

A Soft Floor Covering Quietens Light Impacts but Barely Touches Heavy Ones

— a heavy impact (7 kg) already has soft contact, lengthens only by **1.095445**, and no band drops by as much as **2.3 dB** — the separator is whether one asks about a light impact or a heavy one — [Paper 854]

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Abstract

For footsteps from upstairs, the advice is “lay a soft floor covering”. This paper counts which sounds that helps and which it does not. No new theorem or law is claimed. First, a soft covering lengthens the contact: for a light impact **0.000222 s** becomes **0.002233 s**, a factor of **10.049876** (Section 2). Second, longer contact trims the high bands: the light impact’s 1000 Hz band drops **−27.0558 dB** and its 2000 Hz band **−38.8660 dB** (Section 3). Third, the low bands are hardly trimmed: even for the light impact the **63 Hz** band drops only **−0.1856 dB** (Section 3). Fourth, and this is the core. It barely helps against heavy impacts: contact lengthens only by **1.095445**, and no band drops by **2.3 dB** (the **63 Hz** band by **−2.2767 dB**) (Section 3). Fifth, heavy impacts already sit in the low bands: even on a hard floor the 1000 Hz band’s average is **52.6212 dB** below the **63 Hz** band’s (Section 4). Sixth, the separator is whether one asks about a light impact or a heavy one: added softness works only when the contact was hard to begin with (Section 5). **Keywords:** floor impact sound, contact time, impact force spectrum, soft floor covering, octave band, model.

Scope of this paper (scope note): No new theorem or law is claimed: that floor impact sound is treated separately for light and heavy impacts, that soft floor finishes reduce light impacts well and heavy impacts little, and that a longer contact shifts the force spectrum to lower frequencies, are all known. No design advice is given, which covering to use and how thick to make the floor are not stated. No real floor is claimed: masses of 0.5 kg and 7 kg and stiffnesses of 10^8 , 2×10^5 and 10^6 N/m are model values matching no rating standard. The path from floor to sound is not included: slab vibration, radiation into the room below and room acoustics are not treated; only the force spectrum is examined. Hearing is not included: no frequency weighting for the ear is applied. Relation to earlier papers: Paper 456 showed that doubling the distance does not halve the noise, leaving sound insulation open in its scope note. This paper stands beside it: there the side where sound spreads, here the side where it is born. Paper 584 showed that more damping in a base isolator transmits more shaking on one side: a neighbour in that a soft layer's effect splits by frequency. The contact-time ratio 10.049876 ($\sqrt{101}$) also appears in 584, but there as resonant amplification at damping 0.05, with a different formula and quantity: a distinct root. What is added is laying out band-by-band reductions for two impacts, measuring that no band of the heavy impact drops by 2.3 dB, measuring with band-averaged levels that heavy impacts already sit low, and placing the separator on light versus heavy impact.

1. Notation and the Question

Setting: a mass m strikes the floor with contact stiffness k . The blow is a half-sine of duration τ , compared at fixed momentum.

$$\tau = \pi \sqrt{\frac{m}{k}}, \quad |H(f)| = \left| \frac{\cos(\pi f \tau)}{1 - (2f\tau)^2} \right|, \quad \frac{1}{k_{\text{eff}}} = \frac{1}{k} + \frac{1}{k_{\text{soft}}}$$

$|H|$ equals 1 at zero frequency. A soft covering ($k_{\text{soft}} = 10^6$ N/m) enters in series with the contact stiffness. $|H|^2$ is summed per octave band and compared with and without the covering.

Question: which bands of which impact does a soft covering reduce?

2. Contact Time

Computation 2.1: the contact times of the two impacts were computed.

impact	hard floor	soft covering	ratio
light (0.5 kg, $k = 10^8$)	0.000222 s	0.002233 s	10.049876
heavy (7 kg, $k = 2 \times 10^5$)	0.018586 s	0.020360 s	1.095445

Observation 2.2

the same covering lengthens them differently. By 10.049876 for the light impact and 1.095445 for the heavy: stiffnesses combine in series, so the already-soft side dominates and added softness does little.

3. Band-by-Band Reductions

Computation 3.1: the reduction in each band from laying the soft covering was computed.

band	light impact	heavy impact
63 Hz	−0.1856 dB	−2.2767 dB
125 Hz	−0.7312 dB	−1.3004 dB
250 Hz	−2.9300 dB	−0.5020 dB
500 Hz	−11.4530 dB	−2.0248 dB
1000 Hz	−27.0558 dB	−1.5762 dB
2000 Hz	−38.8660 dB	−1.4157 dB

Observation 3.2

for the light impact, higher bands drop more.—27.0558 dB at 1000 Hz and −0.1856 dB at 63 Hz: a longer contact stops producing force above roughly its inverse.

Observation 3.3

this is the core. For the heavy impact it barely helps in any band. The largest reduction, at 63 Hz, is −2.2767 dB, short of 2.3 dB: contact hardly lengthens, so the spectrum hardly changes shape.

4. Heavy Impacts Are Low to Begin With

Computation 4.1: on a hard floor, the band-averaged level (divided by bandwidth, 63 Hz band set to 0 dB) was computed.

band	light impact	heavy impact
63 Hz	0.0000 dB	0.0000 dB
250 Hz	−0.0274 dB	−29.0829 dB
1000 Hz	−0.4659 dB	−52.6212 dB
2000 Hz	−1.8723 dB	−64.6349 dB

Observation 4.2

a heavy impact already sits in the low bands on a hard floor. Its 1000 Hz average is 52.6212 dB below its 63 Hz average: the high bands a covering would trim hold almost nothing to trim.

Observation 4.3

a light impact is flat into the high bands. Even at 1000 Hz it is down only −0.4659 dB, so there is much for a covering to remove.

5. The Separator

Observation 5.1

the separator is whether one asks about a light impact or a heavy one. What divides the effect is less the weight itself than whether the contact was already hard or soft: added softness works only when the other member of the series is hard.

Observation 5.2

placed beside Papers 456 and 584.456 showed that doubling the distance does not halve the noise. There the side where sound spreads, here the side where it is born.584 showed that more damping in a base isolator transmits more shaking on one side: a neighbour in that a soft layer's effect splits by frequency. The contact-time ratio 10.049876 appears in 584 as $\sqrt{101}$, but there it is resonant amplification at damping 0.05, with a different formula and quantity; by the discipline of Paper 300 it is a distinct root.

Observation 5.3

what is not said.Which covering to use, slab vibration, sound in the room below and the ear's weighting are not treated. What is shown is that the same softness helps or does not according to the kind of impact.

6. Census and Closing

1. light contact lengthens **10.049876** (Computation 2.1): **a lot.**
2. heavy lengthens **1.095445** (Computation 2.1): **hardly.**
3. light, 1000 Hz: **−27.0558 dB** (Computation 3.1): **high bands trimmed.**
4. 2000 Hz: **−38.8660 dB** (Computation 3.1): **more so.**
5. 63 Hz: **−0.1856 dB** (Computation 3.1): **low bands stay.**
6. heavy, at most **−2.2767 dB** (Computation 3.1): **the core.**
7. heavy on a hard floor, **−52.6212 dB at 1000 Hz** (Computation 4.1): **already low.**
8. light, **−0.4659 dB** (Computation 4.1): **flat upward.**
9. $\sqrt{101}$ distinct from Paper 584 (Observation 5.2): **different formula.**
10. light impact, or heavy (Observation 5.1): **the separator; Papers 456, 584.**

Closing: A soft floor covering quietens light impacts but barely touches heavy ones.For a light impact contact lengthens by 10.049876, dropping the 1000 Hz band by **−27.0558 dB** and the 2000 Hz band by **−38.8660 dB**, while the 63 Hz band falls only **−0.1856 dB**: a longer contact stops producing force above roughly its inverse.For a heavy impact contact lengthens only by 1.095445, and no band drops by as much as 2.3 dB: stiffnesses combine in series and the already-soft contact dominates, so added softness does little.And even on a hard floor the heavy impact's 1000 Hz average lies **52.6212 dB** below its 63 Hz average, leaving little to trim.Placed among the earlier papers: beside Paper 456's side where sound spreads, as the side where it is born, and treating the $\sqrt{101}$ shared with Paper

584 as a distinct root by the discipline of Paper 300. To be honest: only the force spectrum is examined; slab vibration and radiation into the room below are not included.

References

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