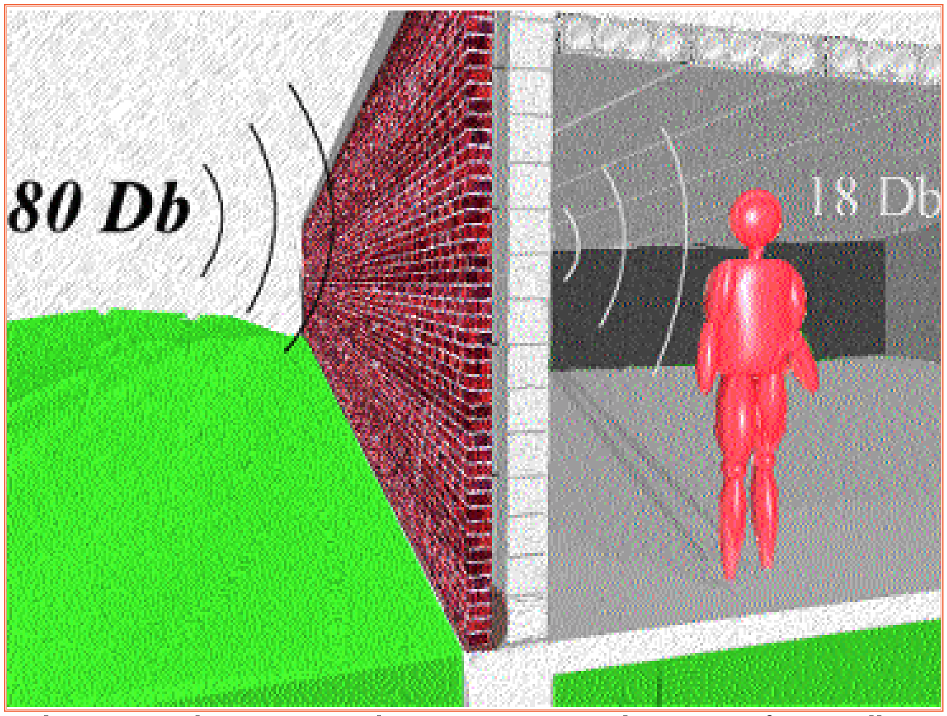
New Data Shows Masonry Wall and Precast Hollow Core Floor Systems Reaching High STC Ratings



Introduction

Noise is a major distraction, both in the home as well as the work environment. In the home, the number of noise making appliances grows as we reach new heights of technological advancement. Televisions, hi-fidelity sound systems, air conditioners, and a vast number of other sound generating devices are standard to every household. The unwanted noises from these internal sound sources are complimented by that from automobiles, sirens, and jets on the outside. The tranquility of the office is also hampered by noise generating devices. Printers, copiers, typewriters, and loud co-workers can all make the workplace a less than ideal place for concentration. Each advancement in technology seems to be accompanied by an increase in the noise level to which modern civilization is subjected. It is, therefore, the responsibility of the building industry to reduce the amount of unwanted noises transmitted through the walls which form the environment in which we dwell.

There are two basic strategies which have been developed to obtain the quiet we seek. These are (1) the selection of walls and floors which prevent outside noise from entering the structure, and (2) the use of absorptive materials which absorb the sound instead of reflecting it back into the room. Sound absorption reduces the amount of noise generated within a room. Sound barriers, or sound isolation, reduce the amount of noise that may be transmitted from one area to another.

Masonry, along with it's proven capabilities of keeping fire from travelling from one room to another, is without equal as a sound barrier between enclosures. With attention to the surface finish of concrete masonry walls, the wall will absorb almost as much of the sound that strikes it as does acoustical tile- 40-50%. Furthermore, the heavy limp mass of the concrete wall provides excellent performance as noise insulation against transmitted sounds.

Numerous studies have proven the effectiveness of a single wythe of masonry alone to perform well as a sound barrier. New data shows that when these walls are sheathed with a finish material and insulation, masonry wall systems reach new levels in sound isolation.

Figure 1 Decibel levels

Decibels	Sound
140	Jet plane takeoff
130	Threshold of discomfort
120	Riveting
110	Thunder-sonic boom
100	Hard rock band
90	Power lawnmower
80	Pneumatic jackhammer
70	Noisy office
60	Average radio
50	Normal conversation
40	Quiet street
30	Quiet conversation
20	Whisper at 4 ft.
10	Normal breathing
3	Threshold of audibility

The Science of Sound

The two main elements of sound are frequency and pressure. Frequency is a measure of the number of vibrations or cycles per second (cps). One cycle per second is defined as a hertz (HZ). The measurement of pressure is in decibels (dB). For each 20 decibel increase in sound there is a corresponding tenfold increase in sound pressure. The human ear has a unique ability to reduce it's sensitivity as the pressure increases. Therefore, while a ten decibel increase in sound results in a threefold increase in pressure, the loudness sensation to the ear is only doubled(see Figure 1). Sounds are generated by vibrating objects. These vibrations are transmitted by contact with air, or other mediums, and are

Determining STC Ratings

carried forward in waves. The speed at which sound travels through a medium depends on the density, absorptive qualities, 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, and the sound will be re-generated on the opposite side. This is true for all solids, including walls and partitions. This transfer effect is particularly noticeable (and measurable) if the wall or partition is light or thin. Conversely, the vibration is effectively stopped if the partition is of heavy, rigid material. In dense solids the natural cycle of vibration will be relatively slow, and only sounds of low frequency will cause sympathetic vibration. An enclosure, such as a cavity wall, or a furred out wall, has it's own sound transmittance characteristics. The enclosure's resonance frequency becomes lower in proportion with the amount of air in that enclosure. Therefore, the greater the air space in a cavity wall, the less audible noise is transmitted.

The human ear can perceive sounds as low as 16 cycles per second to as high as 20,000 cycles per second. However, it is most sensitive to sounds between 500 and 5000 cycles. For human voices speaking in conversational tones, a frequency of approximately 500 cycles is assumed.

Because of it's mass and rigidity, a concrete masonry unit is especially effective in reducing the transmission of unwanted sound. Furthermore, when used in conjunction with furring / insulation / drywall, as it is commonly used, it becomes even more effective as a sound barrier. The cavity wall, which has been proven to excel in the categories of fire protection, insulation, and water protection, also shows extremely good performance in the isolation of sound.

Sound Transmission Class

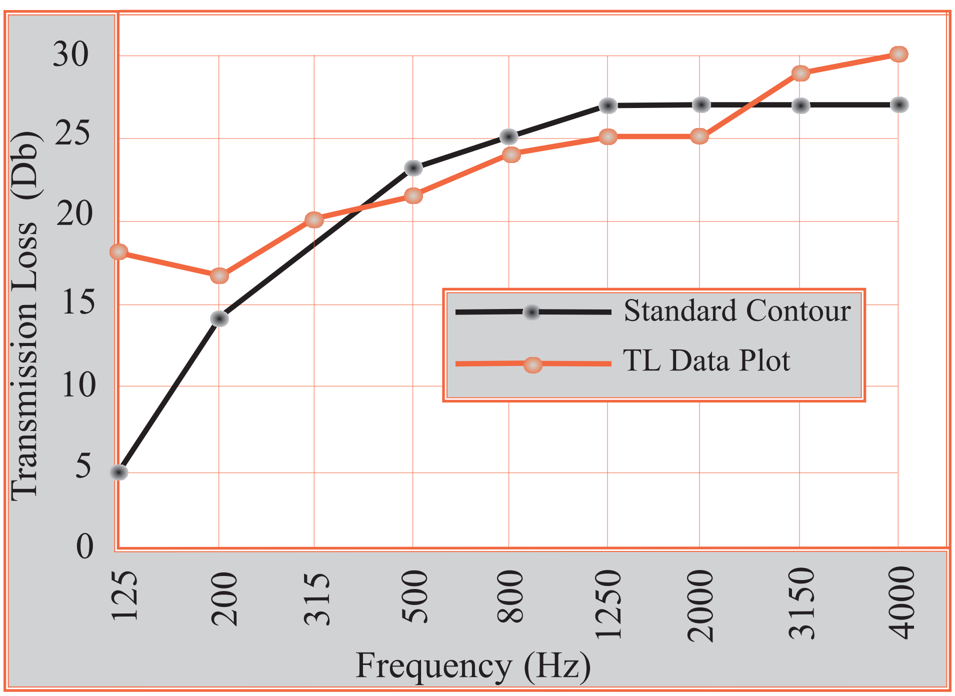
Sound transmission class(STC) is a single-figure rating derived in a prescribed manner from sound transmission loss values. The rating provides an estimate of the performance of the partition in common sound insulating situations.

To determine the effectiveness of a wall system as a means of sound isolation, a two room test is generally used. In this test a steady sound is generated on one side of the wall , and the sound that passes through is measured on the other side. The measurement of sound levels is then recorded at several different frequencies over a range of 125 to 400 Hz. The difference in sound levels (in dB) determines the transmission loss level. If an 80dB signal is recorded at 10dB on the other side of the wall, the transmission loss score is 70dB.

Arithmetic averages of sound transmission loss at selected frequency levels were widely used in the past to rate the effectiveness of walls. This averaging method was sometimes unreliable , however, because a good average could be ascribed to a wall type that performed poorly at an important frequency. For example a given wall could perform very well at low frequency levels, but could allow human voices to be transmitted through the wall unabated. Instead of using an averaging method, we now find STC ratings by comparing transmission loss curves to a set of standard curves as described below in Figure 2.

In compliance with ASTM E-90, the STC of a wall is determined by comparing its transmission loss curve with a set of standard curves, or contours. The standard curve is superimposed over a plot of the actual sound transmission loss curve, and shifted upward or downward relative to the test curve until some of the measured TL values of the test specimen fall below those of the STC contour and the following conditions are fulfilled.

Figure 2 SAMPLE STC PLOT



Designing for Sound

1. The sum of the deficiencies (deviations below the contour) shall not be greater than 32 dB, and
2. The maximum deficiency at a single test point shall not exceed 8 dB.

When the contour is adjusted to the highest value that meets the above criteria, the sound transmission class is taken to be the transmission loss value, measured in decibels (dB), corresponding to the intersection of the standard contour and the 500 cycle per second frequency line, obtaining a more accurate assessment than a raw average.

Building Code

The model building codes have provided minimum recommended allowable sound transmission limitations for partitions that separate adjacent units in multifamily dwellings and similar partitions that separate living space from public and private areas. These limitations are outlined in Figure 3. Generally, living units are considered to be areas of average noise while public spaces such as corridors, stairs, halls or service areas are considered to be areas of high noise levels.

Designing for optimum Performance

The performance of single wythe CMU walls has proven that the mass of concrete masonry results in high STC ratings. A recent study was conducted by the Institute for Research in Construction (I.R.C.) as part of a research study sponsored by the Ontario Concrete Block Association. This study found that when concrete blocks are used in conjunction with furring, insulation, and drywall, the masonry advantage becomes even clearer.

Wall mass has been proven to be inversely proportional to sound transmission through that mass. This new research shows that this is not the only factor that should be observed. When sound vibrates one side of a wall, the more massive the wall, the less vibration will be translated through the wall. When furring and drywall are introduced into the system, the sound waves vibrate through the mass of the block, then through the air in the cavity, and finally through the drywall into the listening area. An enclosure as such has a specific frequency at which sound energy is magnified, its resonance frequency. As the volume of air within the cavity, increases, the resonance frequency of that enclosure is lowered. This type of technology is used to optimize the performance of high fidelity audio speakers. As the air space in a cavity wall is increased, the STC rating will increase as well. This is known as the Mass-Air-Mass factor. Overall conclusions of this study are the following:

1. Concrete block wall systems can reach very high sound insulation values.
2. Measurements made to one octave below standard limits prove that block walls have good resistance at low frequencies.
3. Cavity walls (for interior use can achieve STC values up to 79).
4. A simple chart method for pre dicting transmission loss values for several block systems was validated.

The data contained in this brochure were obtained using the results of this study. They show the value of masonry wall systems as sound insulators.

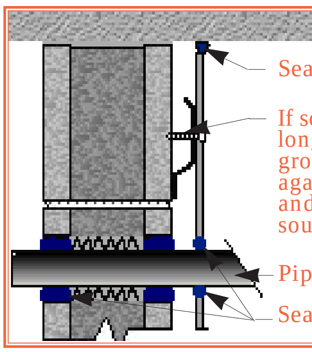
Other Considerations

Air is the basic medium for sound transmission. If air transmission is eliminated, then the passage of airborne sounds is also eliminated through the use of acoustic sealant. A 1/4” perimeter crack surrounding a 96 sq. ft. wall represents an approximate 1 sq. ft. hole. In terms of sound rating, this untreated perimeter space will substantially reduce the overall sound rating of a wall system. It is for this reason that any spaces or penetrations in a wall for pipes or construction tolerances should be sealed with caulk to prevent unwanted sound from travelling through these small openings in the wall system.

Figure 3 Code Requirements

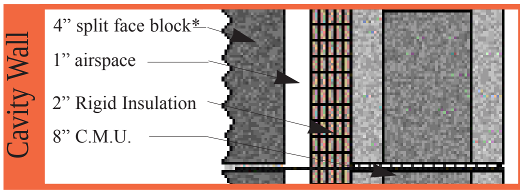
Location of Partition	STC required		
	UBC	BOCA	SBCC
Living unit to living unit (average noise)	50	45	45
Living unit to public space and service areas	50	45	45

Penetrations

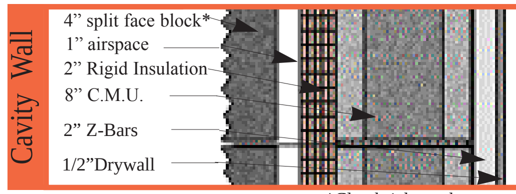


Sound Research Data

Cavity Walls (Exterior)



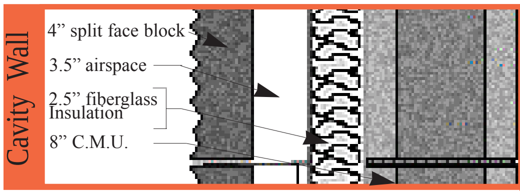
STC
62



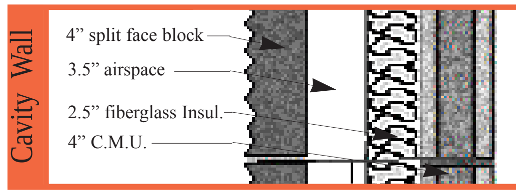
STC
66

*Clay brick can be expected to perform similarly

Cavity Walls (Interior use only)

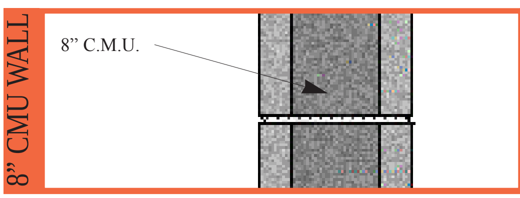


STC
79

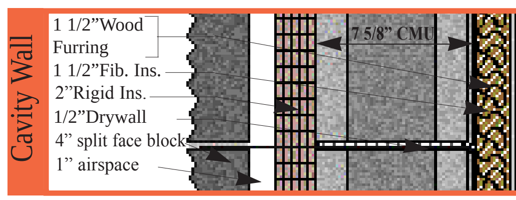


STC
77

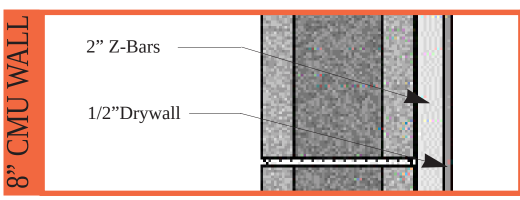
8” C.M.U. Wall Systems



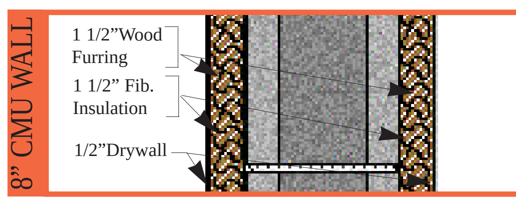
STC
50



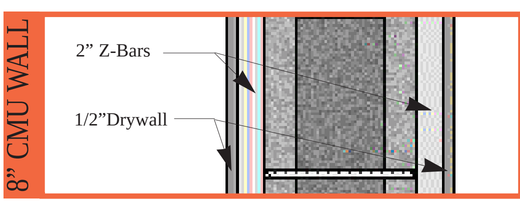
STC
65



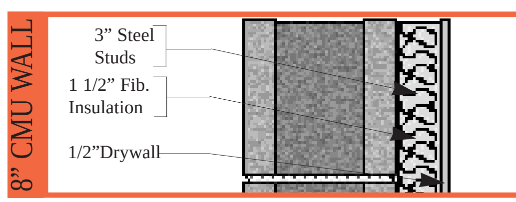
STC
51



STC
54



STC
52



STC
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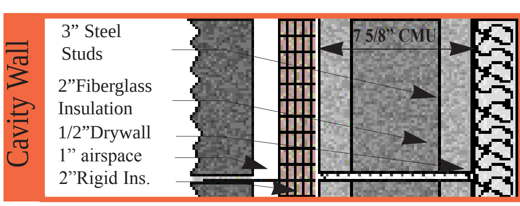
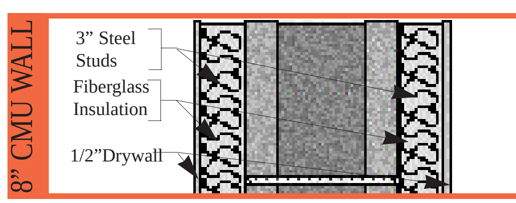
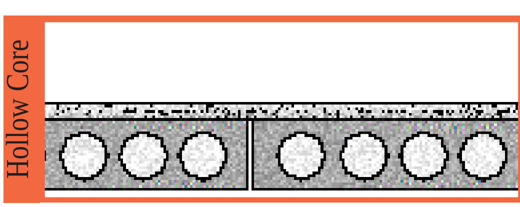


STC
72

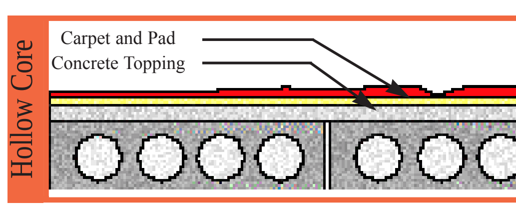


STC
64

8” Hollow Core Floor Systems



STC
53
IIC
28

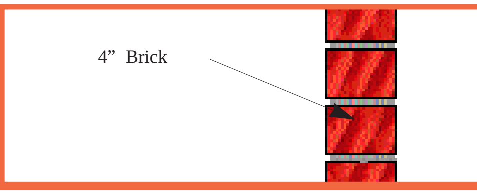


STC
53
IIC
78

Sound Research Data

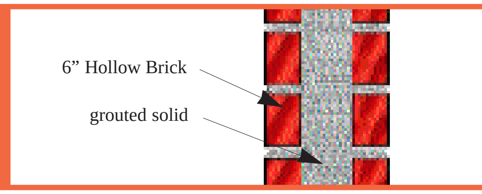
Clay Brick Wall Systems

4" Brick Wall



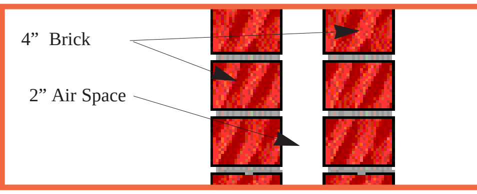
STC 45

6" Hollow Brick



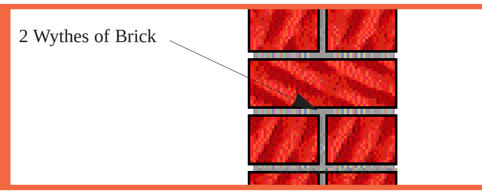
STC 51

10" Cavity Wall



STC 50

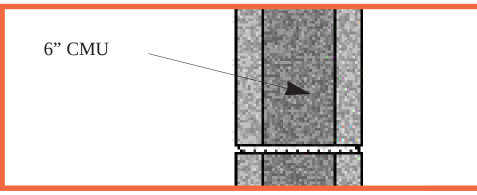
8" Brick Wall



STC 52

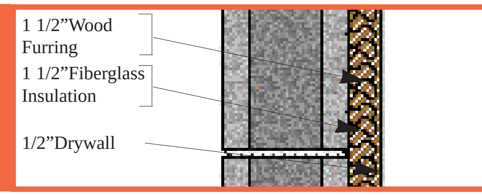
6" C.M.U. Wall Systems

6" CMU WALL



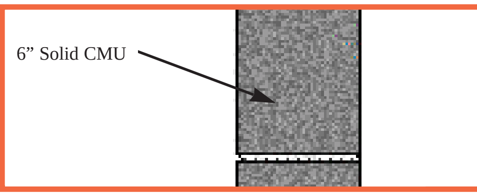
STC 45

6" CMU WALL



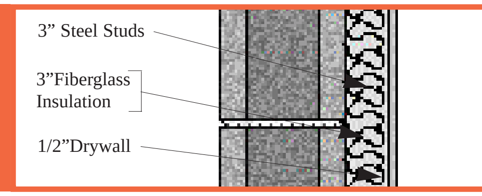
STC 55

6" CMU WALL



STC 50

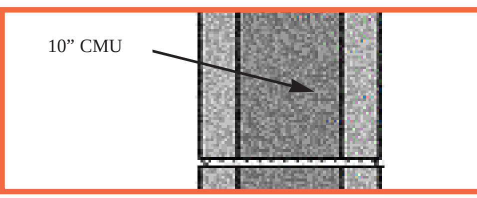
6" CMU WALL



STC 61

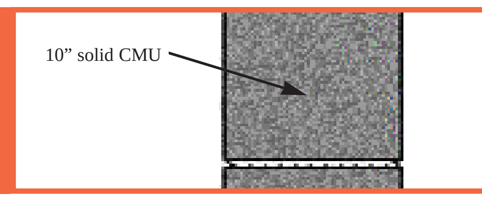
10" C.M.U. Wall Systems

10" CMU Wall



STC 47

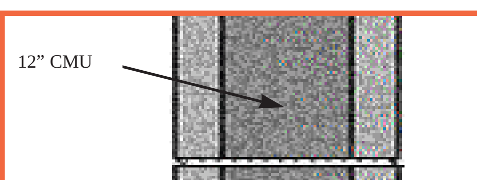
10" CMU Wall



STC 49

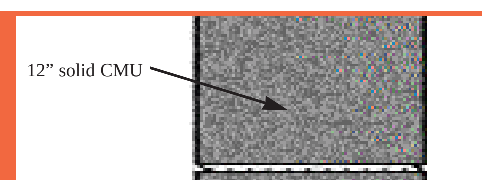
12" C.M.U. Wall Systems

12" CMU Wall



STC 51

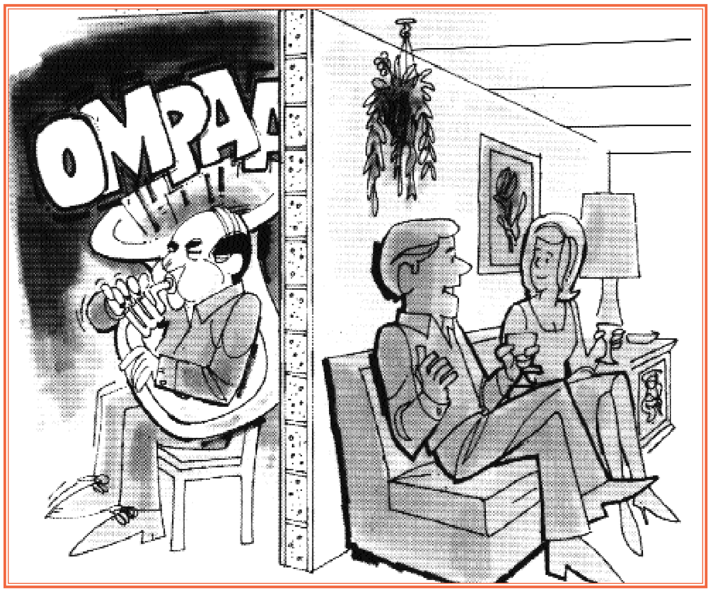
12" CMU Wall



STC 55

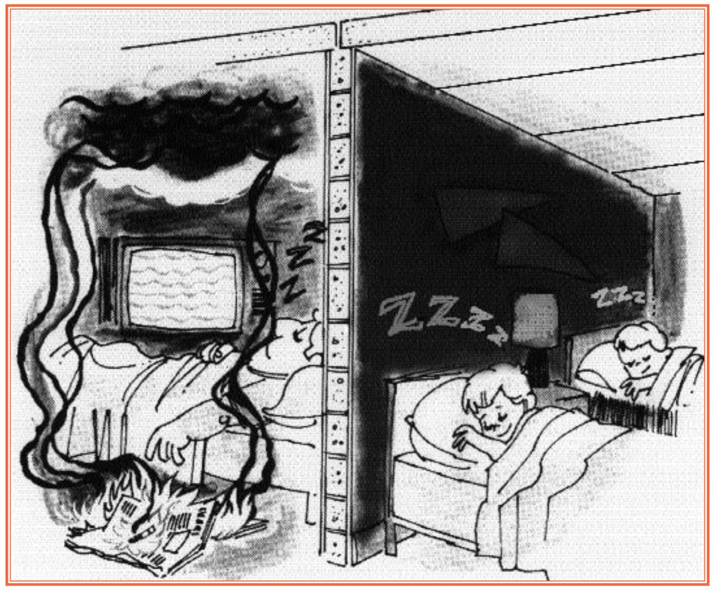
Sound Practice

Masonry Walls and Precast Hollow Core Floors make good neighbors



"Yes we chose it for the quiet Masonry and Hollow core construction, you know"

If your neighbor fell asleep while smoking...



"Protect their dreams with Masonry and Precast Hollow core construction."

"From our experience, soundproofing is just about the most important factor for tenant satisfaction. That's why we like precast hollow core decks. Also, the lack of shrinkage of floor joists, multiplied in a three story building, helps avoid settlement, cracking of walls and doors sticking."

Ernest Peterson

"For wall bearing construction, the added soundproofing effects in the use of precast hollow core help add to the rental ability of the project"

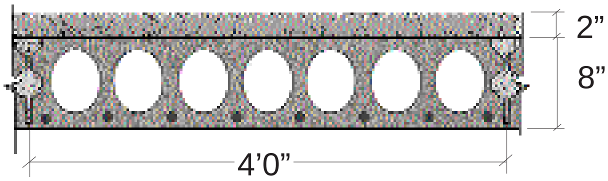
Leo Del Zotto

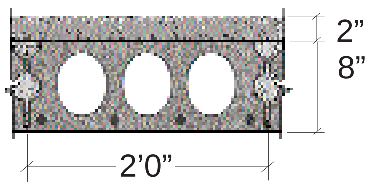
"The hollow core method is very soundproof, easy to work with, firesafe and is not overly expensive. And our renters' fire insurance is low. It's another selling point for our apartments.

John R. Wright

Precast Hollow Core Floors

Precast Hollow Core Systems



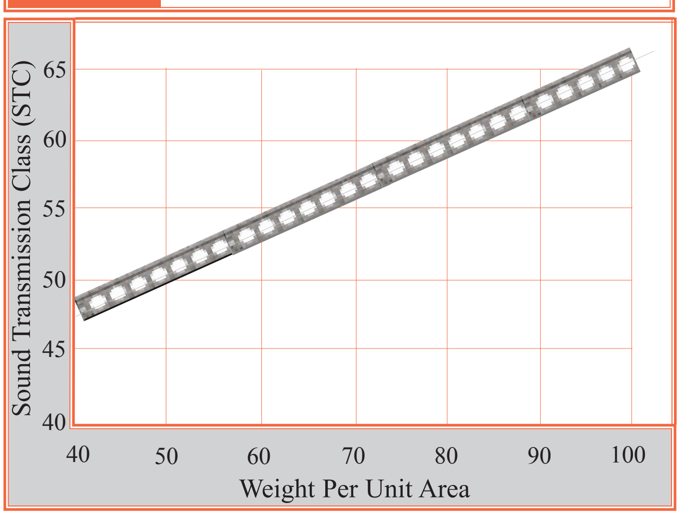


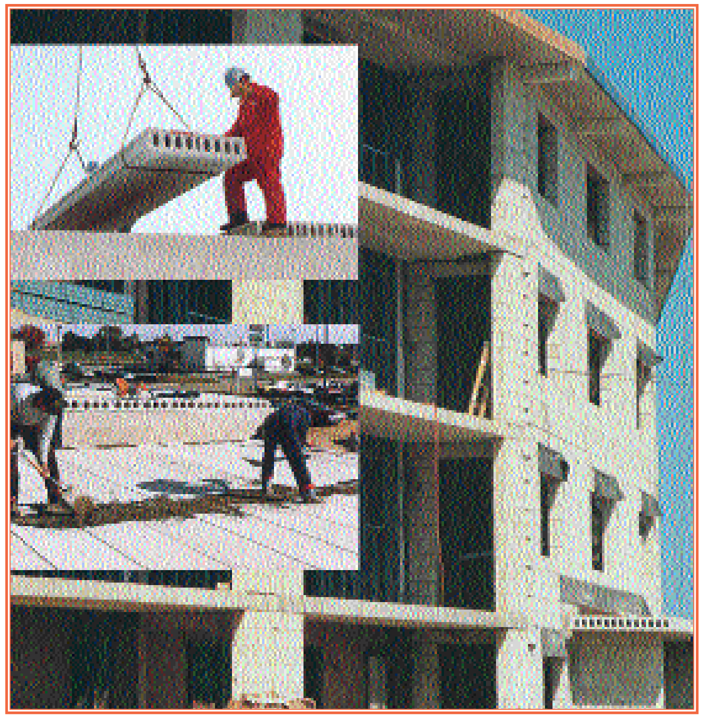
A complete study of sound control within the built environment would be incomplete if it did not extend it’s scope from walls to floors and ceilings. The chain is only as good as it’s weakest link, therefore the acoustic characteristics of all aspects of a given design must be observed. With the use of Hollow Core slabs, the acoustic characteristics of floors and ceilings can be as good or better than the walls, insuring a sound design.

Sound Transmission

Airborne sound reaches the floor, vibrates it, and is radiated through the floor material. Airborne sound transmission loss is most greatly affected by the weight of the material. The relationship of S.T.C. value and floor weight is clearly shown below in Figure 4. For this reason,a hollow core, precast concrete floor systems does not require any additional treatments in order to provide good sound insulation.

Figure 4 STC As a Function of Floor Weight





Impact noise reduction

Footsteps, slammed doors, and mechanical equipment can all cause their own brand of unwanted noise. Even when airborne sounds are controlled, there still can be severe impact noise problems. Impact sound insulation is tested per ASTM E492, *Laboratory Measurement of impact sound transmission using a tapping machine.* Impact transmission is not significantly affected by the weight of the floor. To control impact sounds, a structural concrete floor in combination with a carpet & pad greatly reduces the amount of impact noise (measured as IIC). Figure 5 below shows the sound control potential of the hollow core slab used in conjunction with a carpet and pad system.

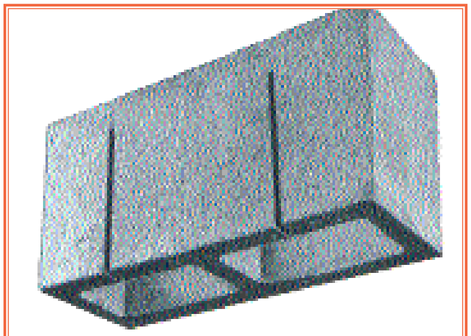
Figure 5 8” Hollow Core STC & IIC

Materials	STC	IIC
8” Hollow Core	50	28
2” Topping	3	0
Carpet & Pad	0	50
Totals	**53**	**78**

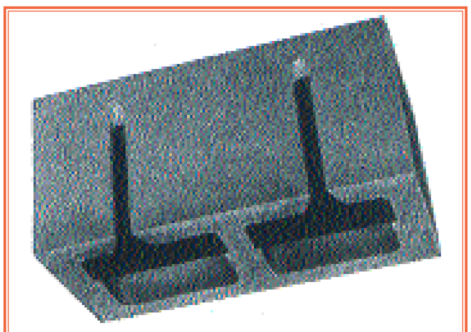
Killing Three Birds With One System

Acoustic Blocks

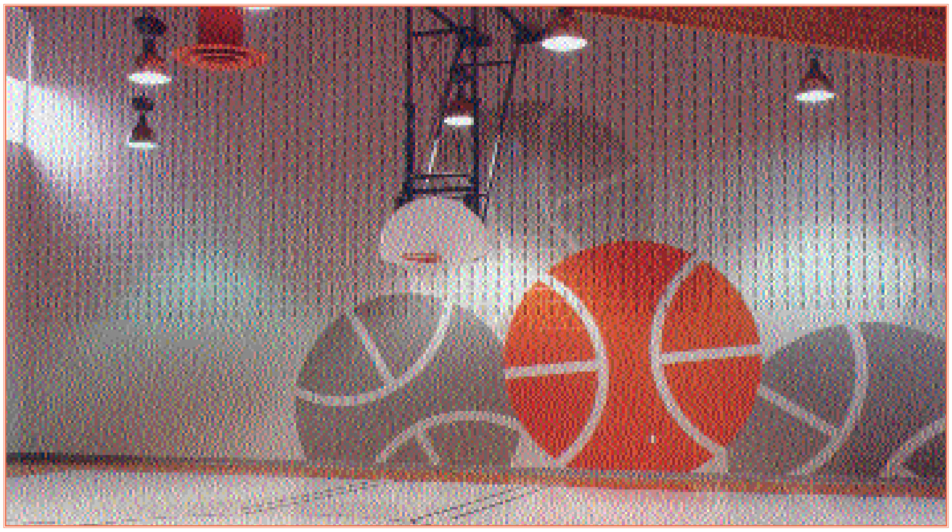
Diffuser Block



Sound Block(slotted)



Sound block with acoustic filler



We have already shown the capacity of common everyday masonry wall systems to serve as noise isolators. For more serious applications such as sound studios, theatres, and other buildings where acoustics are paramount, masonry offers several specialized products.

Sound blocks have been widely used for lecture halls, swimming pool enclosures, and theatres. These concrete masonry units have one vertical slot per core. These vents create a Helmholtz resonator affect. The Helmholtz resonator is used to deaden sound in internal combustion engine mufflers.

The newest evolution of acoustic block is the Diffuser Block by RPG Diffuser Systems as seen above. This system is composed of three distinct units. These three units interlock together to form a wall. The result is a combination of the Helmholtz resonator principle for absorption, and excellent sound diffusion back into the room. This product also provides space to place horizontal joint reinforcement, and offer cores which can be filled with grout, or insulation. These blocks are ideal for professional applications where sound diffusion and absorption are critical. Both types of acoustic blocks boast STC ratings above and beyond the 52 mark.

Conclusion

As the challenge to provide quieter buildings increases, the masonry industry has risen to meet the challenge. Masonry has been proven to be without equal in fire safety, appearance, longevity, and economy. As we have presented in this digest, masonry with hollow core precast concrete floors is an excellent choice for acoustic considerations. With Masonry and hollow core floors, solving problems of fire safety, economy, and noise control, a good designer can kill three birds with one system.

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3. *Sound Transmission Class Ratings for Concrete Masonry Walls,* NCMA-TEK 13-1. National Concrete Masonry Association 1990.
4. *Sound Transmission Loss Measurements on 190 and 140mm Single Wythe Concrete Block Walls and on 90mm Cavity Block Walls* (Client Report for Ontario Concrete Block Association). National Research Council Canada, 1989.
5. PCI Design Manual for the Design of Precast Hollow Core Slabs. Chapters 6 & 7, Copyright©1985 Prestressed Concrete Institute.

Multifamily Construction Advisory Commitee of Illinois

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