Gym Acoustics Guidance Workshop

Launch of a new ProPG

29 March 2023

3.1 SPECIFICATION

Presented by

Adam Fox CEng MIMechE AMOIA

Director at Mason UK Ltd

and

James Bligh BMus MIOA

International Director of Acoustic Engineering at Pliteq UK Ltd

Summary – Why is this section in the guide?

What is this section for?

- Responsibility for selecting a system to control noise covers acoustic performance and fitness for purpose.
- Consultants may not be aware of all the elements required for correct design and installation
- It is also important to consider longevity of the system. Gyms can be punishing to floor treatments and the supporting structure.
- Engagement from the supplier is also crucial to ensure correct in-situ testing is carried out and that the end client receives appropriate support.

Why should specification extent to more than acoustics?

- How is the acoustic performance assured?
- The primary purpose of specification is to ensure that the client is provided with the correct and optimal treatment
- Not all treatments can be accommodated structurally
- There will be a loss of height, which can affect thresholds, access and ability to lift weights above head heigh
- A financial implication which may affect the Gym operation and business model.
- It is recommended that the scope of works for the acoustician extends to a review of the system proposed by the supplier(s).

Summary – Scope of Supply

- The aim is to isolate the Gym activity from the building structure by means of a floating floor and/or covering layer(s). The result shall be a flooring system which isolates Gym activities to a degree as determined by physical testing/prediction carried out by the project acoustician.

- The flooring system supplier should provide independent evidence of final system performance in line with testing carried out, construction guidance, products of demonstrable quality and support to ensure correct installation.

Summary – Scope of Supply

- The supplier should have a responsibility to work with the project acoustician and the client team to demonstrate (by calculation or empirical evidence as applicable) that the proposed floor system:
- Will provide isolation in line with physical testing carried out on site. It is advised that the supplier supports the testing process;
- Will be capable of supporting all intended Gym equipment without detriment;
- Will allow for safe access by users, including those with disabilities;

Summary – Scope of Supply

- Will allow for system penetrations for piping, drainage ducts etc. considering system moment while ensuring isolation is not compromised;
- Will be appropriately restrained if within a seismic or blast zone;
- Will be appropriately interfaced with any surrounding walls.
- Will not exceed the structural capacity of the existing structure. The supplier shall further provide any loading information required by the client team. The supplier should work with the team and make recommendations on how limitations can be overcome;

Getting the specification right

- Site testing of mock-ups is the preferred approach for determining the optimum floor configuration, although as discussed in section 4.7 there are limitations that need to be taken into account.
- This approach should be made clear to the contractor/client to ensure that they understand that every floor is different.
- In some cases, floor treatment can be over specified and needless additional costs to the client could result.
- There is very significant variance in materials, design and floor construction methods so all should be detailed.
- Some aspects may require support and assurance from the supplier, James Bligh will cover aspects related to layer materials

Getting the specification right – floating floors (Why)

- Floating floors comprise of a rigid layer supported by isolating elements over an air void.
- If stiffness of the floating floor, the isolator response and air void are correct, high levels of isolation can be achieved against impact noise.
- Typical only option to isolate weight drops sufficiently on suspended slabs.
- Broadly, floating floors supported by springs are necessary to significantly reduce energy in the 63Hz band and below.

Getting the specification right – floating floors (Properties)

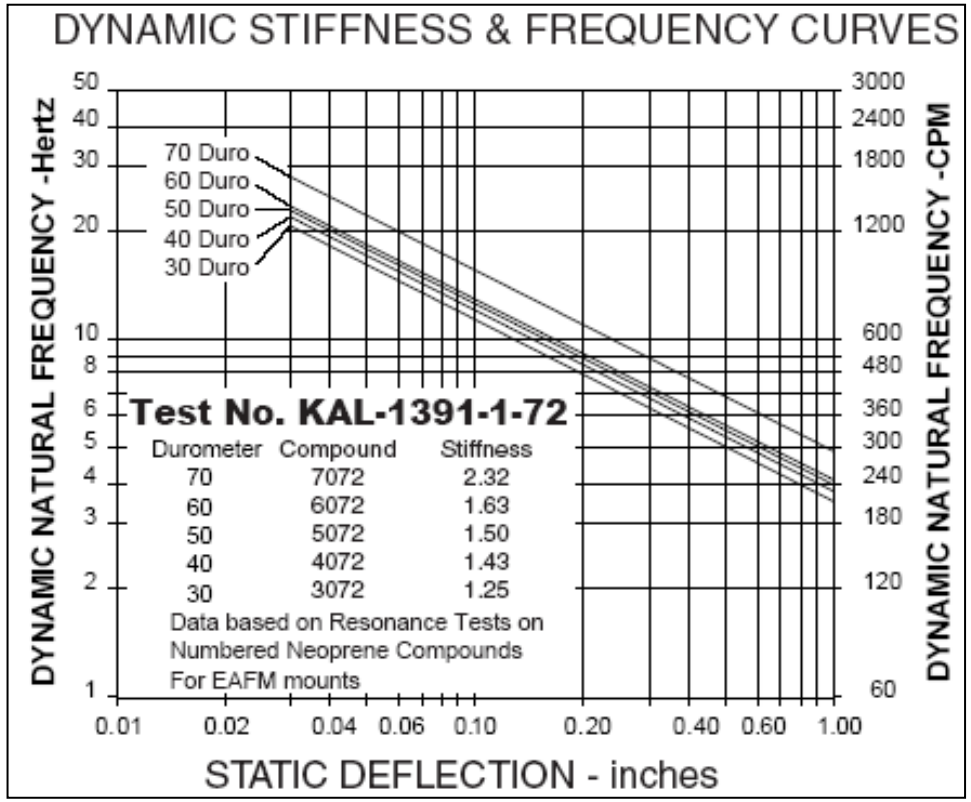
- Due to responsiveness of supporting structural floor or need for good low frequency attenuation,
- Damping characteristics critical and central to low frequency performance.
- Achieving correct natural frequency with respect to structural relies on correct application of live and equipment loading
- Product submittals should include calculations substantiating these points.

Getting the specification right – floating floors (Details…)

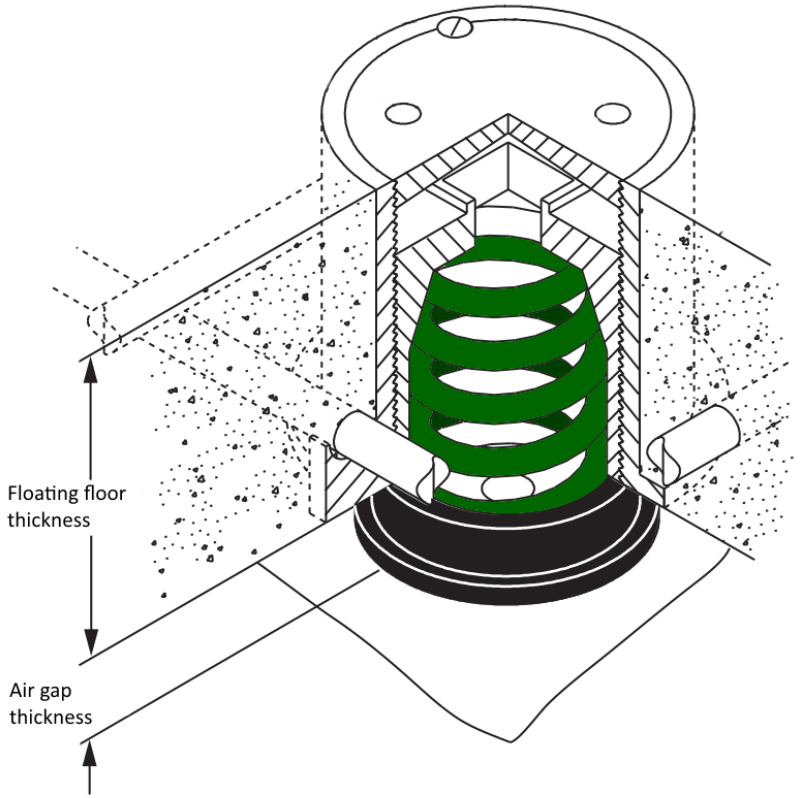
- Millimetres matter, without accuracy of design and installation calculations are redundant.
- All isolating elements to be individually adjustable or shimmed to ensure uniform load and performance of floating floor across the floor plate for floor level and assured response.
- Alternatively proof of uniform load across the floor plate, such as level survey would be equally acceptable.

Getting the specification right – floating floors (details…)

- If elastomeric, the dynamic stiffness can be specified by either the acoustician or the supplier. Typically, this would be a maximum of 1.4 and should not change over the design life of the project.
- If spring, they should sit in an elastomeric cup capable of eliminating spring ring frequencies.
- The maximum creep should be limited to 25% deflection or other suitable standard.



Getting the specification right – floating floors (Outline spec')



- Specify the minimum air gap required and if necessary, venting measures.
- Specify the minimum floating floor thickness and mass.
- The floor design should provide consistent response irrespective of floor loading due to equipment or other features.

Submission quality for review

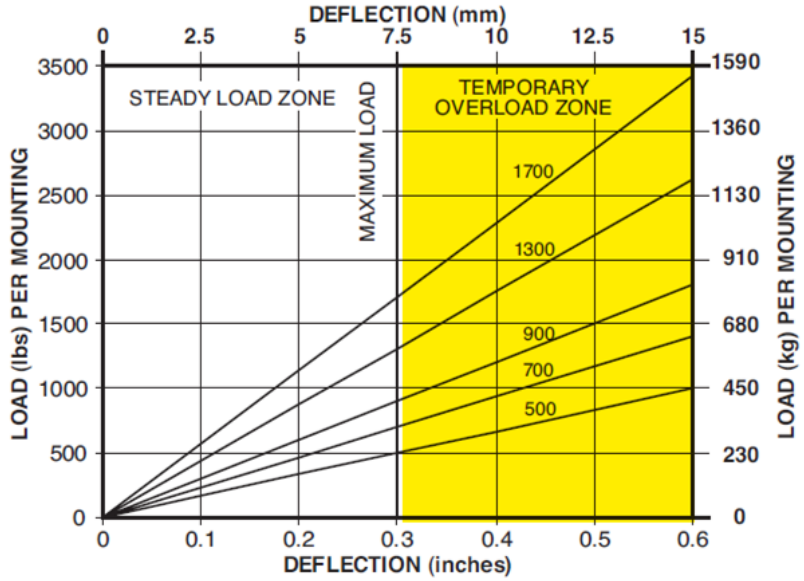
- Detailed product drawings and load/deflection curves of all isolating elements;
- AASHTO (see table 5), BS EN 1337-3-:2005, or agreed equivalent on properties related to product longevity from an accredited independent laboratory for all elastomeric compounds used, in order to ensure that isolators will not stiffen or crush for a suitable period; 50 years is appropriate for semi-permanent floating floor isolators;

PHYSICAL PROPERTIES			TESTING FOR AGEING				
			HEAT RESISTANCE (70h/70°C)			OZONE	COMPRESSION SET
Tests: ASTM D-2240 and D-412			ASTM D-573			ASTM D-1149	ASTM D-395
Hardness (Shore A Durometer)	Tensile Strength (min)	Elongation at Break (min)	Hardness Change (max)	Tensile Strength Change (max)	Elongation at Break Change (max)	25 pphm in air by volume 20% strain 400C	22 hours 700 C (max creep)
50 +/- 5	15.5 MPa	450%	10%	-25%	-25%	No Cracks	25%
60 +/- 5	15.5 MPa	400%	10%	-25%	-25%	No Cracks	25%
70 +/- 5	15.5 MPa	300%	10%	-25%	-25%	No Cracks	25%

Submission quality for review

- For elastomeric elements supporting a floating floor, independent laboratory testing demonstrating that dynamic stiffness does not exceed 1.4 (not relevant for all products);

- All elastomeric elements capable of minimum 200% overload and spring capable of 150% overload to account for live loading;



Submission quality for review

- A drawing or drawings showing:
- Dead, live and concentrated loads;
- Isolator sizes, locations and characteristics;
- All interface details requiring a soft/isolation joint;
- Seismic/blast elements as required and supporting calculations;
- Any penetrations and interface details;
- Outline construction detail.

Expectation of Supply and Construction

- The supplier and/or installer should be responsible for providing guidance to the client on the planning and correct installation of the floor system:
- Assessment of suitability of site for proposed works, for example logistics;
- Provide a full construction drawing supported by applicable PI cover;

Expectation of Supply and Construction

- Be capable of providing support as required by the client, to include:
- Risk assessment and method statements (RAMS) and other advice on health and safety;
- Supervision of installation and/or full installation service with appropriately qualified and experienced staff.

Problematic Gym Equipment

- Where problematic Gym equipment is to be used, isolation can be just to those machines rather than full floor systems, examples are:

- Leg press – often a heavier weight is ‘pushed’ when using a leg press compared to other resistant machines and this resultant impact can be reduced by including specialist impact washers to the base of the weight stack and guide rails reducing the potential impact into the slab.

Problematic Gym Equipment

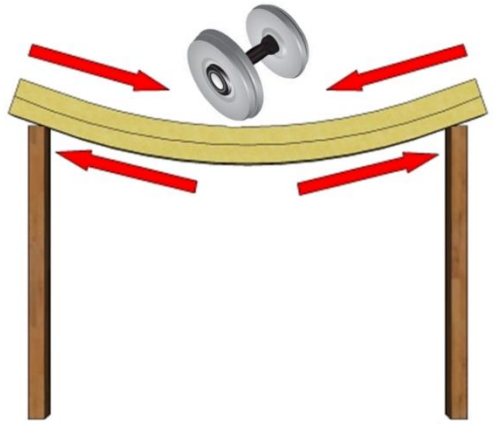
- Olympic lifting platforms – these can be isolated locally, typically on a suitable isolating floor system with suitable mass and strength to deal with point load impacts, the project acoustic and structural consultant should also have input on the suitability.

Summary – Specification

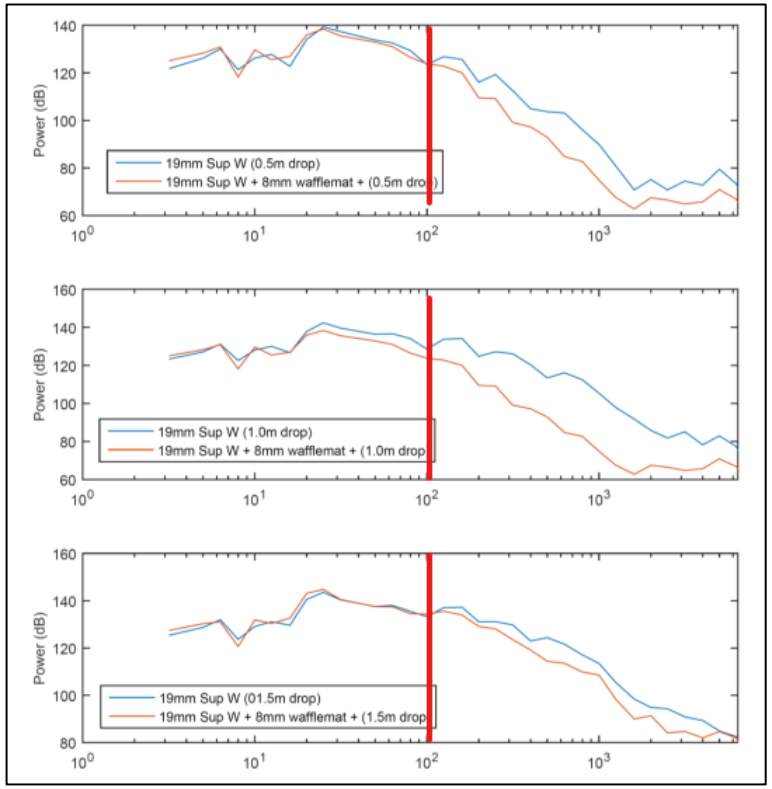
- Experience shows the system is complex as driven by activity and structural response.
- Site testing is a valuable resource but is not always viable and introduces other variables.
- Deeper understanding is necessary to provide accurate predication of insertion loss.
- Characterisation of the floating floor essential first step – remove variables.
- The location has a high stiffness/inertia structural slab by design
- Insertion loss is used rather than transmissibility to produce data independent of supporting structure.

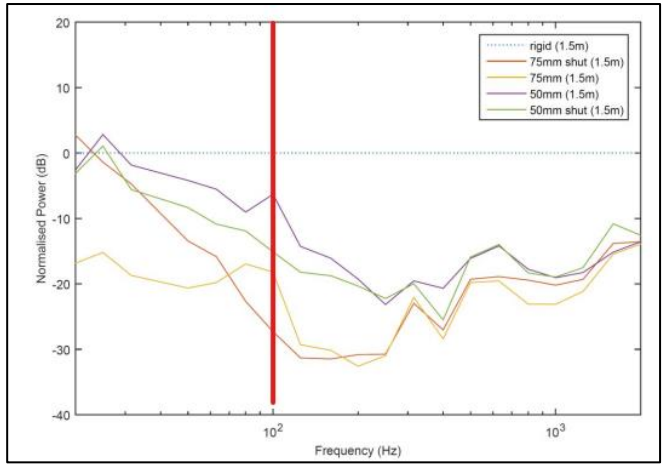
Floating Floor Complexities

- Controlling impact noise from gyms remains a complex problem.
- Experience does not allow us to predict the outcome for a given project
- To aid generation of a prediction method a test validated FEM was constructed.
- Implications of the research.



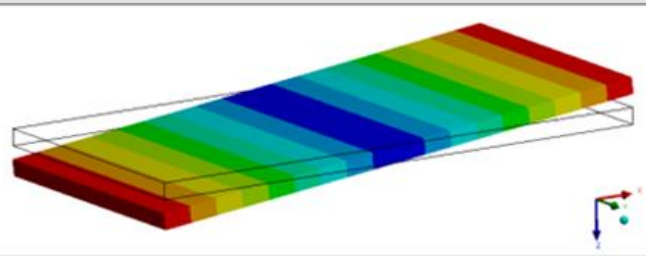
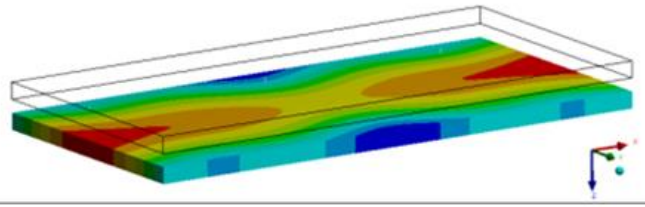
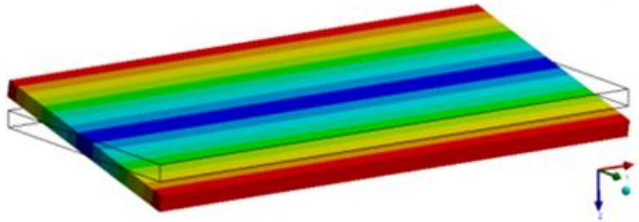
Floating Floor Complexities

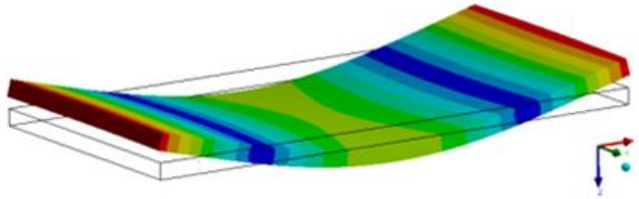
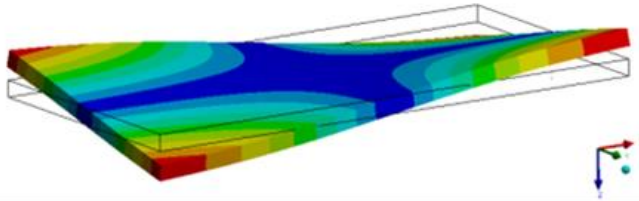
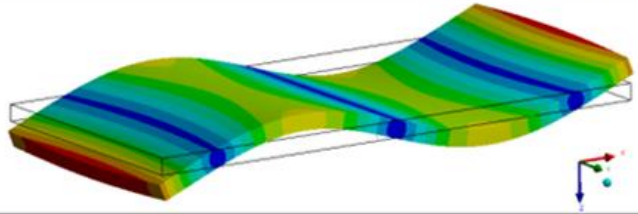




- Functionally springs are used for gyms due to low frequency attenuation, below 100Hz.
- Lack of damping provides ability to attenuate from <10Hz so hence crucial for preventing structural excitation.
- However…

Floating Floor Complexities

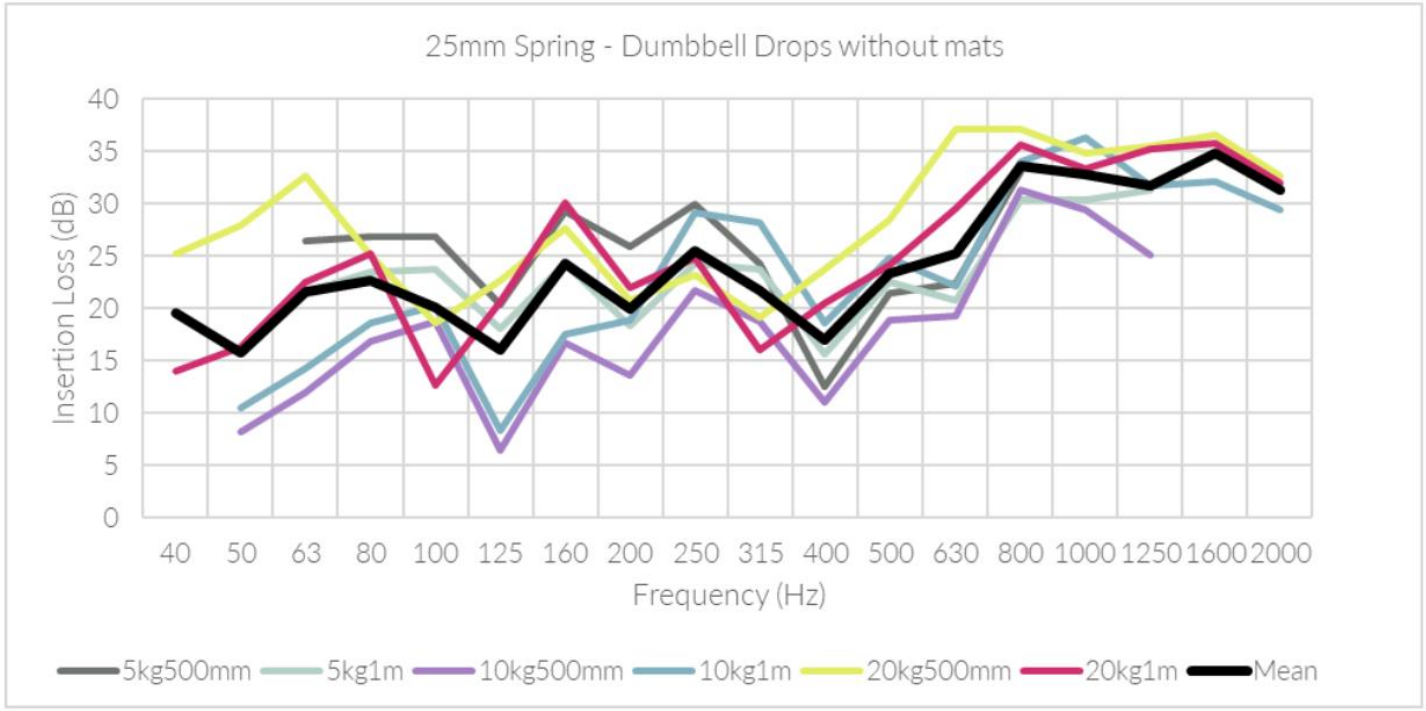
Mode	Modeshape	Frequency	Description
1		≈3.10 Hz	1st rocking mode about central y-axis (shorter dimension)
2		≈3.10 Hz	Rigid body mode (Mass-on-spring)
3		4.02 Hz	2nd rocking mode about central x-axis (longer dimension)

Mode	Modeshape	Frequency	Description
4		33.96 Hz	1st bending mode
5		43.26 Hz	1st torsional mode
6		92.53 Hz	2nd bending mode

- Modes of floating floors are affected by activity and response/placing of isolators.

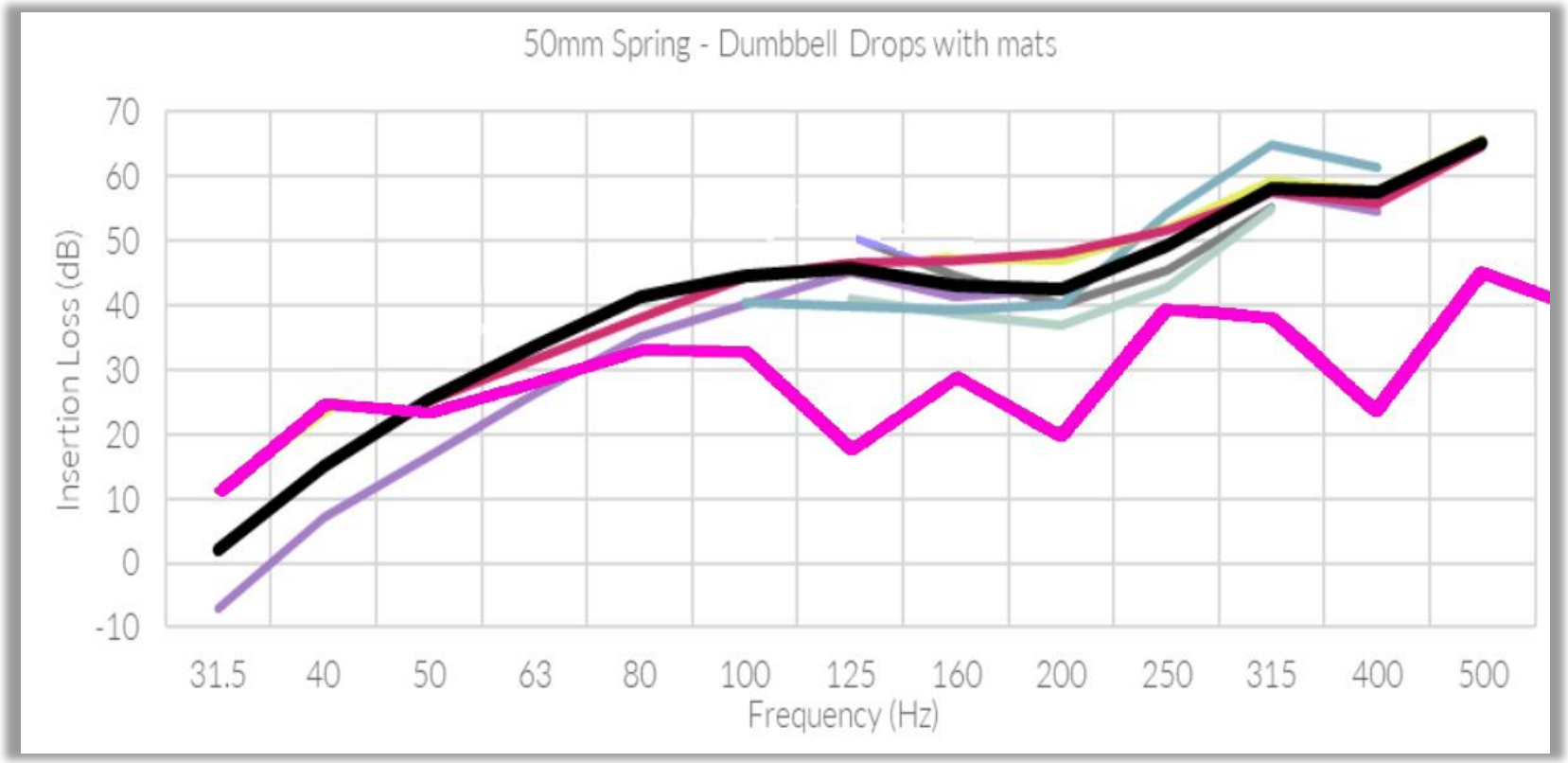
Summary

- How consistent is insertion loss between different activities?
- Critical for knowing independent of activity
- Consistent pattern to insertion loss irrespective of activity – showing linear response.



Summary

- What are the effects of covering layers?
- Covering layers add damping and ‘smooth’ data.
- Exhibited some magnification at low frequencies but benefit towards above 63Hz band.



Specification and Mitigation – Floor Covering Responsibilities

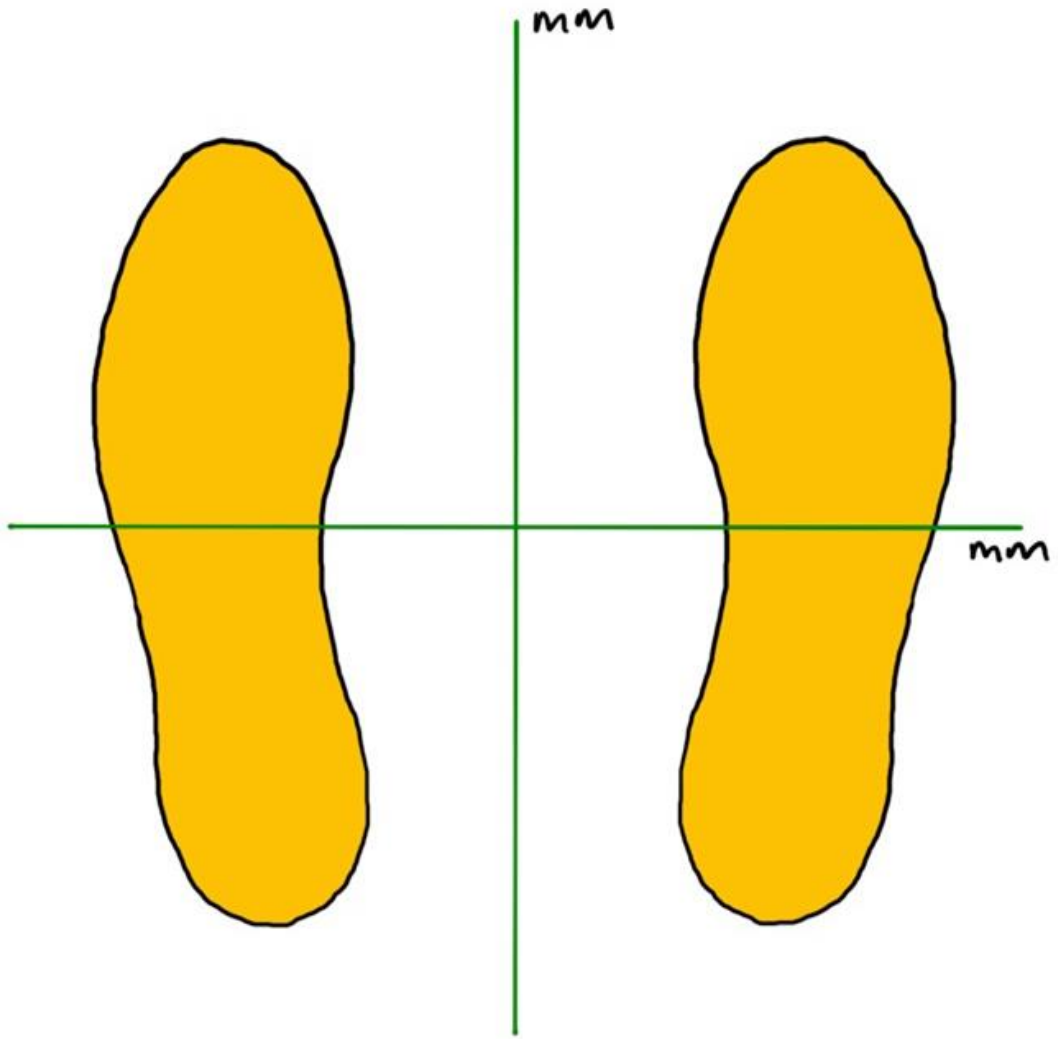
- Large variation in product types and limitations in each of these, and degrees of technical information available on the market. Engaging with suppliers early on in design will steer achievability of requirements and provide solid basis of likely acoustic outcome.

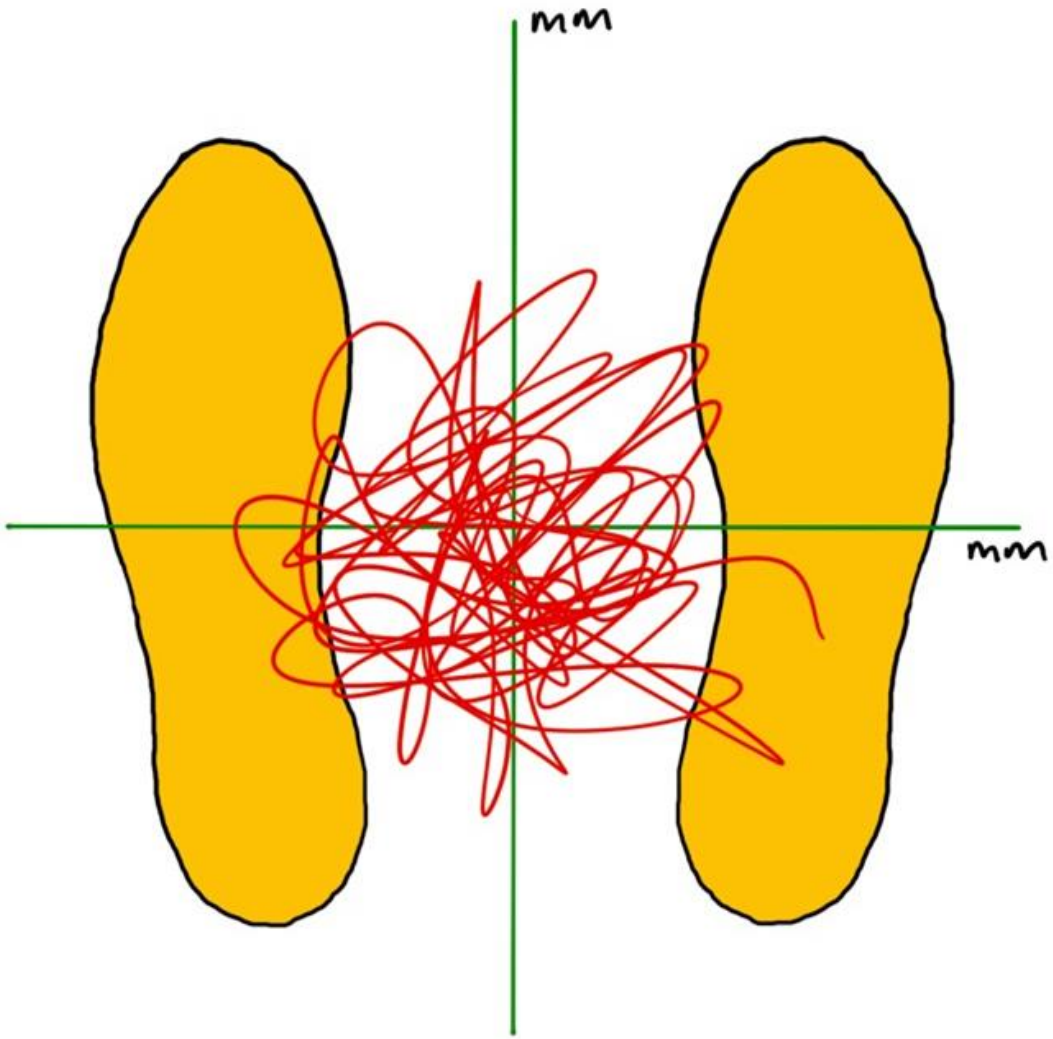
- Onus should be on suppliers to interface with Acoustic and Structural Consultants' requirements using correctly measured/quantified data for their products.

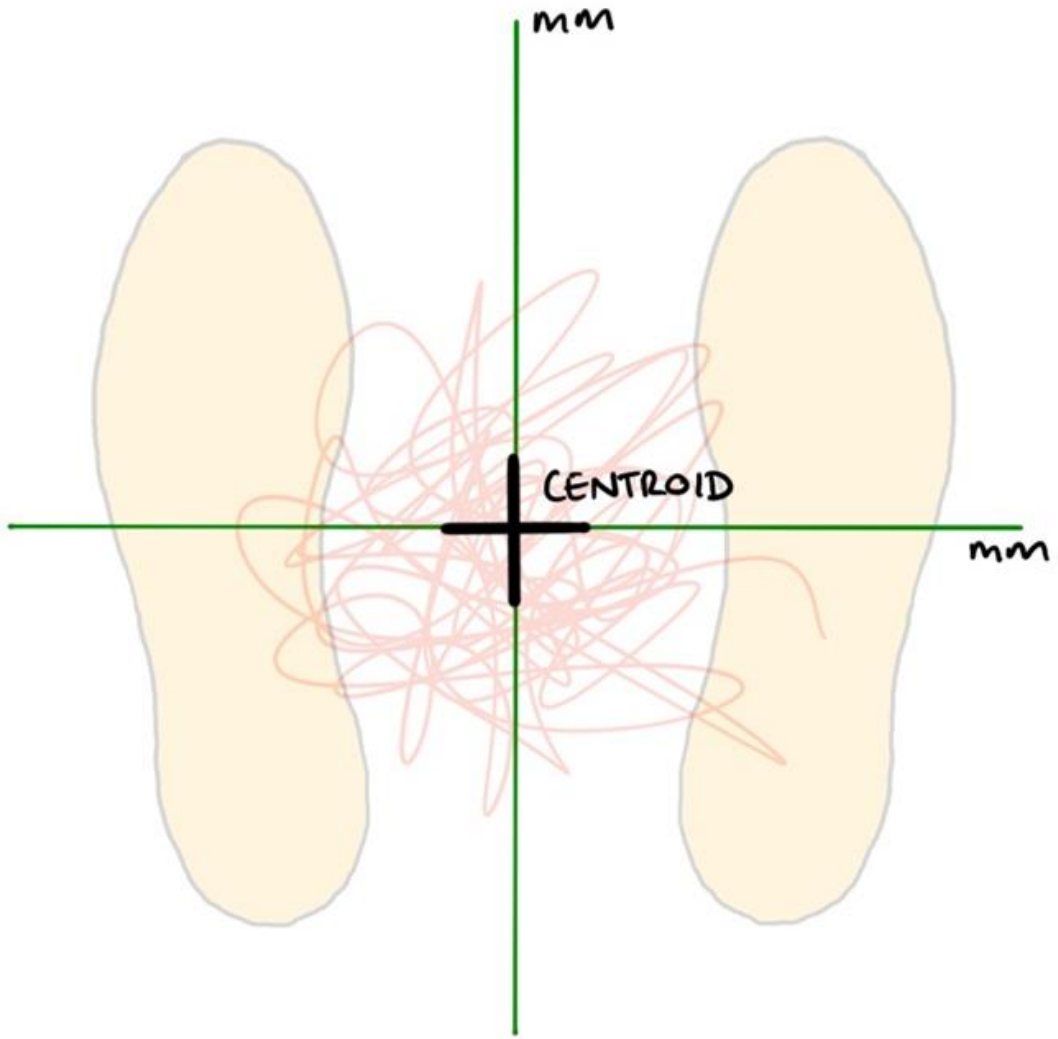
- In-situ testing samples from suppliers that are demonstrably representative of completed floor construction, and are suitable for use.

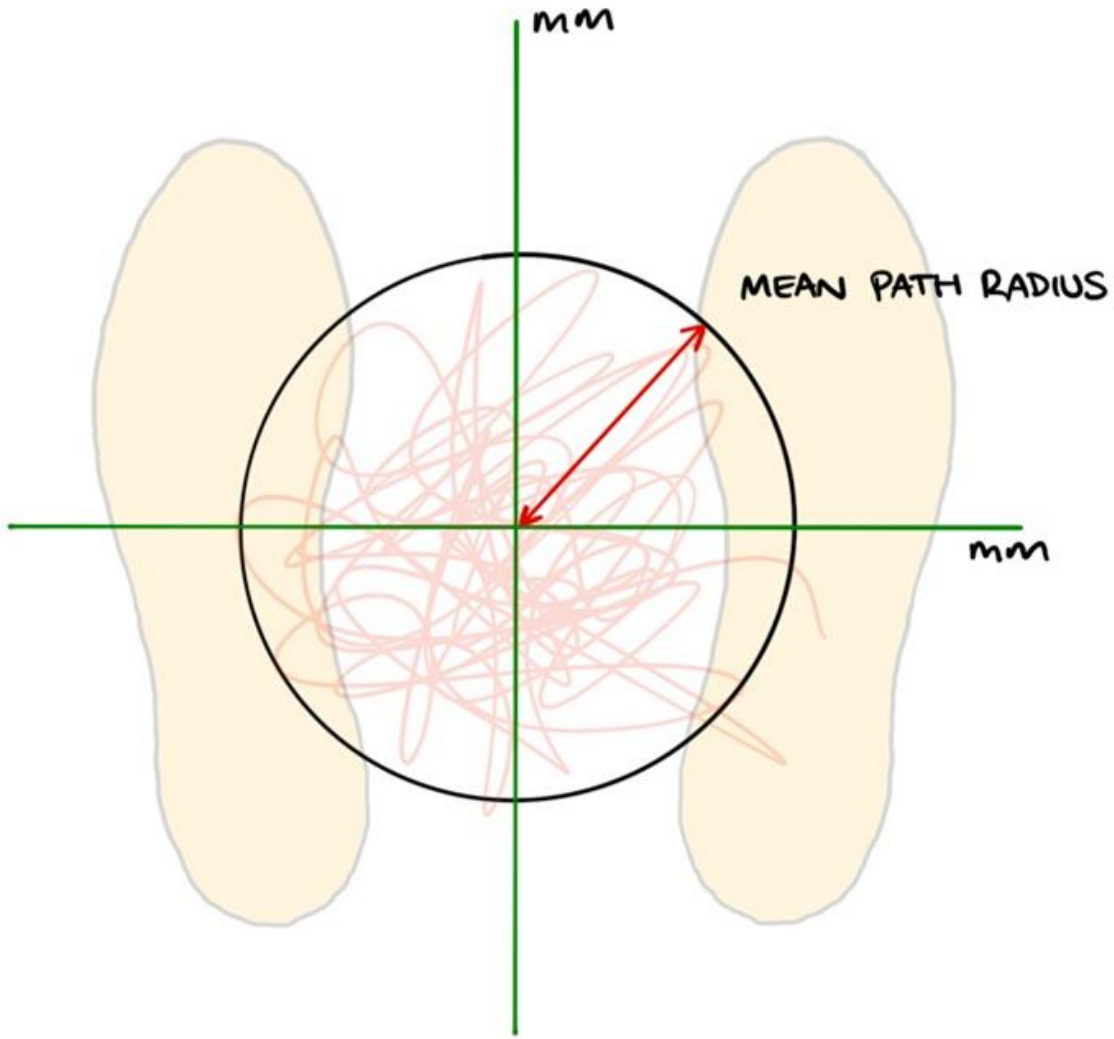
Specification and Mitigation - Floor Coverings Considerations

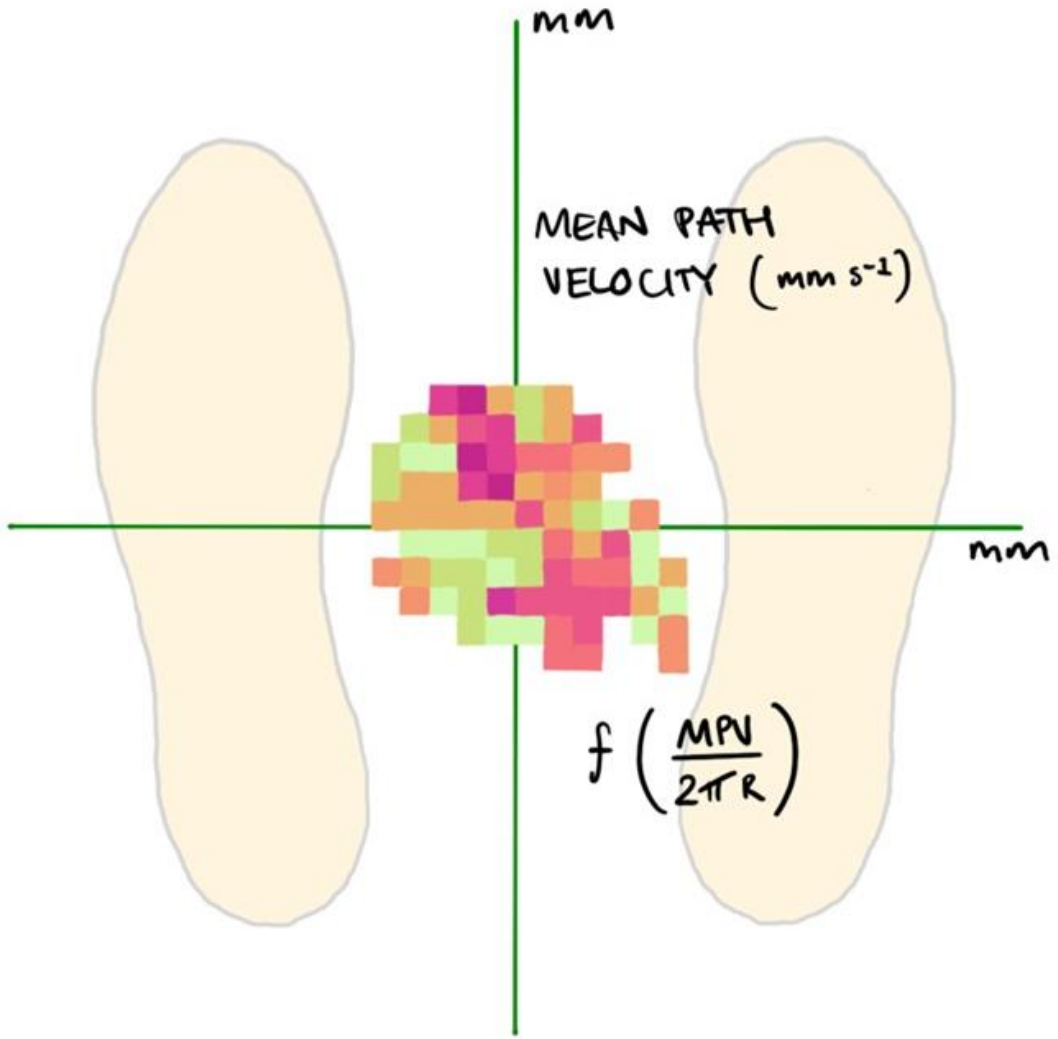
- Foot stability under varying loads (stabilometry) should always be a consideration when specifying resilient floor coverings to avoid risk to users.


mm
mm

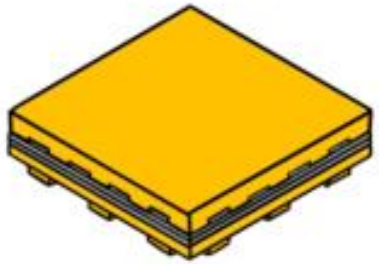

mm
mm


mm
CENTROID
mm

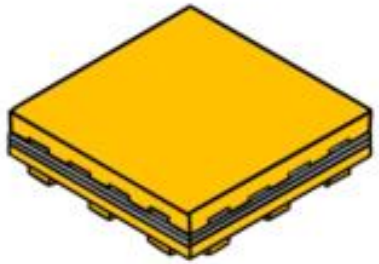

mm
MEAN PATH RADIUS
mm

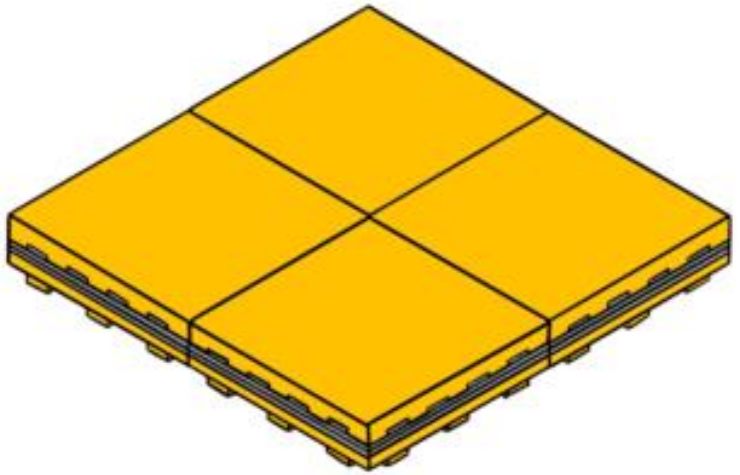

mm
MEAN PATH
VELOCITY (mm s⁻¹)
mm
f (MPV / 2πR)

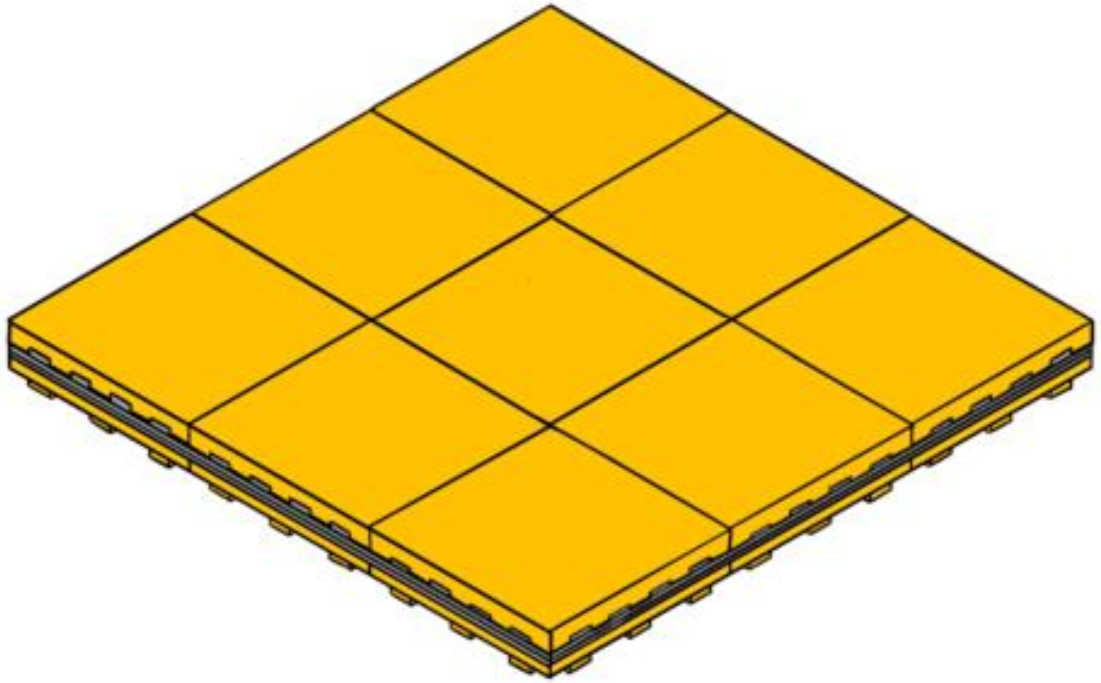
Accuracy of in situ testing with floor samples may have limitations, too …

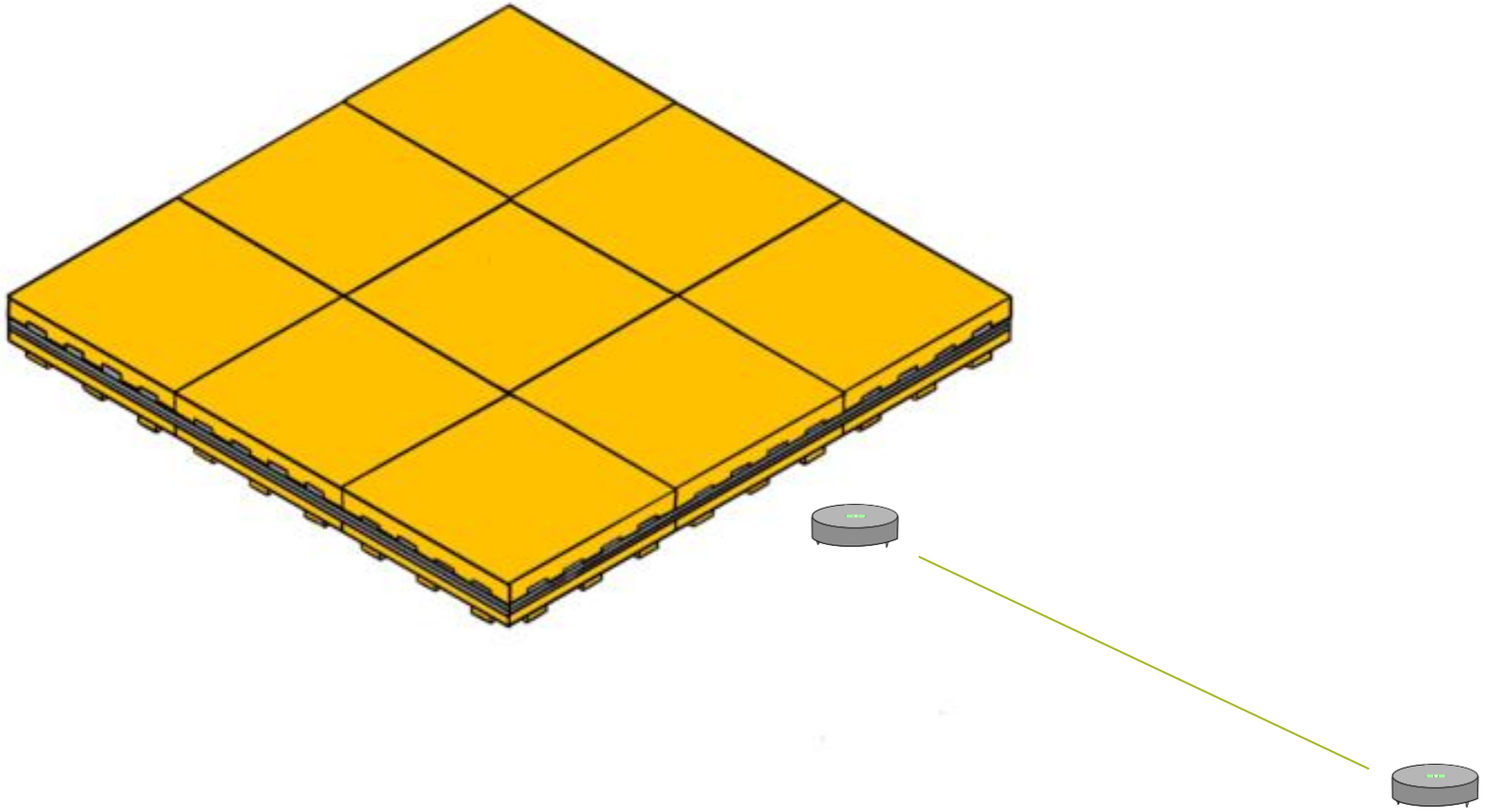


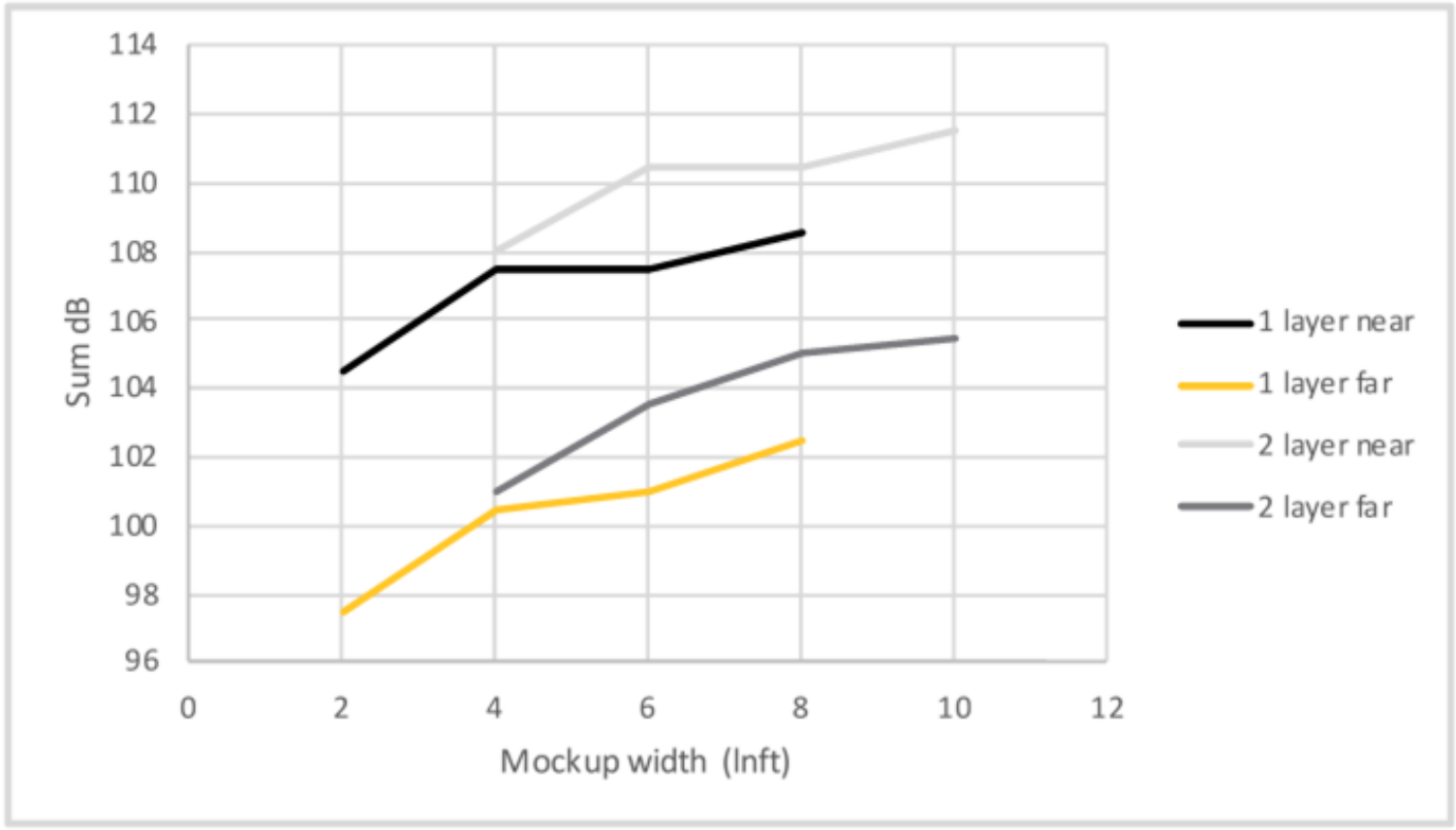
In situ test sample size










114
112
110
108
106
104
102
100
98
96
Sum dB
0
2
4
6
8
10
12
Mockup width (lnft)
1 layer near
1 layer far
2 layer near
2 layer far

Specification and Mitigation - Manufacturer's Role and Test Data

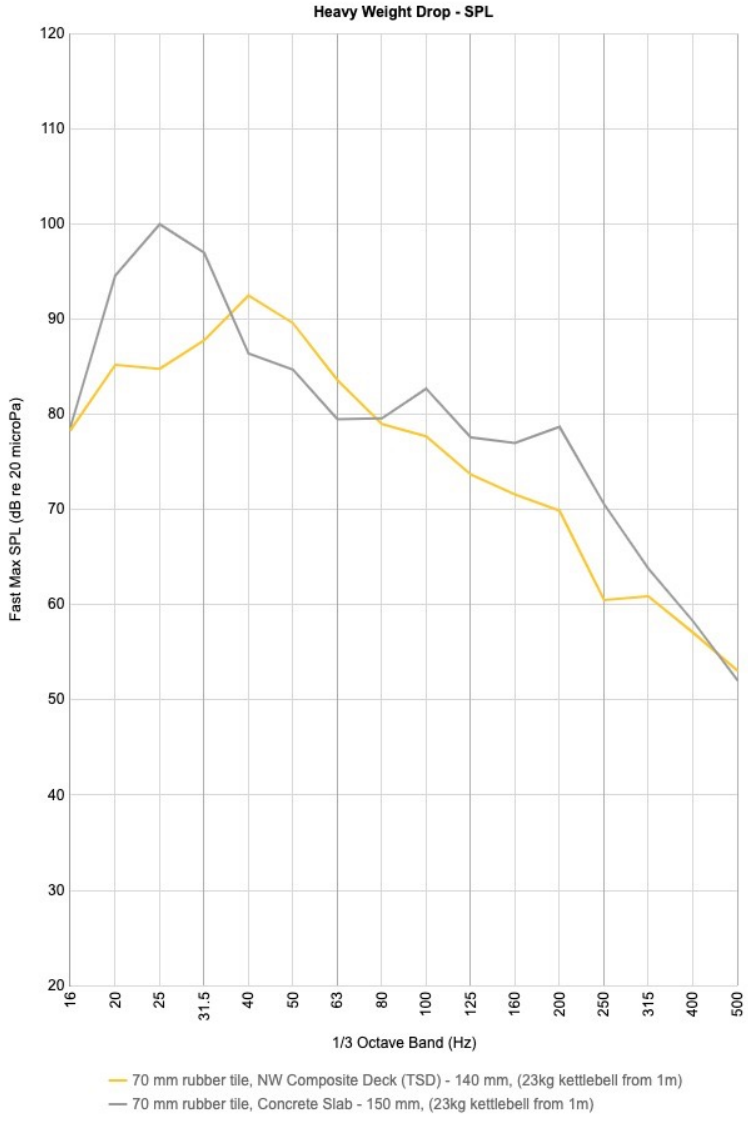
- Given the large material type variation between manufacturers, there are many routes to demonstrating compliance with performance requirements. This may be through prediction modelling, in-situ or third party laboratory measured performance values.

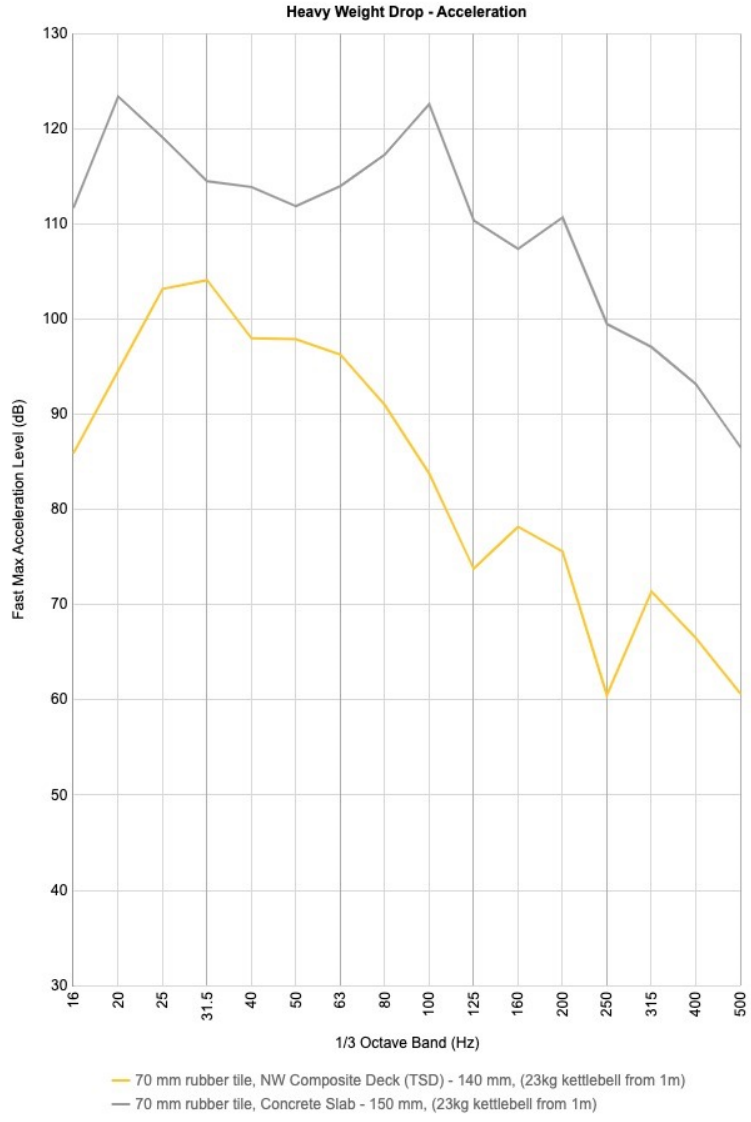
- Manufacturers must produce data that is not only objectively verifiable, but interfaces with performance requirements (i.e. Δ reduction in SPL, acceleration or force, or target Fn for floating floor design).

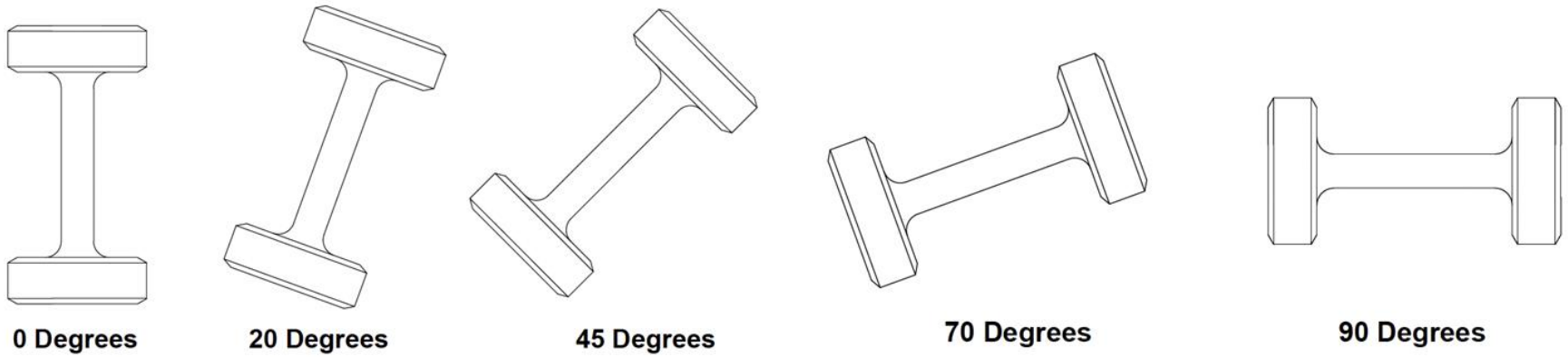
- 'Equal or approved' product shopping naturally happens during the procurement process but provision of the above information ensures that the Acoustic Consultant's performance metrics are met, regardless of procurement paths.

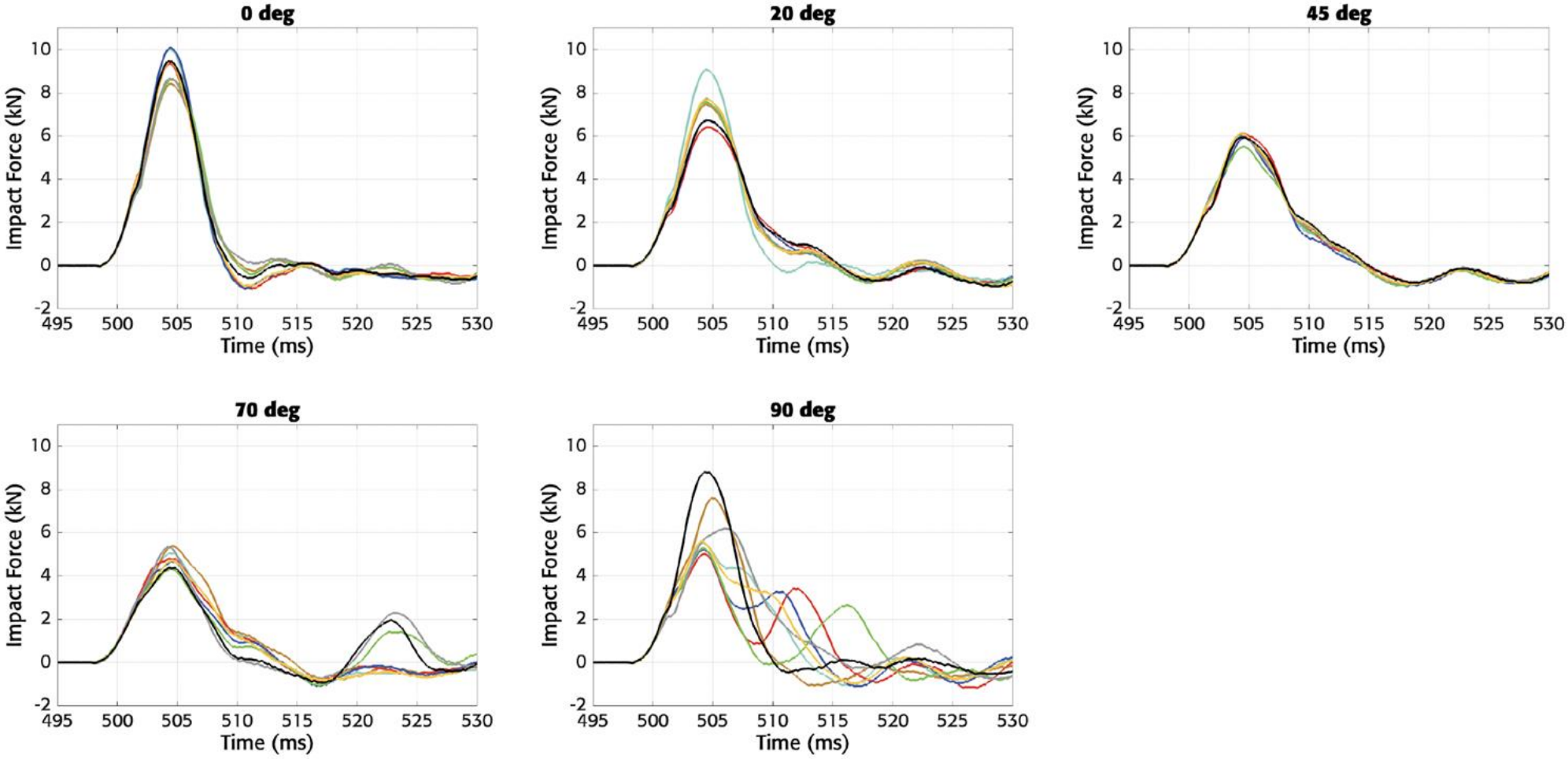
Variables in Floor Covering Performance Considerations

- In situ performance can vary significantly compared to laboratory or previous site measurements given variation in structural types (ground bearing, suspended, column and beam type), weight size, drop height and impact source.


Heavy Weight Drop - SPL
Fast Max SPL (dB re 20 microPa)
120
110
100
90
80
70
60
50
40
30
20
16
20
25
31.5
40
50
63
80
100
125
160
200
250
315
400
500
1/3 Octave Band (Hz)
70 mm rubber tile, NW Composite Deck (TSD) - 140 mm, (23kg kettlebell from 1m)
70 mm rubber tile, Concrete Slab - 150 mm, (23kg kettlebell from 1m)

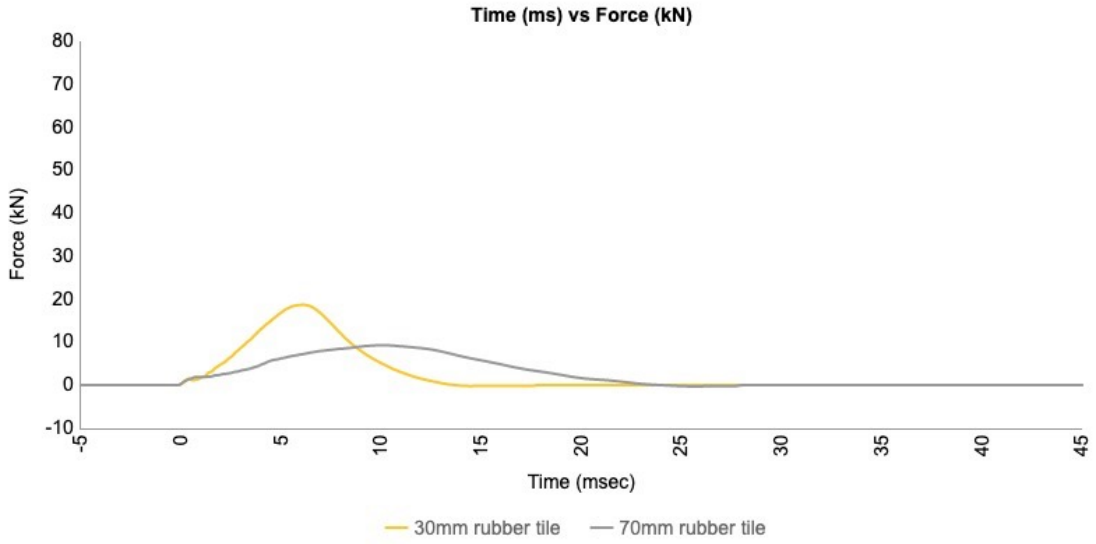

Heavy Weight Drop - Acceleration
Fast Max Acceleration Level (dB)
130
120
110
100
90
80
70
60
50
40
30
16
20
25
31.5
40
50
63
80
100
125
160
200
250
315
400
500
1/3 Octave Band (Hz)
70 mm rubber tile, NW Composite Deck (TSD) - 140 mm, (23kg kettlebell from 1m)
70 mm rubber tile, Concrete Slab - 150 mm, (23kg kettlebell from 1m)

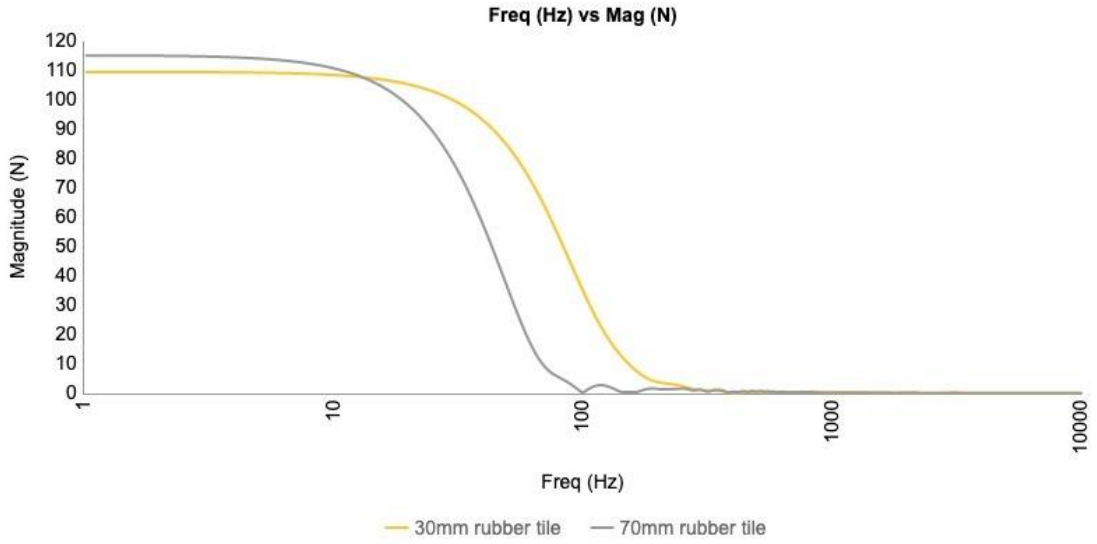

0 Degrees
20 Degrees
45 Degrees
70 Degrees
90 Degrees

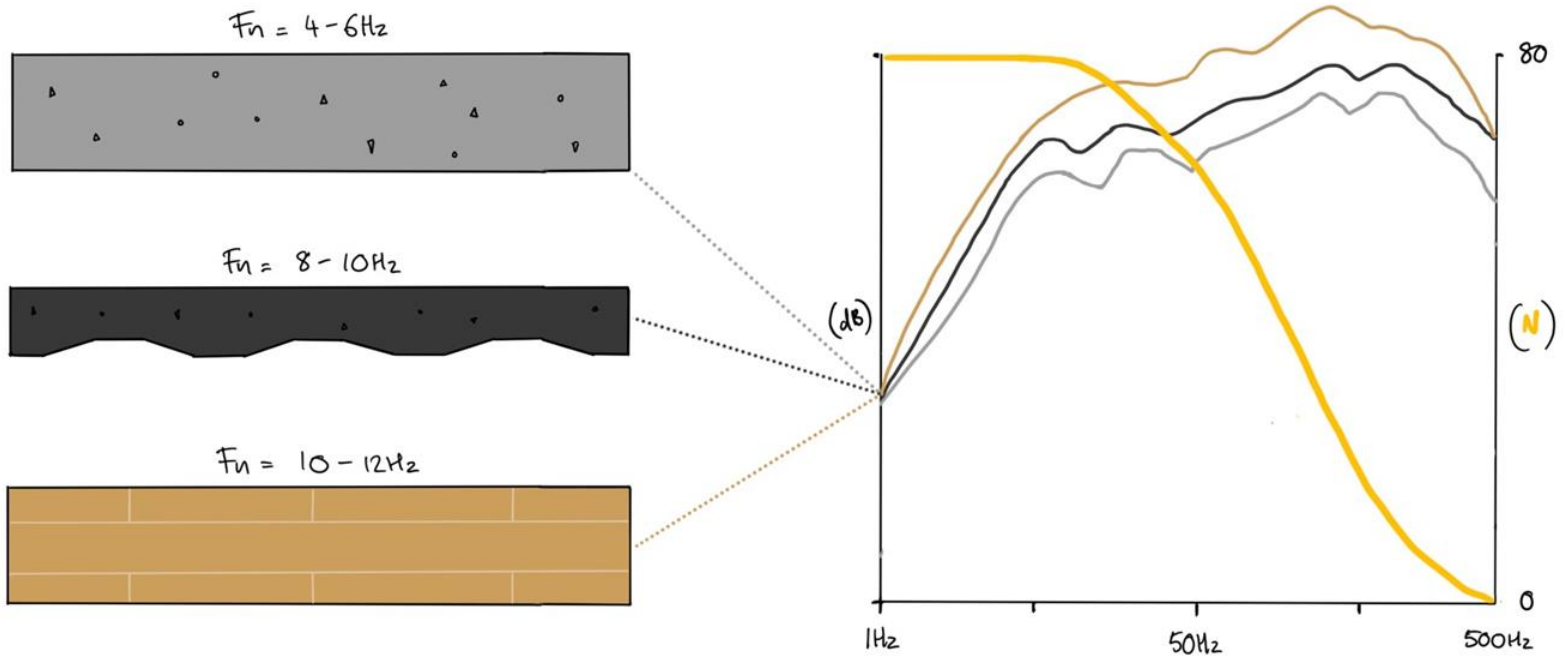

0 deg
20 deg
45 deg
70 deg
90 deg
Impact Force (kN)
Time (ms)
10
8
6
4
2
0
-2
495
500
505
510
515
520
525
530

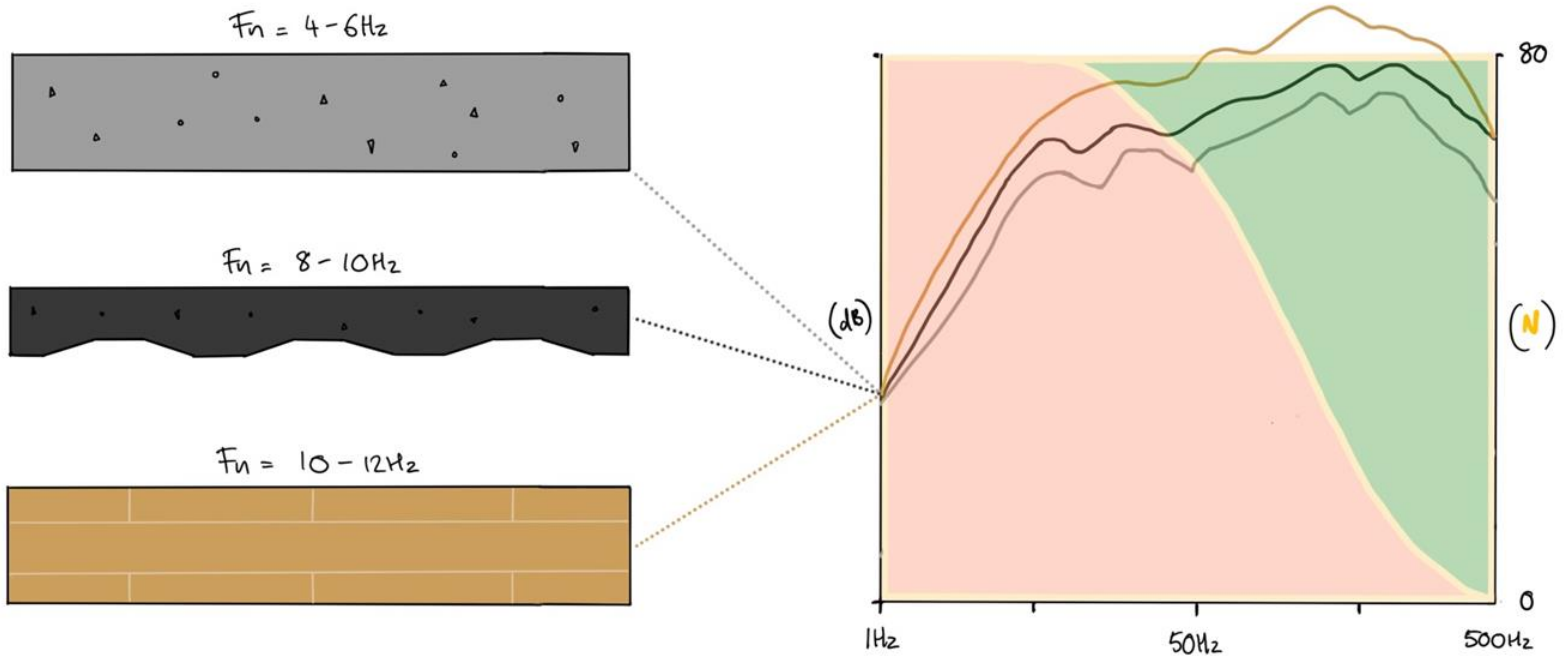
Force Pulse and FFT Performance Data

- Time domain force pulse and FFT analysis of standardized heavy hard impacts can be helpful in determining best product selection relative to structural base and/or floating floor specification. (see page 36, Figures 7 & 8). ‘Hybrid’ (combination of locally and resonantly reactive) systems will be required to achieve upper end of performance estimates given in Table 4 (page 40).


Time (ms) vs Force (kN)
Force (kN)
80
70
60
50
40
30
20
10
0
-10
-5
0
5
10
15
20
25
30
35
40
45
Time (msec)
30mm rubber tile
70mm rubber tile

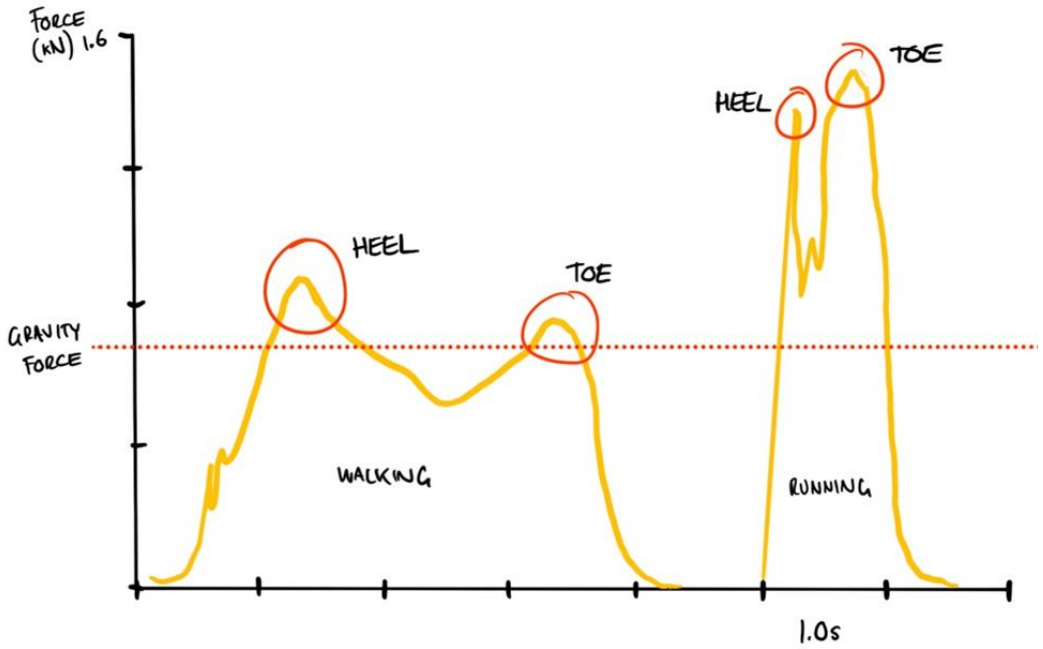

Freq (Hz) vs Mag (N)
Magnitude (N)
120
110
100
90
80
70
60
50
40
30
20
10
0
1
10
100
1000
10000
Freq (Hz)
30mm rubber tile
70mm rubber tile

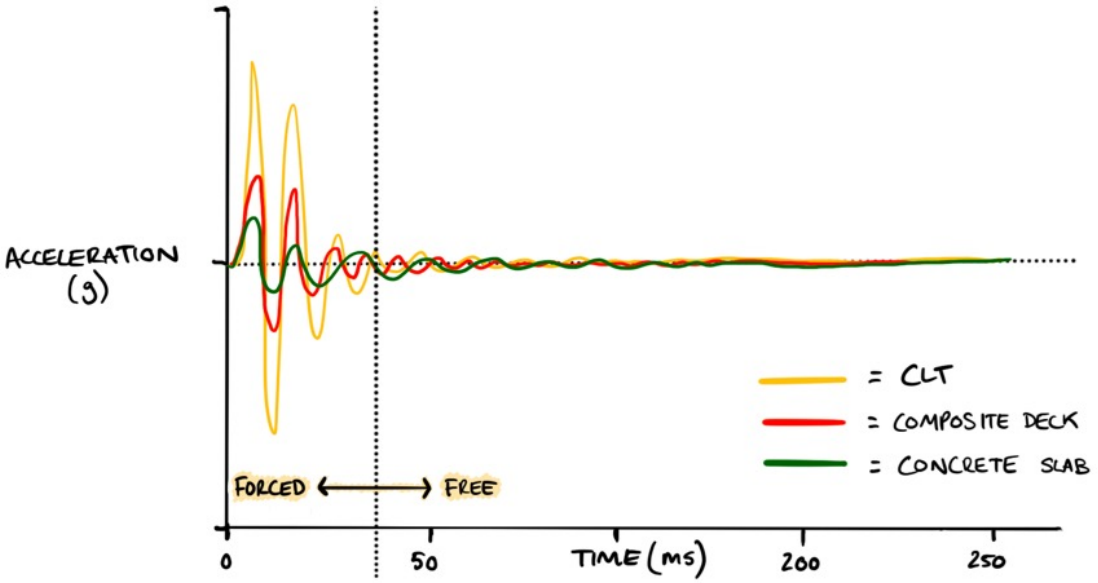

Fn = 4 - 6Hz
Fn = 8 - 10Hz
Fn = 10 - 12Hz
(dB)
80
0
(N)
1Hz
50Hz
500Hz


Fn = 4 - 6Hz
Fn = 8 - 10Hz
Fn = 10 - 12Hz
(dB)
80
0
(N)
1Hz
50Hz
500Hz

- Floor coverings tend to top out at a corner frequency of 20Hz when considering a single layered tiled system. ‘Meaningful’ isolation begins 50Hz and above from single tiled systems, so composite layers (or hybrid systems) may be used.

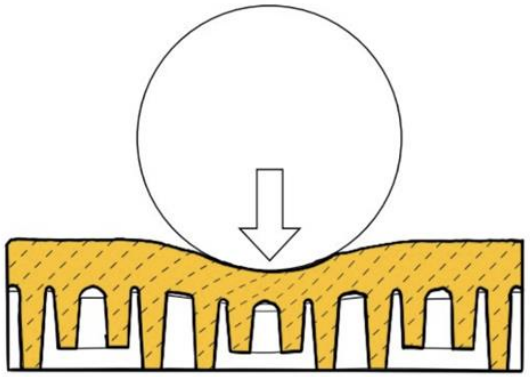
- Impact source/type matters in terms of mitigation approach, i.e. locally vs resonantly reactive


FORCE (kN) 1.6
GRAVITY FORCE
HEEL
TOE
WALKING
HEEL
TOE
RUNNING
1.0s


ACCELERATION (g)
= CLT
= COMPOSITE DECK
= CONCRETE SLAB
FORCED
FREE
0
50
TIME (ms)
200
250

LOCALLY REACTIVE

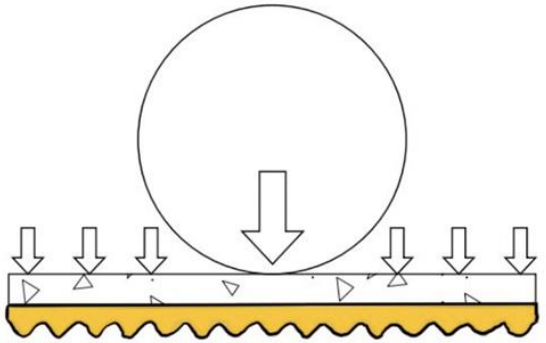
APPLIED LOAD RESULTS IN LOCALIZED DELFECTION



RESILIENT TILE

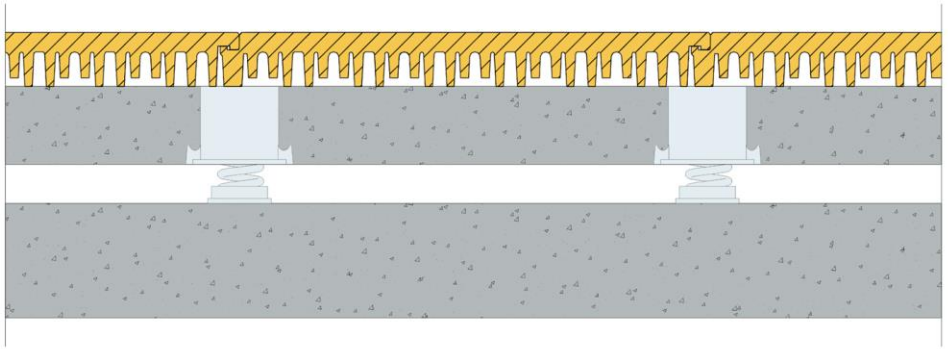
RESONANTLY REACTIVE

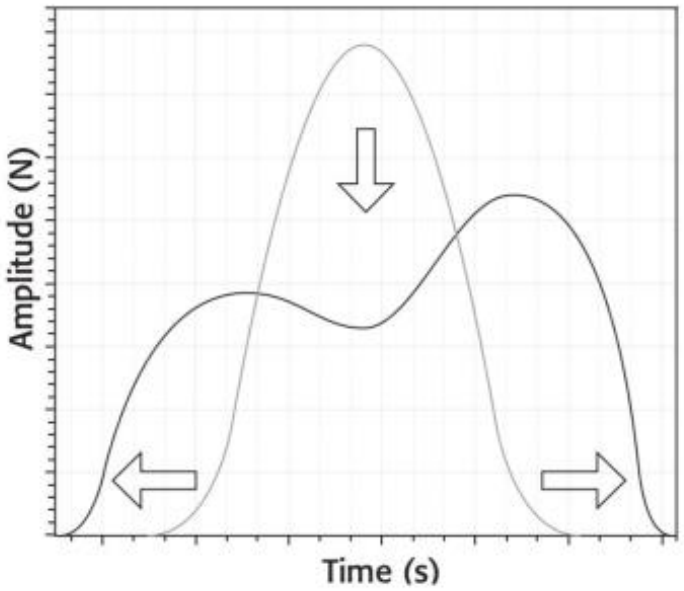
APPLIED LOAD RESULTS IN DISTRUBUTED DEFLECTION



RIGID LAYER & RESILIENT UNDERLAYMENT

LOCALLY REACTIVE ABOVE RESONANTLY REACTIVE CREATES A HYBRID SYSTEM





Summary

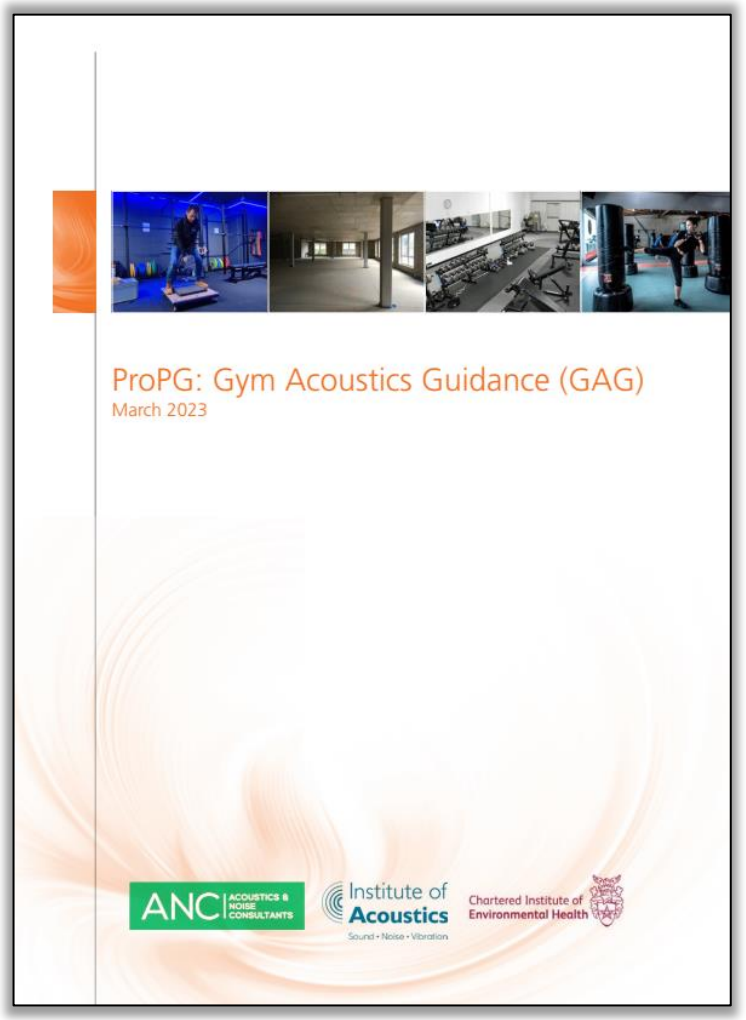
- Details and design matters, if inadequate performance will suffer and cost wasted.
- Retrospective measures are very difficult and introduce additional costing.
- Getting it right first time requires a detail orientated approach.
- Ensuring a long-lasting solution is important, captured by details outside immediate acoustic performance.

Round-up & launch

Shortly the wheels of progress will grind into action and the ANC, IOA and CIEH will formally publish this ProPG on Gym Acoustics Guidance on their websites.

The guidance will formally go live, and will be reviewed in a years time.

THANK YOU


ProPG: Gym Acoustics Guidance (GAG)
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ANC ACOUSTICS & NOISE CONSULTANTS
Institute of Acoustics
Sound • Noise • Vibration
Chartered Institute of Environmental Health