SOUND TRANSMISSION PROPERTIES

LIGHTWEIGHT CONCRETE

INFORMATION SHEET No. 8

EXPANDED SHALE CLAY AND SLATE INSTITUTE - SALT LAKE CITY, UTAH 84117

SOUND TRANSMISSION PROPERTIES

The control of sound in rooms of buildings may be classified with respect to the origin of the sound- namely: sounds originating within the room and sounds originating outside the room. Efficient and economical control of sound is dependent not only upon its origin, but also upon the design of the enclosure and type of occupancy.

For reduction of sound originating within a room, the sound absorption qualities of the walls, ceiling and flooring as well as furnishings are important. The type and use of the room affords the architect latitude in the selection of sound absorption materials for elements of the room, see Information Sheet #9. Enclosures with high ceilings and large expanse of wall areas, as in gymnasiums and churches, might utilize sound absorbing textured masonry walls as an economical solution. On the other hand, for enclosures with relatively low ceilings. and rather small exposed wall areas, as in offices and schoolrooms, the use of acoustical ceilings, floor coverings, and interior furnishings might be the more effective solution.

This information sheet is concerned primarily with the reduction of sound through concrete and concrete masonry partitions from sources outside of rooms. These sounds are transmitted as solid–borne, as well as air-borne noise. For example, a bare concrete floor transmits the sound of footsteps between rooms, the sound traveling through the rigid concrete slab. Solid-borne sound should be suppressed at the source. A concrete floor for example. should be covered with some type of resilient material. depending upon the extent of solid-borne sound transmission which should be suppressed.

Air-borne sound may be effectively reduced by barriers such as concrete masonry partitions. Obviously. attention should be given to doors and their closures. as well as connections of the walls at the ceilings and floors. Too often the effectiveness of a concrete masonry partition which should provide satisfactory acoustical isolation is unnecessarily lost. This may occur by failure to take into account the other important factors that are involved. such as continuing the partition to the structural ceiling. Also, cutting of continuous holes through the wall for ducts, electrical outlets, should be avoided.

SOUND ENERGY

Sound energy is measured in decibels. The decibel is a convenient unit because it is approximately the smallest change in energy that the ear can detect.

The following table of sound intensities will aid in an understanding of decibel values.TABLE I

TRANSMISSION

Sound is transmitted through most walls and floors by setting the entire structure into vibration. This vibration generates new sound waves of reduced intensity on the other side. The passage of sound into one room of a building from a source located in another room or outside the building is termed ''sound transmission"

TRANSMISSION LOSS

Transmission loss is a measure of the effectiveness of a wall, floor, door or other barrier in restricting the passage of sound. The transmission loss varies with frequency, and the loss is usually greater with higher frequencies. Sound transmission loss measurements are conducted in accordance with American Society for Testing and Materials (ASTM) designation E-90. A concrete or concrete masonry wall eleven (11) feet (3.35 m) wide and nine (9) feet (2.74 m) high mounted on a movable base is rolled between two isolated reverberation rooms. Measurements are made at 16 frequencies in 1/3 octave bands from 125 to 4000 cycles per second (cps) (generally called Hertz. Hz). The unit of measure of sound transmission loss is the decibel (dB). The higher the transmission loss of a wall the better it functions as a barrier to the passage of unwanted noise.

Table 1

Sound Levels and Human Response

This decibel (dB) table compares some common sounds and shows how they rank in potential harm to hearing.

COMMON SOUNDS	NOISE LEVELS (dB)	EFFECT
Jet engine (near)	140	
Shotgun firing Jet takeoff (100-200 ft.)	130	Threshold of pain
Thunderclap (near) Discotheque	120	Threshold of sensation
Power saw Pneumatic drill Rock music band	110	Regular exposure of more than 1 min. risks permanent hearing loss
Garbage truck	100	No more than 15 min. unprotected exposure recommended.
Subway Motorcycle Lawnmower	90	Very annoying
Electric razor Many industrial workplaces	85	Level at which hearing damage begins (8 hours)
Average city traffic noise Garbage disposal	80	Annoying. Interferes with conversation
Vacuum cleaner Hair dryer Inside a car	70	Intrusive. Interferes with telephone conversation
Normal Conversation	60	
Quiet office Air conditioner	50	Comfortable
Whisper	30	Very quiet
Normal breathing	10	Just audible
	0	Threshold of normal hearing (1000-4000 Hertz)

SOUND TRANSMISSION CLASS (STC)

Sound Transmission Class (STC) is a single number rating determined in a prescribed manner from sound transmission loss values, This rating is arrived at by comparing the measured transmission losses at the 16 test bands with those of a reference contour having the form illustrated in Figure 1. The sum of the deficiencies below the contour shall not be greater than 32 decibels (dB) and the maximum deficiency at a single test point shall not exceed 8 decibels (dB). When the contour is at the highest value that meets the above requirements, the Sound Transmission Class for the specimen is the transmission loss (TL) corresponding to the intersection of the counter and the 500 Hz ordinate. Sound Transmission Class ratings are established in accordance with ASTM designation E-413, ''Standard Classification for Determination of Sound Transmission Class .' '

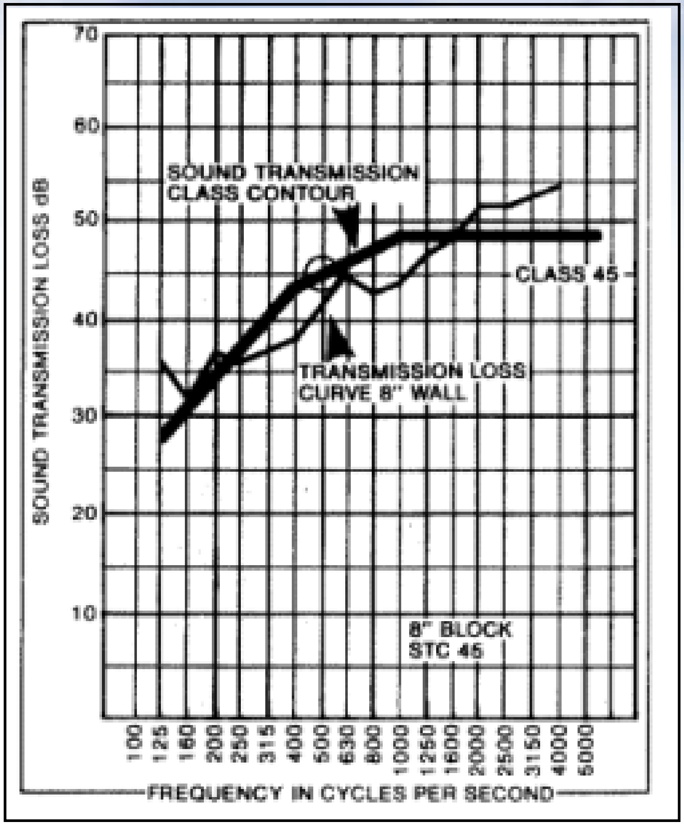

Figure 1

This rating provides an estimate of the performance of a partition in sound insulation. The STC numbers are used to specify the minimum noise insulation needed in a building. For example, the minimum STC values acceptable for Multi-family housing by the Department of Housing and Urban Development (HUD) are shown in Table 2 below.

TABLE 2

HUD SOUND TRANSMISSION REQUIREMENTS FOR WALLS IN MULTIFAMILY HOUSING

LOCATION OF PARTITION	STC
Living unit to living unit, corridor(1) or public space, average noise(2)	45
Living unit to public space and service areas, high noise(3)(4)	50

Notes:

1. These values assume floors in corridor are carpeted: otherwise increase STC by 5.
2. Public space of average noise includes lobbies, storage rooms, stairways, etc.
3. Areas of nigh noise include boiler rooms, mechanical equipment rooms, elevator shafts, laundries, incinerator shafts, garages, and most commercial uses.
4. Increase STC by 5 when over or under mechanical equipment which operates at high noise levels.

Many walls constructed with lightweight concrete masonry units produced with expanded shale, clay or slate by the rotary kiln method have been tested. Tests of these various walls are listed in Table 3.

The results shown in this table indicate that concrete and concrete masonry produced with expanded shale clay and slate aggregates meet existing standards.

TABLE 3

SOUND TRANSMISSION CLASS (STC) for LIGHTWEIGHT CONCRETE MASONRY WALLS

MASONRY WALL THICKNESS	4 inch	6 inch	8 inch	12 inch
Plain	40	44	45	
Painted	41	45	46	50
Wall Board	47	49	56	
Plastered	50	50	51	
Cores Filled with insulation	—	—	51	
COMPOSITES*—Cavity*—Grouted 8"				
4" Block plus 4" Concrete Brick		—plain	51	
		—1/2" plastered on block surface	53	
		—1/2" gyp. on block face	56	
10" CAVITY				
4" Block—2" Cavity—4&#quot;				
Concrete Brick		—plain	54	
		—1/2" plastered on Block	57	
		— 1/2" gyp. on block	59	
8" GROUTED BLOCK		—All cells grouted	48	
		—1/2" plaster both sides	56	
		—1/2" gyp. both sides	60	

IMPACT SOUND

The increased noisiness of our environment has led to increased interest in sound isolation from impact noise. Impact noise is caused by such things as footsteps, dropped toys and some appliances. Isolation against impact noise provided by a given floor construction is measured in accordance with ASTM E492 "Laboratory Measurement of Impact Sound Transmission Through Floor-Ceiling Assemblies Using The Tapping Machine." This procedure utilizes a standard tapping machine that is placed in operation on a test floor specimen which forms a horizontal separation between two rooms, one directly above the other. The transmitted impact sound is measured in 1/3 octave bands over a frequency range of 100 to 3150 Hz in the receiving room below. From the data collected a single figure rating, called Impact Insulation Class (IIC) is derived in a prescribed manner from the values of the impact sound pressure levels measured in the receiving room. The rating provides an estimate of the impact sound insulating performance of a floorceiling assembly. Details of the procedures are outlined in ASTM E492.

The Expanded Shale Clay & Slate Institute sponsored a test program at Riverbank Laboratories, Geneva, Illinois, to determine the effect of the concrete weight and Modulus of Elasticity on impact sound transmission. Slab thicknesses of 5 inches and 10 inches were selected for study. Three concretes designed to weight approximately 95. 115, and 150 pounds per cubic foot were used, so the weight per square foot of floor would cover a broad range. The slabs were designed for 3000 psi (210 Kgsg. cm.) concrete and included reinforcement in keeping with flat plate design.

The Impact Noise Reduction (INR) factors determined from the Riverbank Laboratory tests have been converted to the current designation, Impact Insulation Class (IIC). and are shown in Table #4.

Comparison of the test data with the current HUD requirements indicated that concrete floors of any weight require additional surface treatment to bring the IIC rating to acceptable levels. (see Table 5)

TABLE #4 Impact Insulation Class (IIC)

Slab Thickness	5 inch			10 inch		
Slab Wt lbs/cu.ft.	95	115	150	95	115	150
IIC Bare Floor	23	24	24	23	30	31
IIC Std. Carpet		68			74	
IIC Vinyl Tile					33	
Estimated from NRC (National Research Council) report						
1/8 inch Vinyl asbestos on 1/2 inch plywood on furring						
		48	48	52	53	
Viscose Carpet with 1/8 inch loop pile, coated back	57	58		62	64	

Impact Insulation Class (IIC) values that are
acceptable for multifamily housing under HUD are listed in Table #5 below.

TABLE #5 HUD Sound Transmission Limitations for Floors in Multi–Family Housing

LOCATION OF FLOOR—CEILING	STC	IIC
Floor-ceiling separating living units from other living units, public space (1) or service areas (2)	45	45
Floor-ceiling separating living units from public space and service areas (high noise) (3) including corridor floors over living units	50	50

Note: (1) Does not apply to door above storage rooms where noise from living units would not be objectionable.
(2) Public space of average noise includes lobbies, storage rooms, stairways, etc.
(3) Areas or high noise include boiler rooms, mechanical equipment rooms, elevator shafts, laundries, incinerator shafts, garages and most commercial uses.

CONCLUSION

Expanded Shale Clay & Slate aggregate concrete and concrete masonry meets the commonly accepted specification for air borne noise reduction. This quality combined with its demonstrated durability, fire resistance, thermal insulation properties and aesthetics quality make it an extremely desirable and practical building material.

REFERENCES

Expanded Shale Clay & Slate Institute.

1. Lightweight Concrete Information Sheet No. 9. "Sound Absorption of Concrete Masonry Walls."

National Concrete Masonry Association.

1. TEK Sheet #9. "Estimating Sound Transmission Class of Concrete Masonry."
2. TEK Sheet $#18. "Noise Control with Concrete Masonry in MultiFamily Housing."
3. TEK Sheet #69. "Noise Insulation with Concrete Masonry."
4. TEK Sheet #69.A, "New Data on Sound Reduction with Concrete Masonry Walls.''

Building Materials and Structures Report 144. National Bureau of Standards.

''Insulating Concretes". by R.C. Valore, Jr.. ACI Journal November. 1956.

''Impact Sound Transmission Tests On A Concrete Slab Floor with Various Surface Constructions" by D. Olynyk. Division of Building Research. National Research Council. Ottawa. Canada. July. 1967.

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Sound Absorption

Three terms are introduced to define and evaluate sound absorption. These are the Sound Absorption Coefficient, Sabin, and Noise Reduction Coefficient. The Sound Absorption Coefficient is a measure of the proportion of the sound striking a surface which is absorbed by that surface, and is usually given for a particular frequency. Thus, a surface which would absorb 100% of the incident sound would have a Sound Absorption Coefficient of 1.00, while a surface which absorbs 45% of the sound, and reflects 55% of it, would have a Sound Absorption Coefficient of 0.45. A Sabin or square-foot Unit of Absorption is defined as the amount of sound absorbed by one square foot of surface having a Sound Absorption Coefficient of 1.00. The number of Sabins (Absorption Units) of a given area is then the product of the area and the Sound Absorption Coefficient. 100 sq. ft. of a surface with a Sound Absorption Coefficient of 0.25 furnishes 25 Sabins (Absorption Units). Most materials are tested at frequencies from 125 to 4000 cycles per second (cps) in octave steps. The Noise Reduction Coefficient is the average of the Sound Absorption Coefficient at 250,000, 1000 and 2000 cps in octave steps. The Table lists approximate values of the Noise Reduction Coefficients of numerous materials.

Noise Reduction Coefficients

Material	Approx. N.R.C.	
Expanded Shale Block, Medium Texture, unpainted	0.45	Add 10% for Coarse Texture, Deduct 10% for Fine Texture
Heavy Aggregate Block, Medium Texture, unpainted	0.27	Add 5% for Coarse Texture, Deduct 5% for Fine Texture

DEDUCTIONS FROM ABOVE FOR PAINTED BLOCK				
PAINT TYPE	APPLICATION	ONE COAT	TWO COATS	THREE COATS
Any	Spray	10%	20%	70%
Oil Base	Brushed	20	55	75
Latex or Resin Base	Brushed	30	55	90
Cement Base	Brushed	60	90	—
Material		N.R.C.		
Brick Wall—unpainted		.05		
—painted		.02		
Floors				
Concrete or terrazzo		.02		
Wood		.03		
Linoleum, asphalt, rubber or cork tile on concrete		.03 - .08		
Glass		.02		
Marble or glazed tile		.01		
Plaster, gypsum or lime, smooth finish on tile or brick		.04		
Same, on lath		.04		
Plaster, gypsum or lime, rough finish on lath		.05		
Plaster, acoustical		.21		
Wood paneling		.06		
Acoustical ceiling tile		.55 - .85		
Carpet, heavy, on concrete		.45		
Carpet, heavy, hairfelt underlay		.70		
Fabrics				
Light, 10 oz. per sq. yd. hung straight		.20		
Medium, 14 oz. per sq. yd. draped to half area		.57		
Heavy, 18 oz. per sq. yd. draped to half area		.63		
Audience, seated, depending on character of seats, spacing, etc			3.0-6.0	
Chairs, metal or wood		.20		
Wood pews		.40		
Same with cushions		2.00		
Theatre and auditorium chairs				
Wood veneer seat and back		.50		
Upholstered in leatherette		2.10		
Heavily upholstered in plush or mohair		3.0-3.5		
Openings				
Stage, depending on furnishings		.25-.75		
Deep balcony, upholstered seats		.50-1.00		
Grills, ventilating		.15-.50		

Sound Transmission

The architect in considering the reduction of sound through walls separating rooms of schools, hotels, or office buildings for example, is concerned with reducing a sound intensity of say, 55 decibels to something on the order of 15 decibels or less. He is able to select these values by referring to the Table. Referring to the chart and the curve representing an expanded shale masonry unit with an 8" x 16" face, it is found that a unit weighing 95 Ibs. air dried, will offer a transmission loss of approximately 42 decibels (if properly sealed). The average 4-8-16 expanded shale masonry unit weighs approximately 15 Ibs. air dried, therefore a partition wall made of these units can be expected to reduce the sound transmission satisfactorily for the assumed situation, provided of course, the surfaces of the wall are sealed sufficiently to prevent the direct passage of sound through the voids.

Masonry vs. Steel Stud

Because the sound-diminishing qualities of concrete masonry 'keep the noise outside', structures utilizing the masonry backup system enjoy a quieter internal environment. In contrast, the dry wall component of the steel stud system frequently contains acoustical holes. This negative factor is substantially magnified when we consider the fact that the steel stud system, itself, is inherently noisy. The mass and monolithic properties of concrete masonry make the system far superior in its ability to reduce sound transmission.