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21 October 2020

Mr M. Flewellen
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Email: mark.flewellen@reseneconstruction.co.nz

Dear Mark

Re: Resene Integra Flooring Systems – Acoustic Appraisal

Acoustic Engineering Services Ltd has been engaged to provide acoustic engineering advice with regard to the acoustic performance of Integra Flooring Systems. We have modelled the flooring system to assess the acoustic performance and have provided our opinion of the performance of the system with a number of construction variables, and relative to other typical flooring systems.

Please find our analysis and opinion below.

1.0 PERFORMANCE CRITERIA

There are a number of acoustic metrics that can be used to define the level of sound insulation provided by a flooring system. We have presented the Sound Transmission Class (STC) and Impact Insulation Class (IIC)[1] as these are most commonly used in New Zealand.

The STC represents the reduction in airborne noise levels that can be expected between spaces for typical indoor noise sources such as human speech. It is determined by playing a sound in one room and measuring the level in an adjacent room, and describes airborne noise transmission only.

To quantify the level of structure borne noise such as footfall or tapping from the room above the IIC is used. The IIC is a measure of impact noise transmission between floors and is determined by operating a tapping machine on the floor and measuring the noise generated in the room below. The IIC provides some indication of the system's ability to prevent both low frequency frequency thumping and high frequency clicks and clacks, although it is weighted more to high frequency noise.

2.0 AIRBORNE SOUND INSULATION

Subjectively the noise reductions that can be expected with various numerical STC ratings are given below:

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[1] We note that R_w – Weighted sound reduction index and $L_{n,w}$ – Weighted normalized impact sound pressure level are also used sometimes in New Zealand; however, we have presented STC and IIC only as the R_w and STC are generally interchangeable usually only differ by 1 point or so for the same floor build up and the IIC and $L_{n,w}$ are related by the equation $L_{n,w}$ = 110 – IIC.

- STC 30

  Sentences and phrases may be understood if background noise levels are low in the receiving room. At the higher end of this range the speech becomes unintelligible.

- STC 40

  The occupant would have to strain to hear normal speech, even if the adjoining space has a low background noise, while raised voices may be audible but would likely be unintelligible.

- STC 50

  Expected to reduce quiet and normal speech to be largely inaudible, even when the receiving space is relatively quiet. Noise from amplified music and low-frequency bass beats may still be audible with this level of separation.

- STC 60 +

  These constructions reduce most speech to inaudibility, and are used to control machinery noise (especially that with significant low frequency content, or 'rumble') including noise from plant rooms adjacent to noise sensitive spaces. To effectively eliminate almost all airborne noise sources, a STC 75 + system would be required.

For inter-tenancy situations the NZBC requires that floors between occupancies or between common spaces and habitable spaces have an STC of no less than 55.

For reference a difference of 1 - 2 STC points is inaudible, a difference of 3 – 5 STC points is a just audible change and noise transmitted between floors with a difference of 10 STC points sounds subjectively half as loud.

2.1 Tested Integra flooring systems

Auckland Uniservices Limited tested an Integra Flooring System[2]. The tested system comprised of a 75 mm Integra panel on 190 mm x 45 mm timber joists set at 450 mm centres, without any ceiling below. This system has a tested STC rating of 37.

2.2 Modelled systems

We have considered the acoustic rating of a number of variations to the above system. We have based our analysis on the modelling software Insul (Version 9.0.22) and three typical flooring build-ups using the 75 mm Integra Floor panel. These are described below along with the expected STC ratings. The ratings given are for the system as a whole and there are many variables that can change the ratings such as, the overall weight of the system, whether there is acoustic absorption to the cavity, the type of absorption in the cavity, the stiffness of each element, how rigidly the ceiling is attached to the floor system above, the depth of the cavity, and also how these variables relate to each other.

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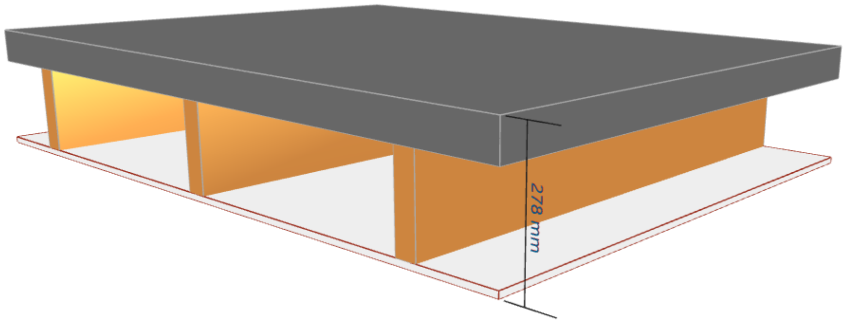
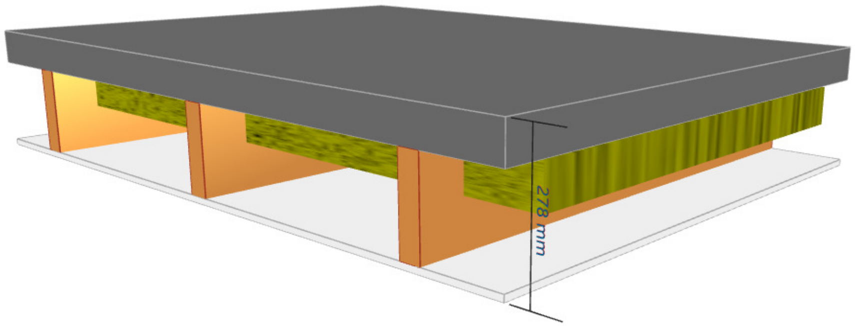
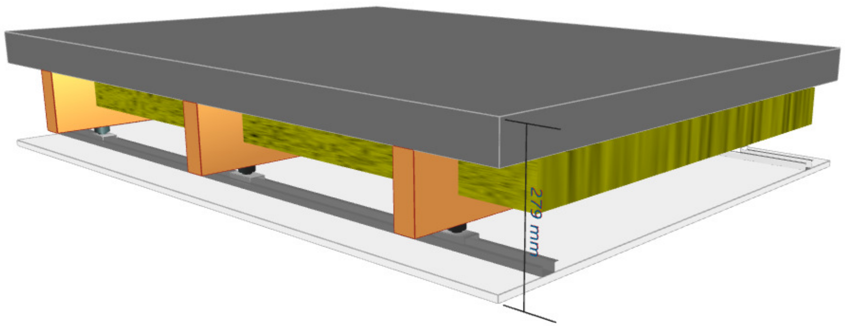
[2] Tested in accordance with ISO standard 10140-2:2010(E) *Laboratory measurement of sound insulation of building elements - Part 2: Measurement of airborne sound insulation*. Ratings were determined in accordance with ASTM E413 *Classification for Rating Sound Insulation*.

Table 2.1 – Expected airborne noise transmission loss (Images from Insul)

System			Expected ratings
System 1		75 mm Integra Floor panel / 190 mm x 45 mm timber joists (set at 600 mm centres) / 1 layer of 13 mm Standard Gib plasterboard direct fixed to the joists	This system has a modelled STC rating of 47.
System 2		75 mm Integra Floor panel / 190 mm x 45 mm timber joists (set at 600 mm centres) with 90 mm fibrous insulation to the cavity / 1 layer of 13 mm Standard Gib plasterboard direct fixed to the joists	This system has a modelled STC rating of 49.
System 3		75 mm Integra Floor panel / 140 mm x 45 mm timber joists (set at 600 mm centres) with 90 mm fibrous insulation to the cavity / 1 layer of 13 mm Standard Gib plasterboard fixed to metal channel on rubber isolation clip	This system has a modelled STC rating of 59.

2.3 Variations to the systems

The STC ratings described above relate to the system as a whole and variations to these systems do not change the ratings in a linear manner. Nevertheless we have provided our opinion of the effect of some common substitutions and variations below.

2.3.1 Alternative framing

The Integra Flooring System may be supported on either a light timber framed system or a light steel framed system. The light timber framed system may comprise of timber joists, plywood webbed joists, trussed joists, laminated timber joists, steel purlins or any combination of the above.

We expect the flooring systems described above would have similar performance the same if the timber framing outlined above was substituted for any of the framing systems listed above, provided the floor framing system has been designed for the appropriate loading, and the minimum cavity depth and joist spacing is maintained.

We note that System 1 above can be sensitive to the joist spacing and if the joists are placed closer than 600 mm apart a resonant effect could cause the rating of the system to degrade noticeably.

2.3.2 Alternative ceiling linings

The Gib plasterboard linings above could be substituted for other brands of plasterboard with the same mass (8.4 kg/m^2) and we would not expect the performance to alter noticeably. In general additional mass to the ceiling lining will increase the performance of the system as follows:

- Adding an additional layer of 13 mm Standard Gib plasterboard or substituting the 13 mm Standard Gib plasterboard for 13mm Gib Noiseline plasterboard would increase the rating by 1 – 5 points

- A ceiling comprised of 2 layers of 13 mm Gib Noiseline plasterboard would increase the modelled ratings by 2 – 8 points.

The lower end of the range generally relates to System 1 and the higher relates to System 3. Specialist acoustic advice should be sought where compliance with NZBC Clause G6 is required

2.3.3 Alternative acoustic absorption

The systems described above are modelled with 90 mm acoustic absorption with a density of 10 kg/m^2 installed within the ceiling cavity. In order to achieve the stated ratings the acoustic absorption product would need to be fibrous (glass fibre, polyester fibre, wool etc.).

Expanded polystyrene or closed cell foam are not suitable as they provide zero or very little acoustic benefit to the system.

We note that without the fibrous insulation System 3 would have an STC rating of 52 which does not meet the NZBC Clause G6 requirement of STC 55 for inter-tenancy situations.

2.4 Comparison with common flooring constructions

We have compared the Integra Flooring Systems to other common flooring constructions found in New Zealand. Based on the following build-up the STC ratings for some common flooring constructions are shown in table 2.2 below.

Table 2.2 – STC ratings of common floor systems

Sub-floor and ceiling / Flooring element	13 mm Standard Gib plasterboard ceiling direct fixed to 190 x 45 mm timber studs at 600 mm spacing (STC)	13 mm Standard Gib plasterboard ceiling direct fixed to 190 x 45 mm timber studs at 600 mm spacing with fibrous insulation to the cavity (STC)	13 mm Standard Gib plasterboard ceiling on rubber mounts on 190 x 45 mm timber studs at 600 mm spacing with fibrous insulation to the cavity (STC)
90 mm Cross Laminated Timber	41	42	53
20 mm particleboard flooring	41	45	55
75 mm Integra flooring	47	49	59
150 mm concrete	57	61	71

The above indicates that the Integra flooring system is expected to provide greater airborne noise transmission than other lightweight systems such as particle board or cross-laminated timber flooring.

3.0 IMPACT SOUND INSULATION

As stated above impact sound is characterised by the IIC parameter. The IIC is a single number rating that some measure of how well both high-frequency “clicks” or “clacks” (from the soles of shoes) and low-frequency “booming” or “thumping” caused by heavy footfall is controlled.

The rating is for a whole flooring system, including the floor covering, floor panel, support and ceiling. There are many variables that can change the ratings such as, the overall weight of the system, whether there is acoustic absorption to the cavity the stiffness of each element, how rigidly the ceiling is attached to the floor system above, the depth of the cavity, and also how these variables relate to each other and the like.

A low IIC rating can indicate that both low and high frequency noise will be heard and a high IIC rating will require both aspects to be controlled. A mid-range IIC may indicate that high frequency noise is well controlled but that low frequency ‘bumps and thumps’ may still be prominent. It is therefore complicated to accurately describe the subjective noise reduction of a single number IIC rating.

A typical lightweight flooring system in a single unit house may have an IIC of 30 – 35 with a hard flooring surface where even light impacts such as dropping a fork may be heard below and footsteps would be easily heard as thumping. Carpeting will increase the rating significantly however thumps and bumps will be easily heard as low frequency noise needs additional mass to be controlled whereas floor finishes can control high frequency noise transmission.

For inter-tenancy situations the NZBC requires that floors between occupancies or between common spaces and habitable spaces have an IIC of no less than 55. We note that the minimum NZBC standard does not mean that the footsteps will not be audible in the spaces below. Subjectively an IIC 55 rating would result in footsteps on hard flooring surfaces *or* heavy thumps to be audible below.

An IIC of 65 or greater and a high mass floor system is required for footsteps to be typically inaudible below.

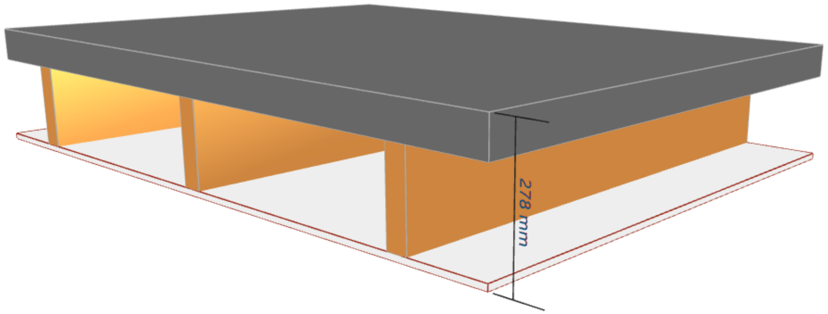
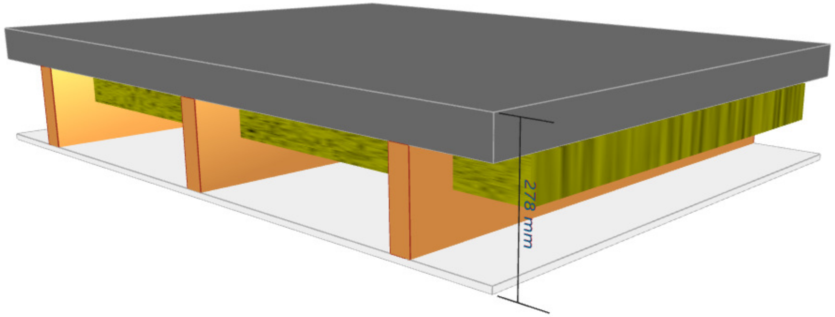
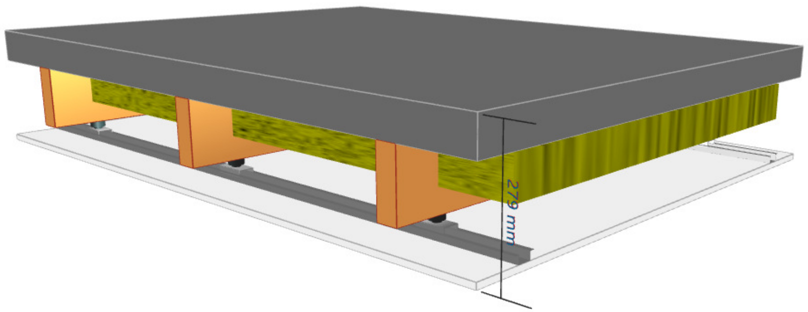
3.1 Tested Systems

Auckland Uniservices Limited tested a number of Integra Flooring Systems. The tested systems are described in Appendix A. The results of these systems ranging from a single panel IIC 12 to IIC 55.

3.2 Modelled systems

We have modelled each of the three systems described above based on the modelling software Insul (Version 9.0.22). These are described again below along with the expected laboratory test IIC rating. We note that the IIC rating is particularly sensitive to the installation particularly for lightweight systems and may be different to the expected laboratory ratings.

Table 3.1 – Expected IIC ratings Variation to the IIC ratings (Images from Insul)

System			Expected ratings
System 1		75 mm Integra Floor panel / 190 mm x 45 mm timber joists (set at 600 mm centres) / 1 layer of 13 mm Standard Gib plasterboard direct fixed to the joists	This system has a modelled IIC rating of 31
System 2		75 mm Integra Floor panel / 190 mm x 45 mm timber joists (set at 600 mm centres) with 90 mm fibrous insulation to the cavity / 1 layer of 13 mm Standard Gib plasterboard direct fixed to the joists	This system has a modelled IIC rating of 33
System 3		75 mm Integra Floor panel / 140 mm x 45 mm timber joists (set at 600 mm centres) with 90 mm fibrous insulation to the cavity / 1 layer of 13 mm Standard Gib plasterboard fixed to metal channel on rubber isolation clip	This system has a modelled IIC rating of 46.

3.3 Variations to the systems

As stated above, predicting the IIC value for various floor systems is difficult (particularly with lightweight floor constructions) as it is affected by an even larger number of variables than airborne noise transmission.

As stated above the variables that can affect the IIC ratings include the overall weight of the system, whether there is acoustic absorption to the cavity, the stiffness of each element, how rigidly the ceiling is attached to the floor system above, the depth of the cavity, and also how these variables relate to each other, and the like.

Lightweight flooring systems are particularly sensitive to changes in these factors. However in general adding more mass to the system and resiliency – both between flooring and Integra floor panel and between the sub-floor structure and the ceiling – will increase the IIC.

In addition the IIC is affected by interaction between the system and the floor covering There are numerous products available which change the IIC of the system by different amounts. Due to this, we cannot give a single number prediction for the IIC ratings for generic floor covering types that have not been tested; however, we have the following comments regarding achieving an IIC rating of over 55 (NZBC Clause G6 requirements) with various flooring types.

3.3.1 Carpet

IIC 55 would likely be achieved with each of the systems described above with thick pile carpet and a foam underlay. Higher IIC ratings are possible (in the order of IIC 75) with System 3 construction. We note that high frequency noise (from shoe taps and the like) will be well controlled, booming noises from footfall (kids running down hallways) may still be heard in the rooms below.

3.3.2 Hard surface finishes

Hard surface finishes such as tiles, timber flooring, or vinyl will change the IIC performance of all the systems described above very little. There is also a risk that the IIC could be reduced if hard tiles are direct fixed to the flooring due to an increase in high frequency noise transmission. The IIC rating will increase with the addition of a resilient underlay beneath the hard surface[3] when installed in strict accordance with the manufacturer's instructions; however, a resilient layer is unlikely to increase the IIC to 55. Appendix A shows tested ratings for various hard flooring types with suspended ceilings ranging from IIC 46 to 55. Test type 4 shows that in specific circumstances the IIC can reach 55; however we recommend that specialist advice is required if compliance with the NZBC is required.

3.3.3 Floating floors

Where a full floating floor system (for example Batten and Cradle) is used in conjunction with the systems described above we expect the IIC to be greater than 55 regardless of the floor covering. This would result in the following construction:

- Particle board or fibre cement / 40 mm battens on resilient cradles with fibrous insulation to the cavity / 75 mm Integra panel / 190 mm x 45 mm timber joists set at 600 mm centres / 1 layer of 13 mm Standard Gib plasterboard resiliently mounted and fibrous insulation to the cavity.

This system would be suitable for use with any flooring type (such as timber, ceramic tiles or vinyl).

[3] We note that the performance of resilient layers is typically quantified using the ΔIIC rating. This is the improvement in IIC the resilient layer provides on a 200 mm concrete flooring system, and should not necessarily be relied upon for lighter-weight systems. Specialist advice should be sought for compliance situations.

3.4 Comparison with common flooring constructions

We have the following general comments regarding how the impact noise performance of systems based around an Integra panel may compare to other construction systems used in New Zealand.

Lighter weight systems are susceptible to greater low frequency noise transmission. The Integra flooring system is heavier weight than typical wood (particle board or CLT) flooring systems and therefore would provide a greater level of low frequency performance. The Integra flooring system has a similar bare IIC to typical wood (particle board or CLT) flooring systems however because the flooring is harder than timber it transmits high-frequency impact noise better than wood flooring and therefore responds better than lighter-weight systems to the introduction of a resilient layer beneath.

In general high mass systems such as standard concrete provide the highest IIC rating and good control of low frequency noise transmission. For these systems the high-frequency noise component can be well controlled with a resilient layer underneath hard surface finishes.

The above indicates that the Integra system is likely to provide greater impact noise insulation than other lightweight systems.

Please do not hesitate to contact us to discuss further as required.

Kind Regards,

Rewa Satory
BE (Mech). MASNZ
Acoustic Engineer
Acoustic Engineering Services

APPENDIX A

Auckland Uniservices Limited tested five Integra Flooring Systems in accordance with ISO standard *10140-3:201 Acoustics -- Laboratory measurement of sound insulation of building elements -- Part 3: Measurement of impact sound insulation* and determined IIC ratings in accordance with ASTM E989 *Standard Classification for Determination of Single-Number Metrics for Impact Noise*. The tested systems and their respective tested ratings are listed below:

Type 1

- 75 mm Integra panel / 190 mm x 45 mm timber joists set at 450 mm centres

This system has a tested IIC rating of 12.

Type 2

- 75 mm Integra panel / 190 mm x 45 mm timber joists set at 450 mm centres / 1 layer of 13 mm Gib Noiseline plasterboard on 28 mm furring channel in ST001 clips screw-fixed to the underside of the joists with 150 mm Pink Batts Silencer to the cavity.

This system has a tested IIC rating of 46.

Type 3

- 75 mm Integra panel / 190 mm x 45 mm timber joists set at 450 mm centres / 2 layers of 13 mm Gib Noiseline plasterboard on 28 mm furring channel in ST001 clips screw-fixed to the underside of the joists with 150 mm Pink Batts Silencer to the cavity.

This system has a tested IIC rating of 47.

Type 4

- 15 mm Oak timber flooring loose laid on 6 mm cork adhered to 75 mm Integra panel / 190 mm x 45 mm timber joists set at 450 mm centres / 2 layers of 13 mm Gib Noiseline plasterboard on 28 mm furring channel in ST001 clips screw-fixed to the underside of the joists with 150 mm Pink Batts Silencer.

This system has a tested IIC rating of 55.

Type 6

- 10 mm thick x 600 mm x 600 mm porcelain tiles adhered to 6 mm cork adhered to 75 mm Integra panel / 190 mm x 45 mm timber joists set at 450 mm centres / 1 layer of 13 mm Gib Noiseline plasterboard on 28 mm furring channel in ST001 clips screw-fixed to the underside of the joists with 150 mm Pink Batts Silencer.

This system has a tested IIC rating of 50.