STC RATINGS OF DRYWALL PARTITIONS WITH AND WITHOUT STRUCTURAL SHEATHING

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1 Introduction

It is often encountered that architects or other building designers specify multiple cavity partitions, with the expectation that they provide equal or greater sound transmission loss performance than a single cavity partition of similar overall mass and dimension. Previous studies confirm that this is not generally true. In particular, the National Building Code lists wood-frame and drywall demising partitions with single large cavities without solid connections, with relatively high Sound Transmission Class (STC) ratings; however, a footnote indicates that the structural sheathing configurations in these walls can degrade the performance from slightly to unpredictably. This article presents a comparison of several field measurements demonstrating the significant acoustical effects of a commonly specified sheathing configuration.

2 Background

2.1 Wood Stud Frame Walls

In wood frame buildings, typically up to 4 storeys (and increasingly up to 6 storeys), the wood stud walls are often part of the load bearing structure, and as such, those walls require a shear panel. Commonly, this involves adding a layer of plywood or OSB on one side of the studs, followed by the required layers of drywall to achieve the fire rating. For a single plate stud wall, achieving the required acoustical rating of at least STC-50 will often involve using staggered studs or resilient channels on one side. An alternative, used for various reasons, is a double-stud wall. For a continuous floor structure, one set of studs will also receive a layer of sheathing. It is noted that builders prefer to construct the framing flat on the floor, add the sheathing layer, and then stand the wall up in place, with the stud cavities open on the suite side to add services and insulation prior to adding drywall facings. This is repeated on the other side of the demising assembly, but without the sheathing. This puts a sheathing layer within the assembly cavity, creating a three-leaf system (two cavities). In cases without a continuous floor plate (i.e., separate floor plates to limit flanking sound transmission through the floor, under the wall), a sheathing layer is required on each stud set, and builders frequently duplicate the sheathed assembly on both sides, resulting in a four-leaf system (3 cavities; two identical insulated cavities and one small un-insulated cavity).

The fully unsheathed assembly is described in the NBC supplementary table as W13a or W13b, which it rates at STC-57, with insulation between both sets of studs and 1 layer of type X drywall (13 mm or 16 mm) on each side [1]. The two-cavity assembly is not listed, however, the end notes in the supplementary table suggest a 3 point degradation in the STC rating with a single inner sheathing layer. This is consistent with past experience and discussed in reference 2. The three-cavity assembly is also noted briefly in the end notes of the supplementary table, however, it is noted that this "may drastically reduce the STC value", but no specific value is assigned [1]. These are shown schematically in Figure 1.

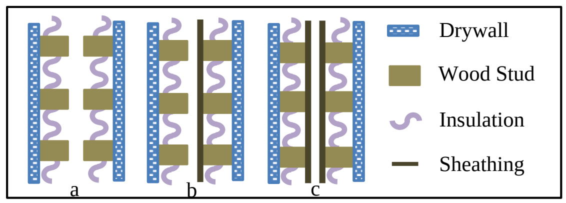

Figure 1: a) Single Cavity; b) Double Cavity; c) Triple Cavity.

HGC Engineering has recently measured the field performance (ASTC) of the unsheathed system and the three-cavity system.

2.2 Cavity Resonances

There are two main sound transmission mechanisms between the multiple layers of the assembly: solid stud connection and airborne coupling via cavity resonance (other factors like mass, damping, and stiffness are the main factors relating to transmission within each material layer).

The solid connection is absent in the unsheathed double stud assembly, hence the high rating from two single drywall layers. In the two-cavity system, the inner layer of sheathing is solidly coupled via the stud to the outer drywall layer on the same stud. This coupling is much stronger than the airborne coupling in that part of the assembly, however, this drywall-stud-sheathing assembly is still only airborne coupled to the other layer of drywall. The airborne coupling cavity depth is approximately halved, raising the resonance frequency and resulting in the 3-point degradation.

In the three-cavity system, both stud assemblies are dominated by solid coupling, and these two assemblies are airborne coupled by a small (usually 25 mm) un-insulated cavity with strong coupling at a much higher resonant frequency, which is within the STC frequency range. Approximate cavity resonance frequencies for the three assemblies are summarized in Table 1. Approximate mass-air-mass resonance frequencies are calculated using the classic empty cavity equation, and the batt-filled cavity mass-air-mass equation from NRC references. Actual resonance frequencies may vary somewhat depending on factors such as total mass, local panel stiffness, panel damping, air-cavity damping, etc.

	1-Cavity	2-Cavity	3-Cavity
1st Cavity	29	44	44
2nd Cavity	-	39	173
3rd Cavity	-	-	44

Table 1: Approximate Mass-Air-Mass Resonances in the 3 double-stud constructions [Hz].

3 Measurement Data

3.1 Laboratory Data

Published laboratory measurement data for the single and double cavity assemblies were readily available from the National Research Council [3]. Measurement results from the following constructions are summarized in Figure 2:

a) Single-cavity with a double row of 90 mm studs, separated by 25 mm, 90 mm batt insulation in both stud spaces, one layer of 16 mm type X drywall each side; no sheathing is included.

b) Double-cavity with a double row of 90 mm studs, 90 mm batt insulation in both stud spaces, one layer of 16 mm type X drywall on inside of one stud set, with a 9 mm space between the inner layer of drywall and the second stud set, one 16 mm layer of type X drywall on each face.

3.2 Field Measurements

Measurements to test the performance of the partitions were required on recently constructed low-rise condominiums to assess their compliance with the building code requirement of STC-50. Measurement results from the following constructions, as tested by HGC Engineering on recent projects, are summarized in Figure 2:

c) Single-cavity with a double row of 90 mm studs, separated by 25 mm, insulation in both stud spaces, one layer of 16 mm type X drywall each side (sheathing, where required, may be included behind the face drywall).

d) Triple-cavity with a double row of 90 mm studs, sheathing layer on inside of each stud set, separated by a 25 mm cavity, insulation in the stud spaces, one layer of 16 mm type X drywall on each face.

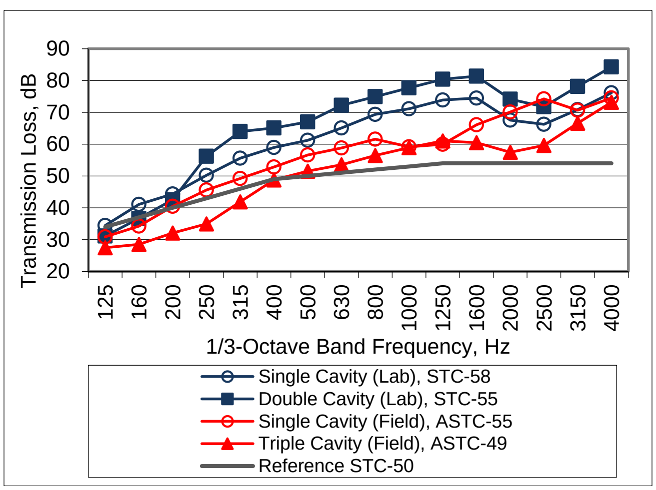

Figure 2: Transmission Loss Results

4 Discussion

4.1 Comparison of Assemblies

There is reasonable agreement between the two single cavity results (laboratory versus field); the field performance dip at 1000 and 1250 Hz is ascribed to observed leakage at back-to-back outlets (only 3 STC points below laboratory rating despite leakage). As noted in the NBC supplementary tables notes, the double cavity rating is only degraded by 3 STC-points from the single cavity, however it is clear that the low-frequency degradation (at 200 Hz and below) is responsible for the reduced STC rating, despite the boost at higher frequencies. The triple-cavity assembly measured below the target (ASTC-47 to 49) in all but one case where it managed to achieve ASTC-51. Despite adding material, it is seen that the performance is significantly degraded by the uninsulated small cavity between sheathing layers. The note in the NBC supplementary tables is accurate in discouraging these assemblies.

4.2 Possible Mitigating Assemblies

If encountered in the field (as-built), upgrading these triple cavity walls without rebuilding may include adding a second layer of drywall with a constrained damping compound, but improvement may only be marginal and should be tested. A better approach would be to remount the face layer on one or both sides of this demising wall using a resilient attachment (e.g., resilient metal channels, or rubber-based clips for snapping furring channels in). Again, this should be tested in the field to confirm whether this is required on one or both sides. In design, this issue should be flagged and alternative constructions considered (staggered studs, resilient mounts, or simply placing the sheathing under the face layers of drywall).

5 Conclusions

It has been noted in various references to avoid double cavity assemblies to not degrade the performance rating. The foregoing confirms this with laboratory data, but goes further to demonstrate the serious degradation resulting from three cavities, especially including a small uninsulated cavity, which was demonstrated to reduce the rating by up to 10 points.

References

[1] National Research Council Canada. National Building Code of Canada, Volume 2. 2010.

[2] W. Gastmeier and M. Wu, Field Sound Transmission of Demising Walls and Floor / Ceiling Assemblies. *Internoise 92 Proceedings* Volume 2. 1992.

[3] National Research Council Canada. Gypsum Board Walls: Transmission Loss Data. 1998.

[4] A.C.C. Warnock and J.D. Quirt, National Research Council Canada. Control of Sound Transmission through Gypsum Board Walls. *Construction Technology Update No. 1*. 1997.