Airborne Sound Insulation in a Series of Wood-Frame Apartment Buildings

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TECHNICAL NOTE

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PREPARED FOR Central Mortgage and Housing Corporation

SUBJECT AIRBORNE SOUND INSULATION IN A SERIES OF WOOD-FRAME APARTMENT BUILDINGS

This Note records measurements of sound insulation in typical wood-frame apartment buildings made for the Central Mortgage and Housing Corporation. The four buildings reported on here have essentially similar floor and wall structures: the floors are wood joist with hardwood wearing surfaces and the ceilings are plasterboard or plaster. The party walls consist basically of 8-in. concrete block and the exterior walls are generally wood frame with brick veneer or stone facings.

Emphasis in this study was on vertical sound transmission through floors (airborne sound only). Of special interest was the importance of flanking transmission through ducts associated with heating systems. In addition, one party wall was tested for airborne sound transmission in one building (Building A).

DESCRIPTION OF BUILDINGS

Four buildings located in Laval des Rapides, P. Q., all of recent construction, were examined on 9 and 10 August 1967. About half of the rooms tested were furnished. Construction details are given below.

Building A (569-571 Eighth Avenue)

1. Floor Construction: 1-in. hardwood on 1- by 3-in. furring strips at 12-in. centres on asbestos paper on 1/2-in. wood fibreboard on subflooring of 1-in. square-edge board nailed to 2- by 10-in. wood joists; ceiling side, 5/8-in. plasterboard nailed to 1- by 2-in. furring strips nailed to joists.

2. Hot-air heating system: sheet metal ducts (approximately 28-gauge thickness) installed in a plenum area made by furring down the ceiling from the joists; return air ducts in hallway located adjacent to each other.

3. Party-wall construction: 8-in. hollow concrete block (surface weight ÷ 47 lb/ft^2), finish on each side consisting of 1/2-in. plasterboard nailed to 1- by 2-in. furring strips at 12-in. centres.

Building B (464-466 Branly Street)

1. Same floor construction as in Building A.

2. Hot-air heating system: sheet metal ducts carried through independently in a vertical direction.

Building C (562-564 Lartige Avenue)

1. Same floor construction as in Building A, except (a) furring strips nailed through fibreboard sandwich material and (b) ceiling side of 3/8-in. gypsum lath with 3/8-in. plaster.

2. All electric heating system.

Building D (2064 De Melbourne St.)

1. Floor construction: 3/4-in. hardwood on 5/8-in. plywood subfloor nailed to 2- by 8-in. wood joists at 16-in. centres; ceiling side, 5/8-in. plasterboard screwed to resilient aluminum channels nailed at 24-in. centres to joists.

2. Hot-air heating system: sheet-metal ducts carried through independently in a vertical direction.

DESCRIPTION OF TESTS

The airborne sound transmission loss tests, designed to determine the performance of a construction under disturbances such as speech and domestic noise, follows ASTM E90-66T: "Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions."

The sound transmission loss of the construction was measured with test signals of random noise with a bandwidth of one-third octave. It is given by:

$$TL = NR + 10 \log (S/A_2)$$

where NR is the measured noise reduction in decibels between the rooms separated by the partition,

S is the surface area of the transmitting surface in square feet, and

A_2 is the sound absorption of the receiving room in sabins.

The last term in the equation is a standard correction term that normalizes the measurements to allow for variations in the area of sound-transmitting surface and in the sound absorption in the receiving room. In some cases, S and A_2 are not well defined; for example, a living room may not be separated from another room or hallway. Fortunately, the correction is not sensitive to small errors: a 25 per cent error in S or A_2 would amount to 1 decibel in the final determination.

As a single-figure rating for airborne sound transmission loss, the ASTM Sound Transmission Class (STC) is used. This provides a measure of the performance of the partition against the sounds of speech, television, and similar domestic noises.

RESULTS

Single-figure ratings for all constructions are summarized in Table I. Transmission loss measurements over the range 125 to 4000 hertz (cycles per second) are given in the enclosed figures.

Figure 1 shows sound transmission losses in Building A for a standard wood joist floor with an added sandwich material of 1/2-in. fibreboard. Flanking transmission through air ducts of the heating system was investigated by sealing the duct outlets with batts of mineral wool stuffed tightly into the openings. Measurements were carried out on floors between living rooms, hallways and kitchens, and also on a party wall separating bedrooms.

Figure 2 shows similar measurements in Building B with the same floor construction and a slightly different air distribution system in which the ducts are carried through independently in a vertical direction.

In Figure 3, data is obtained in Building C for essentially the same floor construction, except for a slightly different ceiling finish. The floor construction is free of ducts piercing the structure, as heating is by electrical means.

Figure 4 shows transmission loss data for Building D on a standard wood joist floor with plywood subfloor and a resilient channel suspension for the ceiling. The heating system is the same as that used in the second building.

CONCLUSIONS

According to Residential Standards, National Building Code of Canada, the airborne sound insulating properties of a construction are divided into three categories. Very good performance in resisting airborne sound can be achieved with an STC 50 or better, fair performance with a rating between 45 and 50, and poor performance with a rating less than 45. In this study the most serious complaints were received for constructions rated less than STC 45. Our experience indicates that complaints are rare for STC 50 or better, but are increasingly more frequent for STC 47 and below.

The Sound Transmission Class 50 obtained in the one measurement of airborne sound through a party wall is about what would be expected in the laboratory. To protect against inadequacies of mortar and block porosity, it is desirable to seal with heavy paint or, preferably, plaster, one side of the block wall even though it is furred out. These precautions should help the wall to consistently achieve an STC 50 or more.

Our investigation of hot-air heating systems showed that flanking transmission was quite serious with a plenum carrying the metal ducts and most serious when return air ducts were located adjacent to each other. This is exemplified by Building A where a maximum of STC 47 was obtained between living rooms with duct outlets sealed up and a minimum of STC 40 between hallways for the unmodified floor.

Building B, similar to Building A except for a different air distribution system in which the ducts are vertical and independent, was found to be unaffected by flanking transmission in the one room tested. The rating obtained, STC 49, is the maximum expected for this type of floor construction.

The most interesting inconsistency obtained was for Building C. The floor construction in this building is similar to that of Building A except for two details: (1) the fibreboard is nailed through, and (2) lath and plaster is used for the ceiling instead of plasterboard. In addition, Building C does not have any ducts piercing its floor construction. An STC 40 obtained between a set of bedrooms in this building was believed to be much too low; consequently, measurements made between a second set of bedrooms gave the same results. The effect of nailing through the fibreboard is small for airborne sounds; at most it would be 2 or 3 STC points and certainly not enough to account for the 7 to 8 dB discrepancy for this floor. The transmission loss is about normal at middle and high frequencies, but is very low at low frequencies. A possible explanation is that there is cavity communication in the external wall between upper and lower storeys. No detail is shown in the drawings, but the description suggests an unusual external wall construction, and it is possible that the necessity of blocking at the floor level may have been overlooked. (This might be a serious omission from the fire viewpoint also.)

Building D shows evidence of flanking transmission for the air distribution system with vertical ducts carried through independently. For this building, the combined floor area of living room and hallway was tested. The STC rating obtained for the unmodified floor is dictated by a severe dip in the low frequency range where measurement itself is quite difficult. Thus, the measured improvement obtained by sealing the ducts is not very precise. In addition, Building D was not completely finished and the measurements made are not as reliable.

DISCUSSION

These measurements support the conclusion that in many instances the sound insulation capabilities of such floor constructions are not fully realized because of flanking transmission problems, especially via air ducts. This is evident in Building A where the main supply duct for the upper storey is carried mainly in a plenum furred down from the joists. It is important that the plenum not only be constructed of material equivalent to the ceiling finish, but also that no leaks occur.

Ducts piercing floors are usually troublesome, as sound can enter or leave a metal duct not only through an opening or grill, but also through the thin metal sides. Consequently, ducts through sound barriers should be kept to a minimum and any openings around duct work in party walls or floors should be sealed with tightly packed insulation or caulking. In any case, our measurements indicate that Building B, for which the air distribution system consists of vertical ducts carried through independently, presents the least problem in regard to duct flanking transmission.

It is important to pay attention to detail in wood-frame construction. Even though the wall or floor constructions themselves are reasonably good, flanking may still occur at the wall/floor connections. Upper wall cavities may not be well separated from lower wall cavities and floor cavities may not be well separated from the wall cavities. If joists run perpendicular to a sound barrier wall, the space between joists should be well blocked off. Similarly, for joists parallel to the wall, care must be taken in blocking so that flanking is not transmitted into the wall cavity.

TABLE I

SUMMARY OF SINGLE-FIGURE RATINGS FOR ALL CONSTRUCTIONS

	Location	Sound Transmission Class	Test Details
FLOOR TESTS			
Building A	Living rooms	47	Existing floor.
		45	Ducts sealed.
	Hallways	40	Existing floor.
		44	Ducts sealed.
	Kitchens	40	Existing floor.
		41	Ducts sealed.
Building B	Living rooms	49	Existing floor.
		49	Ducts sealed.
Building C	Bedrooms	40	Existing floor.
Building D	Combined floor area of living room and hallway	42	Existing floor.
		47	Ducts sealed.
PARTY WALL TEST			
Building A	Bedrooms	50	Existing wall.

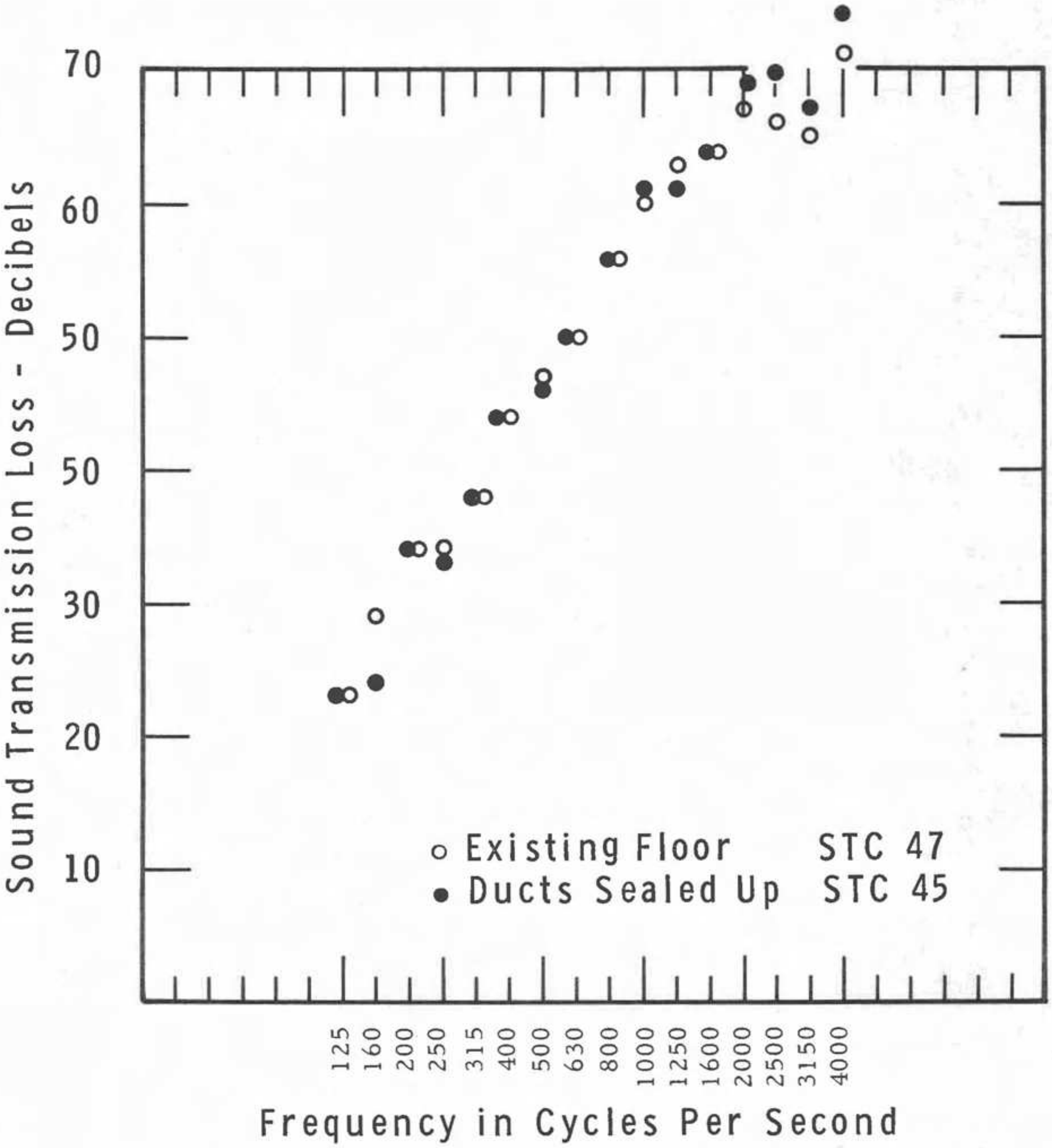

Figure 1(a)

Building A:
Sound Transmission Test on Floor Separating Living Rooms

BR 4000-1

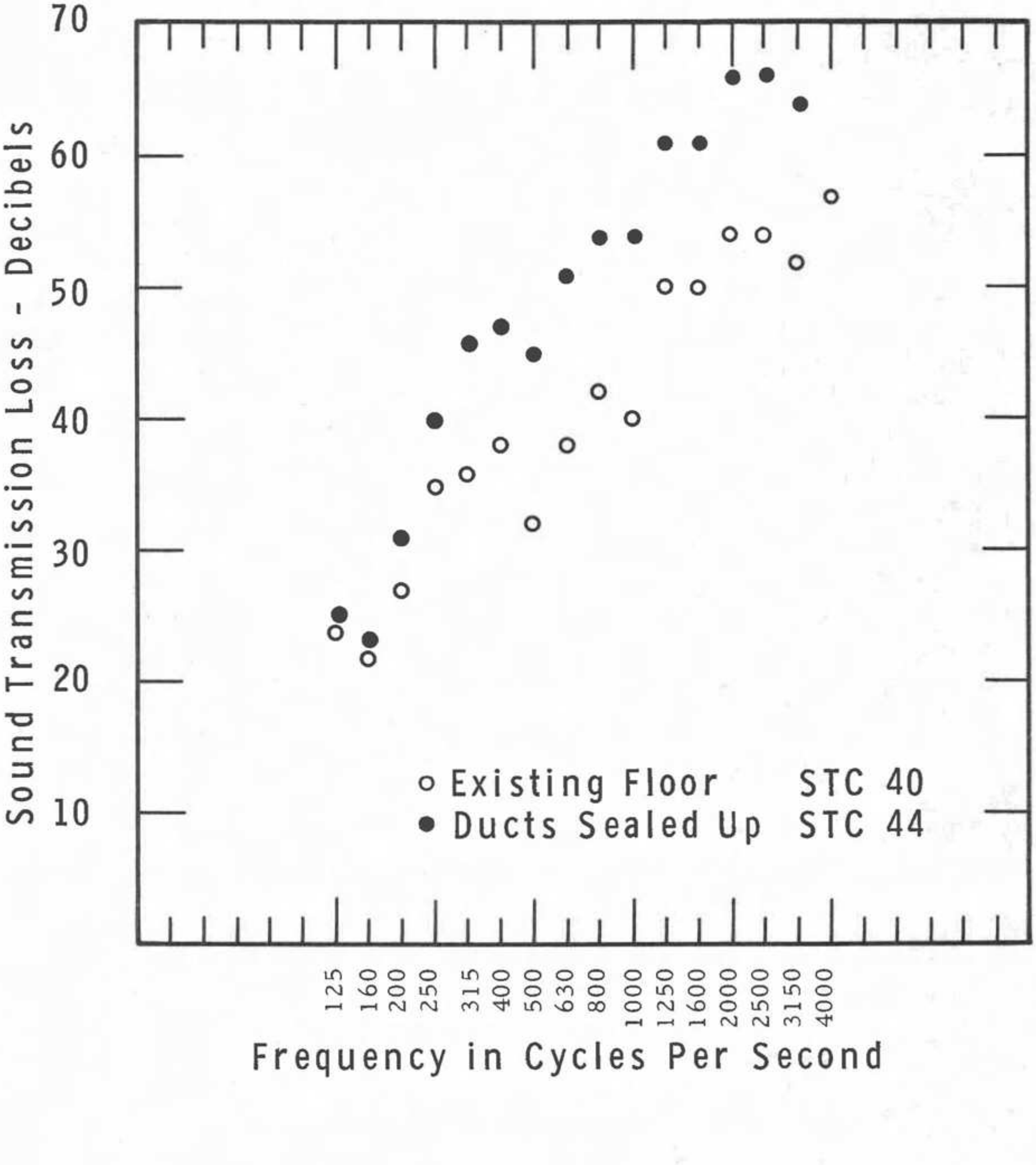

Figure 1(b)

Building A:
Sound Transmission Test on Floor Separating Hallways

BR 4000-2

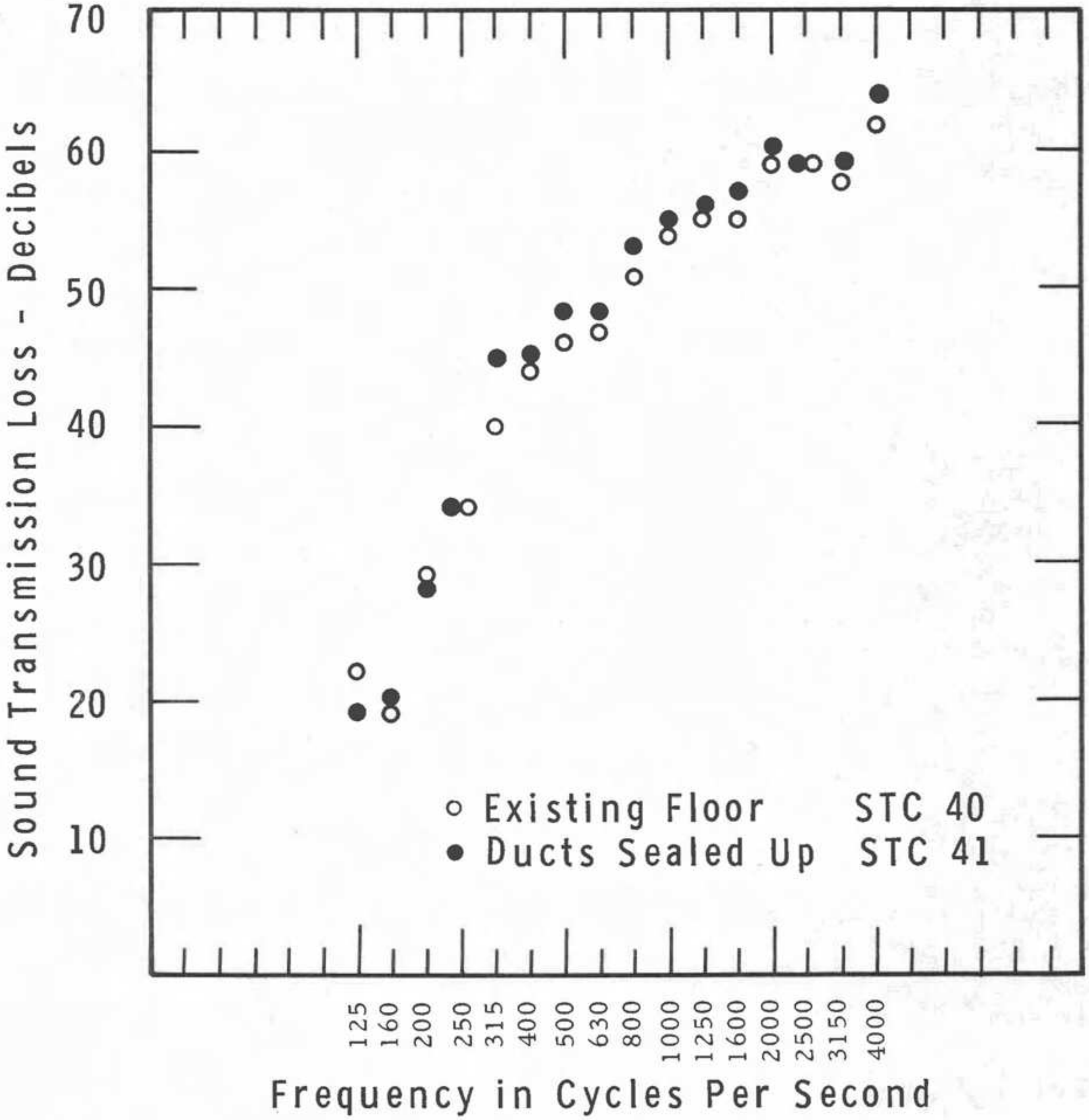

Figure 1(c)

Building A:
Sound Transmission Test on Floor Separating Kitchens

BR 4000-3

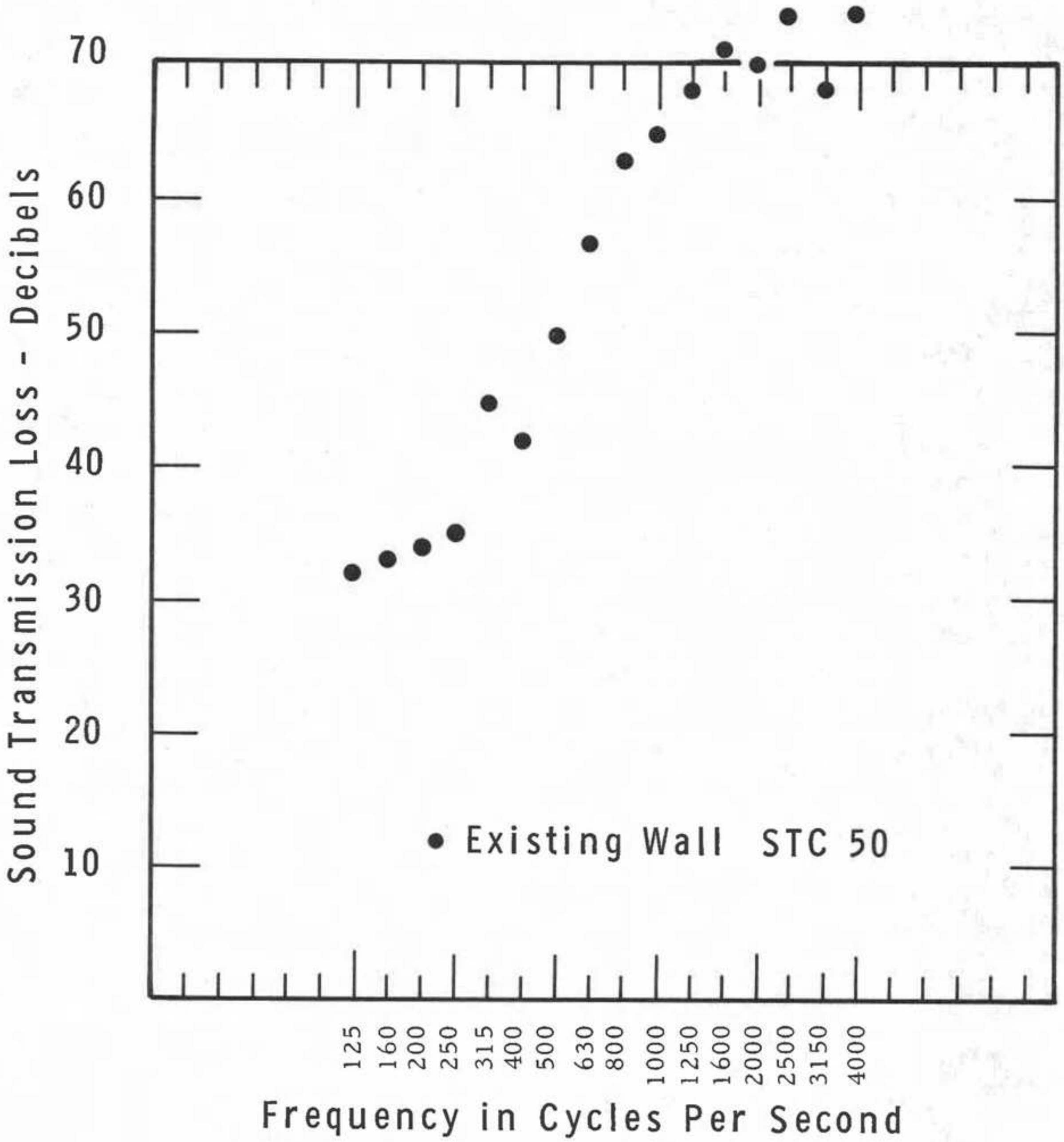

Figure 1(d)

Building A:
Sound Transmission Test on Party Wall Separating Bedrooms

BR 4000-4

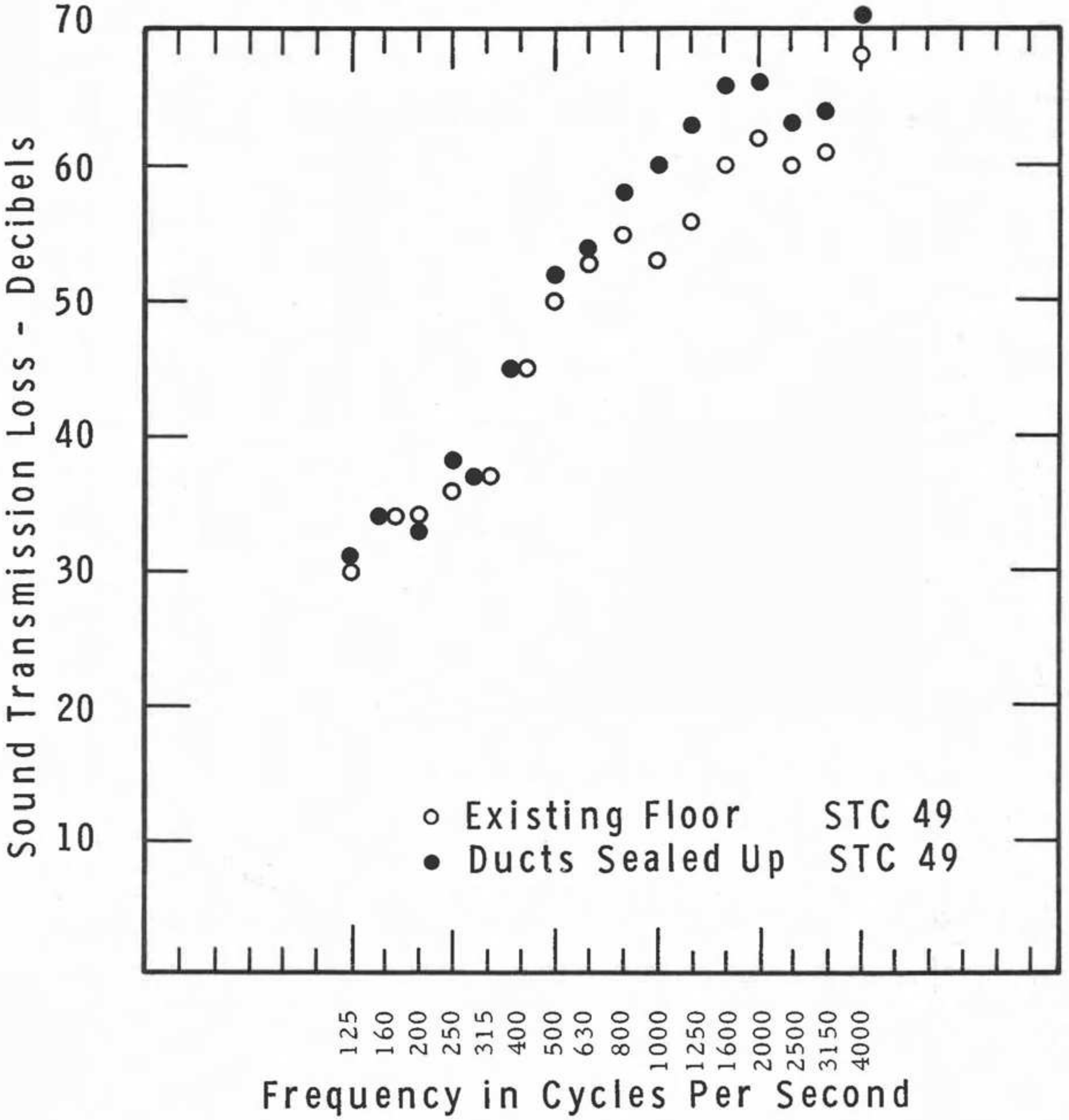

Figure 2

Building B:
Sound Transmission Test on Floor Separating Living Rooms

BR 4000-5

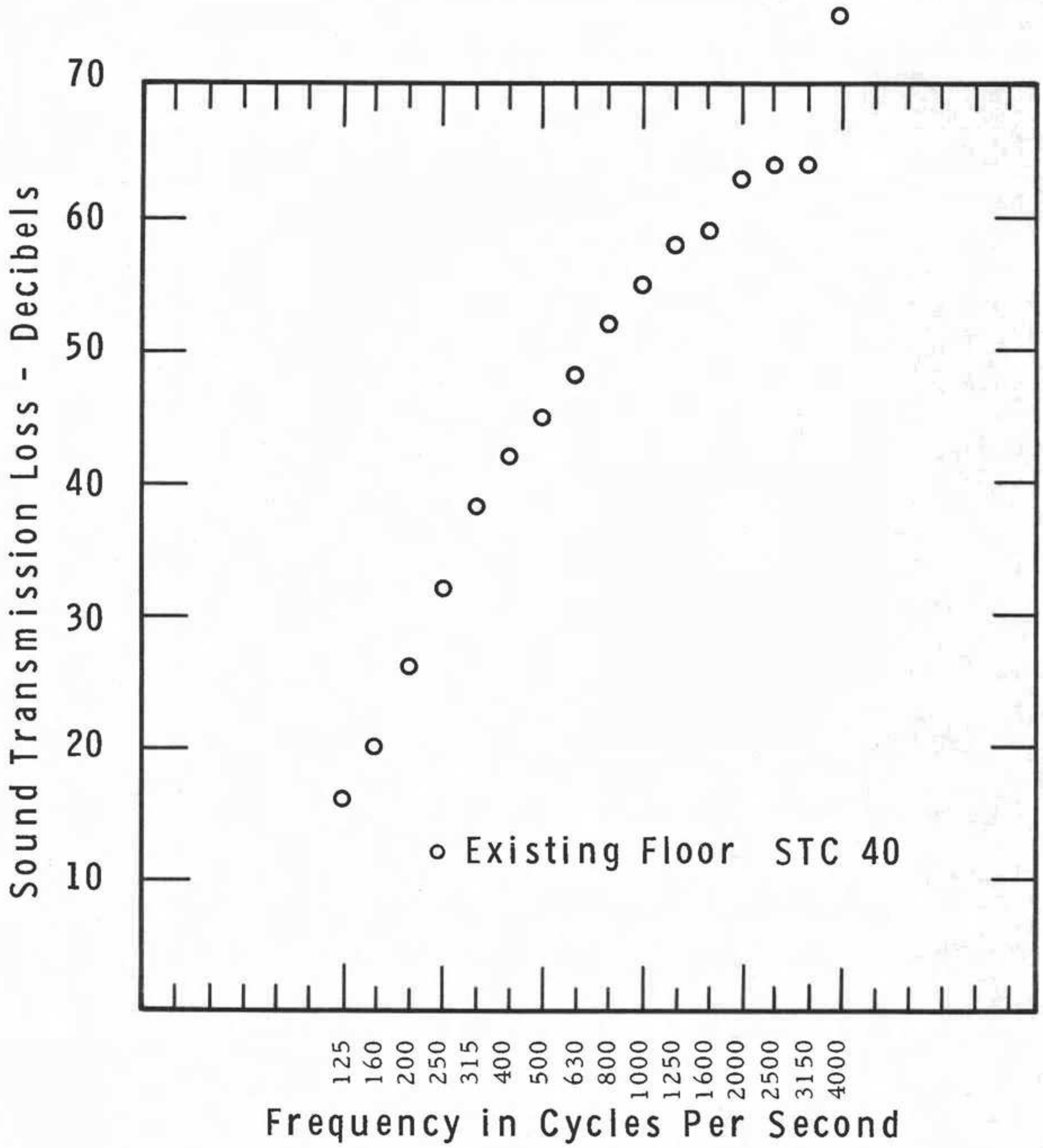

Figure 3

Building C:
Sound Transmission Test on Floor Separating Bedrooms

BR 4000-6

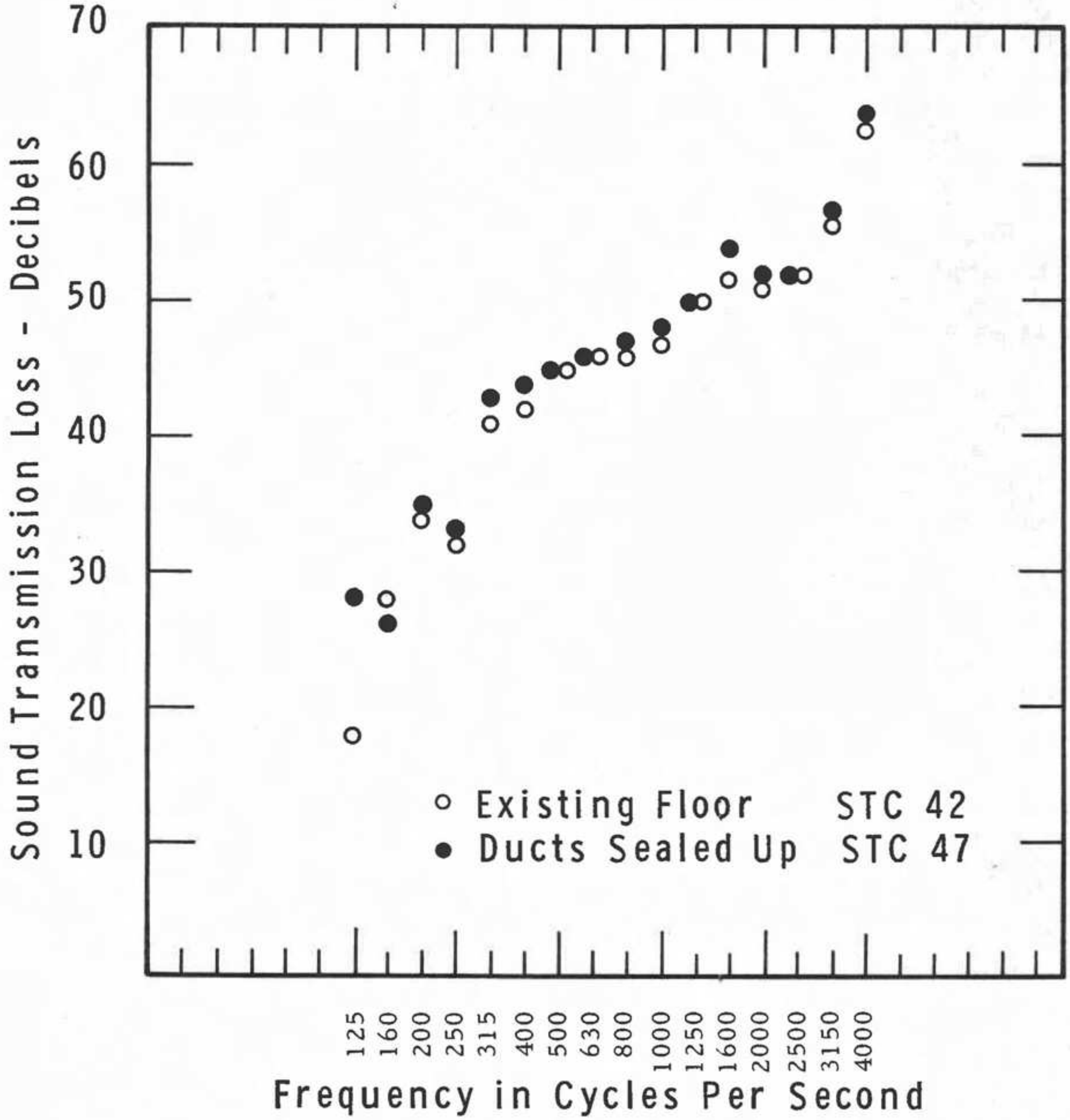

Figure 4

Building D:
Sound Transmission Test on Floor Separating Combined Living Room and Hallway Areas of Each Apartment

BR 4000-7