Sheet Steel Facts 16

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Acoustic Properties of Perforated Steel Deck

Introduction

Steel deck is generally a structural product designed to resist gravity loads. However, from the time it was first commercially introduced, there have been successful attempts to utilize deck to perform more than one function. Acoustic roof deck is one example of using the decking material to perform multiple functions with very little increased cost. The acoustic deck provides a finished ceiling with noise reduction capabilities while still providing the required vertical and horizontal load resistance.

The noise reduction is achieved by the perforations and the acoustical insulation or material shown in Figure 1. The sound penetrates the deck through the perforations and is absorbed by the insulation. The perforations in the deck do cause a small reduction in strength and stiffness. The reduction varies from 5 to 10%. You should consult your deck supplier for the exact capacity.

Noise Reduction

Table 1 shows the sound absorption data at various frequencies for typical acoustic roof deck. This data is obtained by conducting the ASTM C423 test, with mounting conforming to ASTM E795, at the National Research Council of Canada. The sound absorption coefficients represent the percentage of noise that the tested surface converts to other energy forms which does not reflect as sound. The usual tested frequencies range from 80 to 6300 Hz. The Noise Reduction Coefficient (NRC) is the average of the 250, 500, 1000 and 2000 Hz coefficients rounded to the nearest 0.05. Because of the measurement methods, the sound absorption coefficient for a particular frequency can be greater than 1; but, for any specific use at that frequency the value should be taken as 1.

The sound absorption at any particular frequency and the NRC is a function of the total construction. Higher NRC values can be obtained by using fiberglass insulation board for the insulation material on top of the deck system in lieu of the commonly used foam board insulation. Consult individual CSSBI member companies for their recommendations and be aware that insulation board selected for its thermal characteristics will not have the same NRC as fiberglass board. Substitution of specified roofing components will affect acoustical performance.

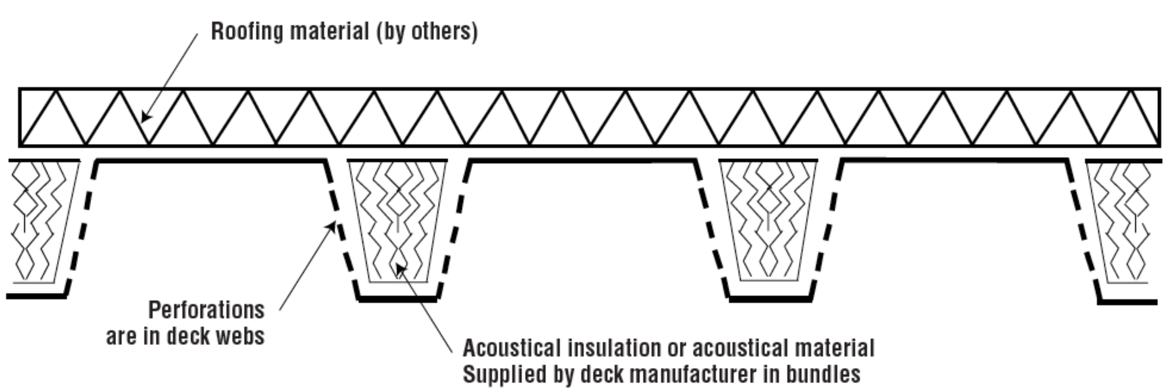

Figure 1: 1-1/2” and 3” acoustic roof deck

Table 1: Measured Sound Absorption Coefficients for Acoustic Deck					
	FREQUENCY (HERTZ)				
	250	500	1000	2000	NRC
1-1/2” Deck (6” flute spacing, 1.1 lb/ft³ glass fibre)	0.25	0.75	1.08	0.55	0.65
1-1/2” Deck (6” flute spacing, 0.75 lb/ft³ glass fibre)	0.30	0.76	1.05	0.57	0.65
3” Deck (6” flute spacing, 1.1 lb/ft³ glass fibre)	0.52	0.97	1.00	0.51	0.75
3” Deck (8” flute spacing, 1.1 lb/ft³ glass fibre)	0.44	0.91	0.95	0.56	0.70

Listed in Table 2 are the Noise Reduction Coefficients (NRC) values for various interior surfaces and materials. Complete tables of coefficients of the various materials that normally constitute the interior finish a building may be found in the reference books on architectural acoustics.

Table 2: Noise Reduction Coefficients							
MATERIALS	FREQUENCY (HERTZ)						NRC
	125	250	500	1000	2000	4000	
Brick	0.03	0.03	0.03	0.04	0.05	0.07	0.05
Carpet on heavy concrete	0.02	0.06	0.14	0.37	0.60	0.65	0.30
Carpet with heavy pad	0.8	0.24	0.57	0.69	0.71	0.73	0.55
Carpet with impermeable backing	0.8	0.27	0.39	0.34	0.48	0.63	0.35
Concrete block - course	0.36	0.44	0.31	0.29	0.39	0.25	0.35
Concrete block - painted	0.10	0.05	0.06	0.07	0.09	0.08	0.05
Light fabric	0.03	0.04	0.11	0.17	0.24	0.35	0.15
Medium fabric	0.07	0.31	0.49	0.75	0.70	0.60	0.55
Heavy fabric	0.14	0.35	0.55	0.72	0.70	0.65	0.60
Concrete, terrazzo, marble or glazed tile	0.01	0.01	0.015	0.02	0.02	0.02	0.00
Wood	0.15	0.11	0.10	0.07	0.06	0.07	0.10
Heavy glass	0.18	0.06	0.04	0.03	0.02	0.02	0.05
Ordinary glass	0.35	0.25	0.18	0.12	0.07	0.04	0.15
Gypsum board 1/2”	0.29	0.10	0.05	0.04	0.07	0.09	0.05
Plaster	0.013	0.015	0.02	0.03	0.04	0.05	0.05
Water Surface	0.008	0.008	0.013	0.015	0.020	0.025	0.00
Steel plate - flat							0.05
Steel plate - corrugated*							0.15
Typical Acoustical Steel Roof Deck							0.70

* May be used for Non-Acoustical Deck

It is interesting to note that suspended acoustical ceilings normally have an NRC of 0.50 to 0.75 - a common base design value is 0.60 - and the NRC of acoustical roof deck is in the 0.70 range. The excellent performance of the steel deck is often a surprise to many designers.

In various working environments a worker's exposure to sound may be limited to the times shown in Table 3. This table illustrates the importance of acoustical treatment. A one decibel drop in the noise level allows about 13% more exposure time. (A one decibel difference is about the smallest change discernible by the human ear.) It is not difficult to estimate the dollar savings and also appreciate the improved comfort of the working environment provided by improved acoustics. With the use of acoustic deck, productivity is also improved because speech intelligibility is enhanced. This results in employees being able to hear clearly and understand instructions. Table 4 shows levels that commonly exist and may or may not be acceptable. Regulations may change over the years and specific maximum exposure for a given activity should be verified with the regulatory body having jurisdiction.

Table 3: Time limits for exposure to steady noise level

	Maximum sustained sound intensity (dB(A))		
Duration (H)	British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland	Federal jurisdiction, Companies	Quebec
8	85	87	90
4	88	90	95
2	91	93	100
1	94	96	105
0.50	97	99	110
0.25	100	102	115

Summary of Canadian regulations.

Table 4: Decibel reading for various sounds

SOUND SOURCE	dB
Threshold of Feeling	120
Thunder	115
Noisy Factory	110
Subway	100
Loud Street Noise	90
Noisy Office	80
Average Street Noise	70
Average Conversation	50
Quiet Conversation	20
Whisper	15
Soundproof Room	10
Threshold of Hearing	5

The total absorption of an area (room) is obtained by multiplying the noise reduction coefficient (NRC) by the surface area: the result is expressed in Sabins. A Sabin is defined as the sound absorption of one square foot of surface area with an absorption coefficient of 1.00.

$A = C_1S_1 + C_2S_2$ ...etc.

Where A is the total absorption in Sabins; C_1, C_2, etc. are the NRC values and S_1, S_2, etc. are the corresponding square foot surface areas. The reduction, R, in decibels is then found by;

$R - 10 \log_{10} (A_a / A_b)$

Where A_a is the sound absorption after acoustical treatment, and A_b is the sound absorption before. A_a and A_b are in Sabins or metric Sabins.

Example Problem

An owner wants to duplicate an existing manufacturing plant but would like to improve the acoustics in the new building.
The existing plant has a noise level of 94 decibels (dB) and the construction is:

SIZE: 100' x 200' x 20' (high)		{30 m x 60 m x 6 m (high)}
WALLS: painted concrete block NRC	= 0.05	
CEILING: precast plank NRC	= 0.05	
FLOOR: concrete slab NRC	= 0	
PEOPLES: 20 (4.5 Sabins per person)		{20 (0.4 metric Sabins per person}

The total Sabins for the existing construction is:

WALLS: 12,000 sq. ft. x 0.05	= 600	{1 080 sq. m x 0.05 = 54}
CEILING 20,000 sq. ft. x 0.05	= 1,000	{1 800 sq. m x 0.05 = 90}
FLOOR: 20,000 sq. ft. x 0.00	= 0	{1 800 sq. m x 0 = 0}
PEOPLES: 20 x 4.5 Sabins per person	= 90	{20 person x 0.4 = 8}
TOTAL	= 1,690 Sabins	= 152 metric Sabins

Instead of precast planks, use acoustic roof deck with an NRC of 0.70. The total Sabins would then become (1,690 - 1,000) + (20,000 x 0.70) = 14,690 Sabins.
{ (152 - 90) + (1 800 x 0.70) = 1,322 metric Sabins}.
The sound level reduction would be: $R = 10 \log_{10} (14,690 / 1,690) = 9.39$ dB: use 9,4.
The sound level for the proposed construction is then 94 - 9.4 = 84.6 dB.
By replacing the precast plank ceiling construction by acoustical steel deck ceiling construction, the sound absorption of the ceiling surface would decrease the sound level in the workplace and allow longer exposure to the ambient sound produced by the same equipment.

SI Values

A System International (SI) unit has not been designated to measure sound absorption. However, a metric Sabin is the sound absorption effect of 1 square metre area of absorbing material with a NRC of 1.00. One can then use the listed NRC values to obtain a noise reduction coefficient in metric Sabin by multiplying the NRC value of the material by the surface in square metres of this material. The metric Sabin number will be 10.8 times less then the Sabin number and formula using Sabins may require adjustment when using metric Sabins.

Reflection and Reverberation

Sound reaches a listener's ear inside an enclosed area in two ways - directly from the source and as reflection from surfaces. Multiple reflections will occur as the sound ricochets from surface to surface. At each reflection some absorption occurs and the sound gradually diminishes. But, if the sound source is continuous, such as a machine, reverberation can add to the effect. Reverberation time is the time, in seconds, required for the sound level in a room to decrease by 60 dB after the source is stopped. The time may vary from 1/2 second in a "dead" room to 5 or 10 seconds in a live reverberant large room. The maximum reverberation time for clear speech is about 2 seconds. As the reverberation time gets longer (than 2 seconds) speech becomes increasingly difficult to understand. At 4 to 10 seconds, speech is unintelligible. By the same measure, speech is increasingly easier to understand as reverberation times go below 2 seconds. Classrooms and lecture areas are ideally at less than 1 second. Music is best enjoyed at 1-1/2 to 2 seconds. Chamber and organ music is ideal at 3 seconds (as in churches).

Other Considerations

Sound Transmission Class (STC) values are a measure of a different acoustical problem than noise reduction. While acoustic roof deck is intended to reduce the noise level inside an area, an STC value expresses the airborne noise that either enters or leaves an area by going through the construction.

Room Crossover

Room crossover, or flanking, of sound can occur through penetrations and cracks under and around doors for example. Sealing around penetrations can help to minimize the effect. Noise can travel along the underside or through an acoustic roof deck ceiling and enter an adjoining area across the top of a partition. Rubber closures shaped to fit the deck ribs can be supplied by the deck manufacturer to help reduce sound crossover. Concrete or mortar can be used to fill between CMU and deck or in flutes above partitions.

General

Hard, reflective, non porous interior building surfaces such as glass, wood, plaster, brick and concrete absorb 2 to 5% of the sounds striking the surface and, therefore, reflect 95% or more of the sound. Acoustic steel deck is one of the best and most cost effective products that can help absorb more of the sound. There are, of course, other materials and methods available that can be used alone or with acoustic deck to achieve significant reductions in noise such as acoustical wall panels, acoustical baffles and acoustical carpets.

The purpose of this paper has been to demonstrate how acoustic steel deck can be used as an economical and effective method to reduce noise. The information presented was prepared in accordance with generally recognized acoustical principles but it is a general treatment and is only intended to introduce topics that can give insight into a complex subject. The CSSBI recommends that professional analysis and evaluation be conducted by an experienced acoustical consultant for either a building in the design stage or for existing buildings that need treatment.

For More Information

For more information on sheet steel building products, or to order any CSSBI publications, contact the CSSBI at the address shown below or visit the website at www.cssbi.ca.