THE TREND IN STAGE SRUCTURE DESIGN; ARE WE FORGETTING THE MUSIC?

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1 INTRODUCTION

Akukon team started this study along the ongoing building process of the new Turku Music Hall in Turku, Finland. With the design of the new stage a riser mock-up was constructed and needed to be acoustically evaluated. By chance a year later, Lahti symphony Orchestra was introduced to a new concept of a single player podiums designed especially for double basses by a German company. Akukon team joined the testing sessions. Along these two testing sessions the team came up all together with four different platforms: two different top thicknesses of the Turku Music Hall project stage riser model, a German designer individual podium and the existing stage front section of the Lahti Sibelius Hall.

The preceding research has concluded that the physical measurements never seem to be concordant with the aural monitoring [1, 2] In each of the studies the same team of engineers and musicians conducted both physical and aural monitoring invariably agreeing with aural impressions. This proves that the discrepancy cannot be just “musicians’ attitude problem”. Also, the audiences’ opinions would always follow the preferences of the aural testing teams.
We can measure the stage structures how detailed we want but the ultimately significant qualities are revealed only by listening from the audience.

In this article, we aim to establish a synthesis of the facts and findings of the earlier and current research for suggesting a stage riser structure principle that would actually be based on the best knowledge.

2 EXPERIMENTS AND RESULTS

2.1 Raisio test

The first testing session was conducted at Raisio Carpenters’ premises in Raisio near Turku. In the workshop they built a model section of the stage riser of the upcoming Turku Music Hall. The riser top was tongue and groove joined ash planks on double layer cross joists of 2 x 4 inches on CLT (cross-laminated timber) mass structure. Half of the top was 45 mm thick with sanded and waxed surface. The other half was milled to 38 mm thickness with oiled surface. The riser structures were evaluated with double bass music excerpts, during which continuous measurements were conducted with two microphones (G.R.A.S. type 46AE; distances approx. 3 m and 6 m) and accelerometers (MMF KS48C; 20 cm from the riser front edge and centre of the riser top plate between joists).

The subjective findings were as follows:

38 mm surface

- For the test player the playing touch was initially promising, vibrating a lot for the player himself. However, later the vibration felt somewhat excessive impairing clarity. The surface enhanced mostly the mid register of the instrument.

- For aural monitoring group the sound appeared somewhat nasal and sporadic extra resonances occurred. The lowest frequences felt attenuated.

45 mm surface

- For the test player the sound on the thicker section was generally better balanced and with good clarity. Despite of its bigger mass the surface "awakened" easier (*possible impedance match with the instrument*) and the lowest frequences were more present.
- The aural monitors liked the clarity and warmer, deeper sound.

Spectrograms:

Music excerpt in all graphs: **Giuseppe Verdi's opera Don Carlos original Act IV, scene 2 opening**. According to the modern interpretation the double bass part is played an octave lower from printed following the line of contrabassoon, i.e. the lowest line in graphs is actual octave. The spectrograms are without frequency weighting, and the scale is normalized relative to the maximum magnitude.

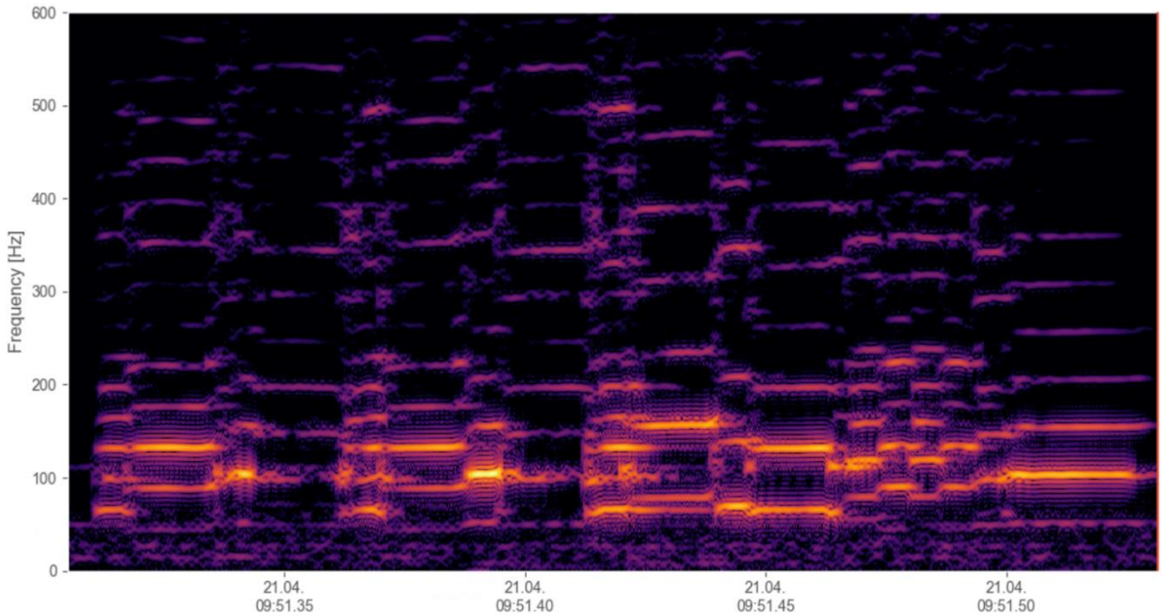

Figure 1. Raisio, 45 mm surface, near microphone

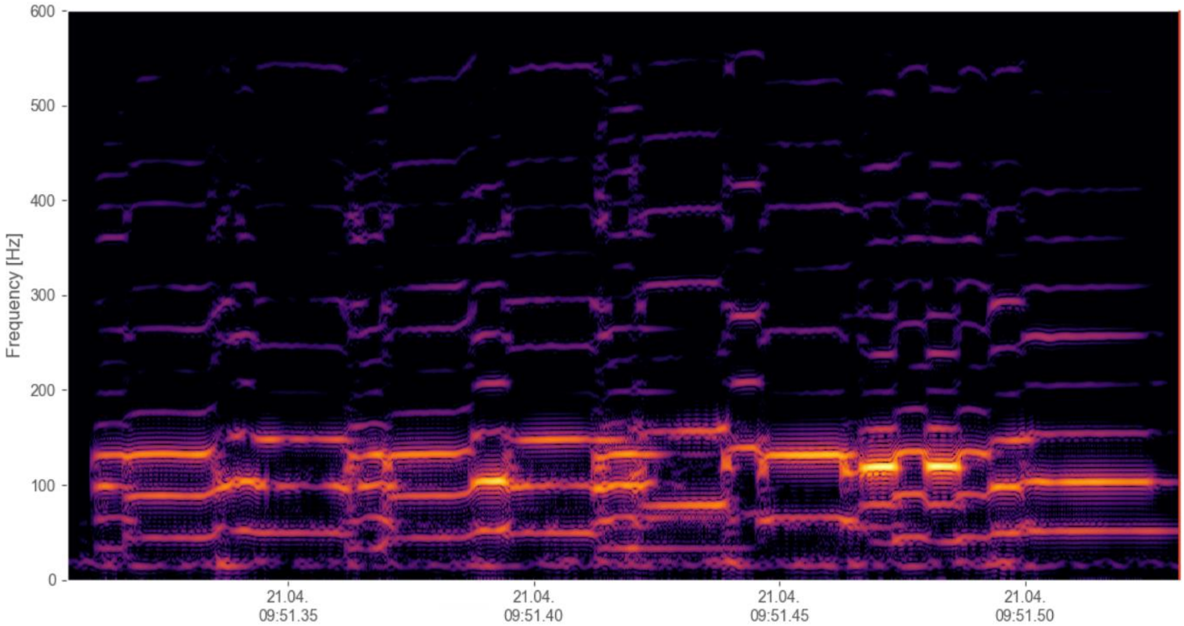

Figure 2. Raisio, *45 mm surface, accelerometer at riser centre*

Notes

In **Figure 1.** the lowest frequences at the close microphone recording are below the background noise level in the testing space, and it unfortunately hampers reading the complete lowest range. However, we can assume that it follows the visible parts of the lowest line and the accelerometer reading in **Figure 2.** where we can distinctly see 3 to 4 lowest harmonics including some support of the fundamental frequences below 50 Hz.

2.1.1 Raisio summary

The thicker 45 mm surface appeared clearly better working in most counts providing appropriate feedback through vibration, clarity, projection and to some extent support for the lowest range of bass sound. Here we need to take to into consideration the small scale of the tested riser mock-up. We can assume that a full-size riser section would act even more favourably to bass sound because of greater surface area combined to its bigger mass.

From practical usability point of view, the test team was somewhat hesitant about the endurance of the basically untreated thick ash plank surface in the changing Finnish climate. The top seemed already have cracked within weeks. Most likely the planks would be subject to uncontrolled humidity and temperature changes during storing and installation process before the activation of humidification and heating system in the hall.

2.2 Lahti test

Despite some musicians' subjective preferences concerning strongly vibrating surfaces, it is largely known that smaller podiums or stage riser sections have no physical potential to significantly help the low frequency resonance.[1, 3]

Aware of the fact above, for stage array reasons the Lahti Symphony Orchestra double bass section was merely seeking a set of three individual podiums, which would at least not absorb the lowest frequences.

An experiment setup like Raisio tests was arranged on the Lahti Sibelius Hall stage. Sound and vibration were measured during double bass music excepts. Microphone position was in front of the double bass at 2 m (near microphone), and vibration was simultaneously measured from the riser top plate and the stage deck.

Double top pine/plywood frame single podium

- For the test player the playing touch on the podium felt at first pleasant and the surface vibration was remarkable but in the end hampered the clarity. The podium seemed to modify the players sound somewhat.
- The auditing team noticed extra buzzing sound all the range through but no proper projection to the audience. Compared to the stage itself, clarity was not very good. Also, no noticeable support for the lowest range was detected but extra boost for parts of the mid register.

More serious problems appeared later when the podium was taken into orchestra work. The podium surface didn't seem to awaken for resonance soon enough to give player response for separation of individual notes, pointing to a possible impedance mismatch.

Spectrograms:

Music excerpt: **Verdi: Don Carlos Act III, scene 2 opening**. Again, the spectrograms are without frequency weighting, and the scale is normalized relative to the maximum magnitude.

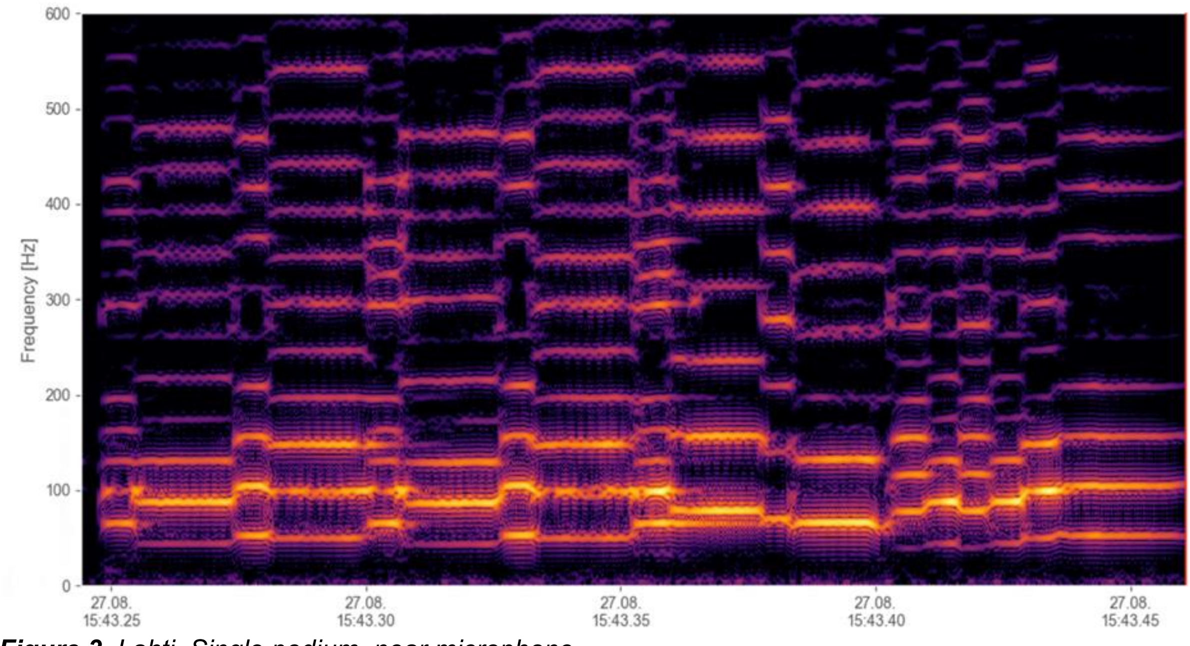

***Figure 3**. Lahti, Single podium, near microphone*

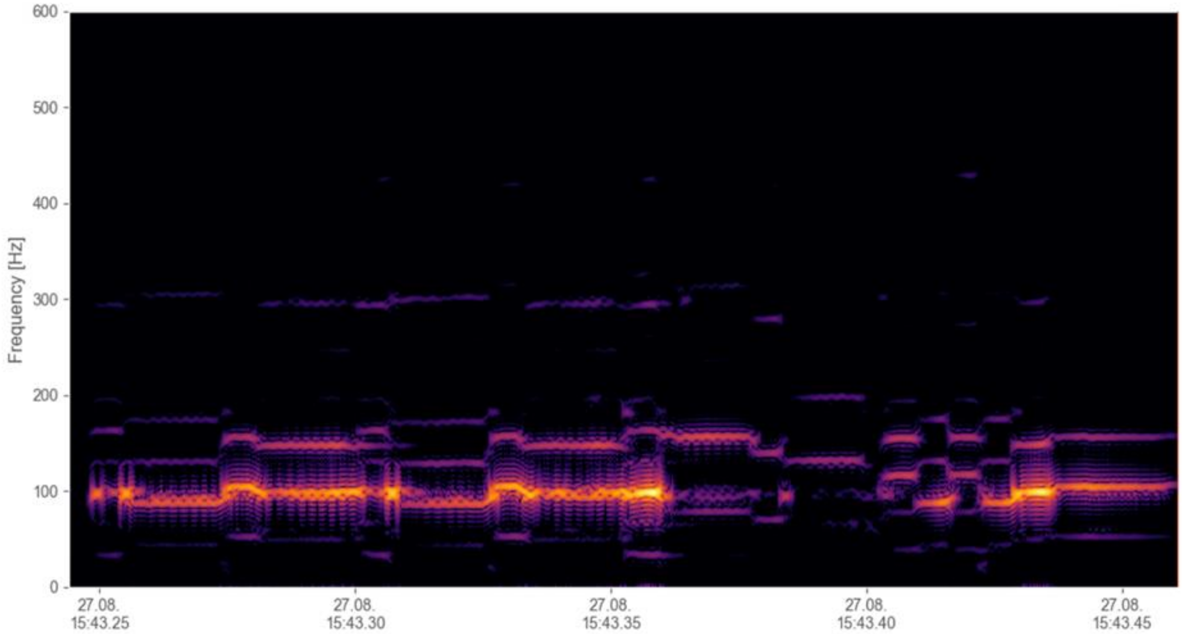

Figure 4. *Single podium, accelerometer*

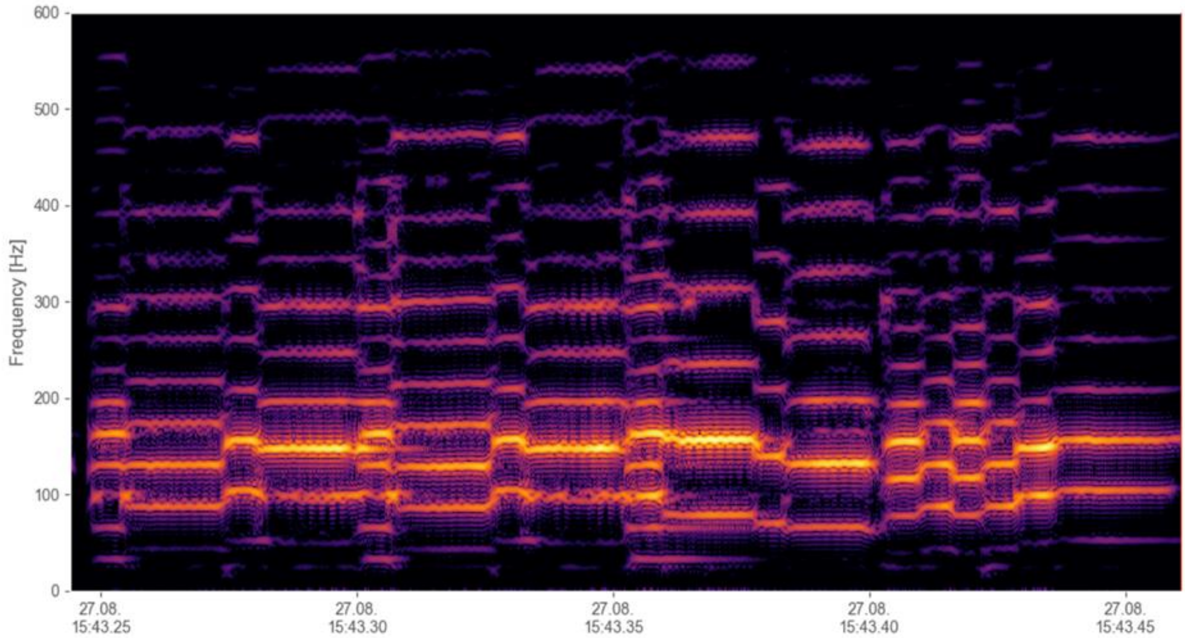

Figure 5. *Lahti main stage underneath Single podium, accelerometer*

Notes

Figure 3. didn't reveal any surprises but **Figure 4.** demonstrates the narrow frequency band of vibration response. On the other hand, in **Figure 5** we can observe a relatively more wide-band response as an assumed combination of mechanical vibration coupling through the podium to stage

and airborne-to-structureborne coupling resulting in a frequency content with clearly more harmonic components. Despite the shown vibrational limits of the podium surface, the stage seems to deliver the sound to the audience in rather balanced form although naturally attenuated.

Sibelius Hall main stage front section

Lahti Sibelius Hall stage has three all scene wide sections in which the joisting underneath the top planks deepens by section towards the rar. The joisting is 48 x 48 mm in the front section, 4+4 inches cross joisting in the middle- and 4+5-inches cross joisting in the rear section. According to the earlier playing experience onstage, sections with deep cross joisting vibrate too much to provide optimal projection.

The front section of the Sibelius Hall stage has proven to be ideal for double bass sound. It gives a desirable, moderately but firmly resonating, response for single player and works that way also with the complete double bass section. Projection to the audience is generally favorably perceived.

- The test player had very little earlier experience of the stage beforehand but was very happy with the response and firm bass sound onstage.
- The aural monitoring group felt the projection to the audience very good. Clarity was good and the support for the lowest range the best in this test series.

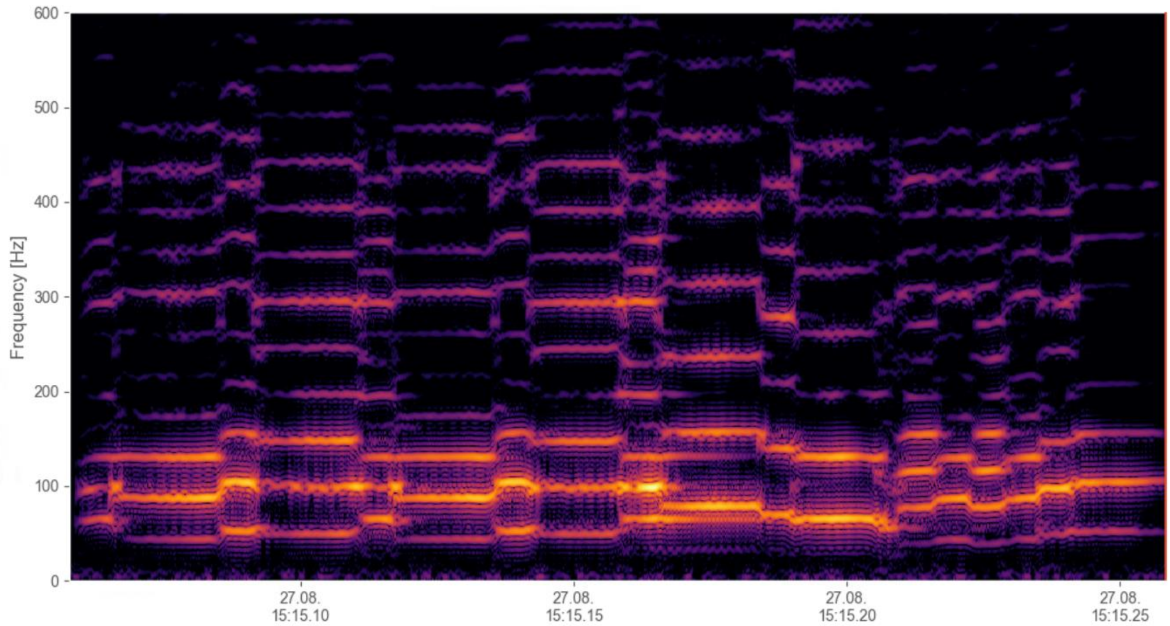

Figure 6. *Lahti main stage front section, near microphone*

2.2.1 Lahti summary

According to the subjective test and measurement results it seems that the tested single podium is designed to predominantly please the player on it by emphasized surface vibration, giving an impression of stronger bass sound with excess commotion. In concern of acoustic projection, clarity and lowest range support the structure of the podium does not seem to have been designed nor tested thoroughly enough. Like in the case of Raisio riser, the testing team was also concerned about the endurance of the delicate double top structure in changing humidity and temperature conditions.

Sibelius Hall stage with its knowingly excellent qualities appeared to be a useful benchmark in these test sessions.

3 DILEMMAS

In practice a resonating podium physically coupled to a double bass creates additional impedance [1,4,5] like another rejoined body that needs to be awakened to resonate with the instrument. If the impedances between the instrument and the podium don't match, playing feel is arduous [1] especially in orchestra work when fast individual notes cannot necessarily be aurally distinguished but should be felt as vibrational impulses.

The measurements tell the double bass vibrates only minimally below its average Helmholtz frequency at app. 60 Hz. However, the players and listeners know how in optimal circumstances the lowest fundaments of bass line are revealed by suitable assist of the stage/riser structure.

4 DISCUSSION AND CONCLUSIONS

The main trend in stage structure design has earlier been on the side of stiff, minimally vibrating solutions. However, the direction has recently been clearly shifting towards more vibrating stage surface and especially riser structures. The focus has moved towards pleasing the orchestra players with the unnaturally excessive surface vibration and better mutual visibility on the risers.

Afresh in this test series it was proven that individual freely on-stage standing podiums remain a problem acoustically. We are yet to be introduced to a podium that would at least not impair the lowest range of bass sound. Music word is full of implements (especially concerning double bass) but this kind of presumably simple device remains un-invented.

According to the results of this and preceding studies we need to discard the changing trends in stage design and hold to the facts proven in practise. To optimise playability and stage resonance assist for lowest range we should aim to **compromise between stage vibration and projection** and possibly **match the impedance of stage structure and double bass** in 31- 63 Hz octave band. [1, 4, 5]

To minimise the risks of stage riser absorption and ensure the lowest range support we should plan to place the first row of orchestra double basses onto the stage itself and design the riser system structure as similar as possible if not identical to the solid stage. The riser structure should also be structurally symmetrical, for all the time more often the conductors vary the orchestra seating on stage.

In addition, the riser sections, when in elevated position, should be rigidly locked together and to the solid stage to avoid their individual vibration or even wobble. Both Guettler [1] and Wulfrank [2] teams highlight the potential advantage of vibration transfer between stage and audience floor. Obviously, that hasn't been considered in most of the modern stage design.

According to the first author's long experience in orchestra work worldwide, listening to double bassists' opinion about stage playability and sound projection to the audience provides absolutely the best guidelines for stage structure design. *(Excluding some double bassists that have been seduced by the specially designed excess surface vibration.)* All the other instruments coupled directly to the stage would be equally happy with the results. Celli are much less firmly connected because of the considerably lesser weight and with the longer endpin having greater distance to the stage floor. Besides, depending on the cello endpin's structure and material it rather often tends to vibrate on its own decreasing further the coupling to the stage. Timpani and other large percussion instruments stand mostly on hard wheels causing partial vibration isolation. As for the winds, contrabassoon and bass clarinet use rubber stopper in the end of the endpins reducing the connection to the stage.

4.1 Suggestion for stage and riser structure

When evaluating the results of the tests and comparing them to the earlier research, Akukon team perceived the obvious similarity between two individual stage structures with outstanding qualities.

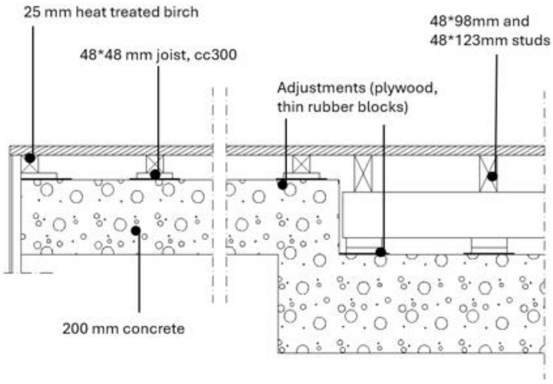

Figure 7. *Sibelius Hall stage structure, lower front and deeper middle section. Joist clearance 300 mm. Drawing by Sara Vehviläinen, Akukon.*

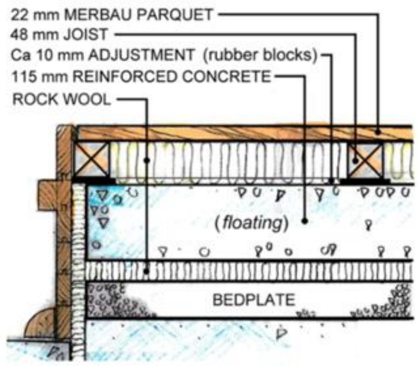

Figure 8. *Oslo Lindeman Hall stage structure. Joist clearance 300 mm. Drawing by Arkitektgruppen Lille Frøen AS.*

As far as is known, the stages of the Lahti Sibelius Hall and the Oslo Conservatory Lindeman Hall have been independently designed. They both have been evaluated to provide the best qualities of lowest frequencies' enhancement, playability and sound projection. The structure in both is remarkably similar.

The differences are the rock wool between the joists and the floating first concrete layer in the Lindeman Hall. Despite the rock wool filling between the joists the Lindeman Hall stage has yet been described as "rather pliant" [1] resembling the impression on the Sibelius Hall stage without filling. According to the test teams and audiences the sounding result seems to be very similar.

In other words, **for optimal stage and riser structure we suggest max. 25 mm plank surface on app. 50 x 50 mm joisting adjusted directly on massive base material. Narrow clearance (max. 300 mm.) of the joists also ensures meeting the stage load requirements**. The top in our both examples present an already stable wood material (heat treated birch and merbau parquet) to avoid surface cracking and warping with the humidity and temperature changes. **Stable and dense wood material also reduces the uncontrollable excess surface vibration**. For the same reason the lowest adjusting layer underneath the joists should be of resilient material. Whether the structure needs the rock wool between the joists could be tested further but no extra boom on the Sibelius Hall stage has been detected.

Because concrete cannot be used in stage riser structure, a base material that simulates it as well as possible is needed. As far as we know CLT should be the closest and easiest to use. Moreover, it enables the stage and the riser structures be identical, which would solve several problems.

Akukon team suggests that this structure should be deployed in the future stage and riser design.

5 REFERENCES & LITERATURE

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