is 60 dB, it will require a partition having a reduction factor of 60 dB to render the noise in the adjoining room inaudible. However, if the noise level in the room under consideration is 30 dB, a partition having a sound reduction factor of approximately 40 dB (see Fig. 3) will make the sound in the adjoining room inaudible. Experiments have shown that for one sound to mask another, there must be at least 10 dB difference between the two sounds. This effect of the sound within the room under consideration is known as the "masking effect". Figure 3 illustrates this "masking effect" principle.



Effect of Masking Noise on "Listening" Side of Wall

FIG. 3

CONCLUSION

This issue of *Technical Notes* has discussed recent test data for, and sound insulation performance of, brick and tile walls and partitions. Future issues of *Technical Notes* will contain some suggestions and recommendations for the control of sound transmission through brick and tile walls and partitions.