Pop venues in living areas

Ir. Maarten Luykx MSc
Peutz Consultants, Mook, Netherlands, www.peutz.eu

Ing. Margriet Lautenbach
Peutz Consultants, Zoetermeer, Netherlands, www.peutz.eu

Dr. Ir. Martijn Vercammen MSc
Peutz Consultants, Mook, Netherlands, www.peutz.eu

Summary

In 2014 four pop venues have been opened that were consulted by Peutz. In Venlo (NL), Zwolle (NL) and Nijmegen (NL) as well in Turkey (Volkswagen Arena Istanbul). All four are in close vicinity of living areas, and therefore have specific demands for a sufficiently high sound insulation. In all four venues high sound insulations of the roof and facades have been realized, using box-in-box principles for the pop venue when necessary. The highest sound insulations had to be realized in the new pop venue in Nijmegen where, for the first time in the Netherlands, dwellings have been build on top of the pop centre. This is realized by a vibration-isolated mounting of the dwellings on the pop centre and with a box-in-box principle for the pop halls. By using a special measurement setup with 18 subwoofers with noise level of 125 dB(A) house spectrum inside the pop venue, extremely high sound insulations of more than $D'_{nT,A,house}$=99 dB towards the dwellings could actually be measured.

In Istanbul, in an earth-quake zone, a large black box pop venue (68,000 m3 and 6,000 seats) has been realized with high sound insulations for roof and facades. Additionally, a special mounting for the roof on large elastic bearings has been applied which allows the roof to move up to 45 cm sideways to make it resistant for earth-quakes.

All four venues are successful since their opening, in which their optimal sound insulation and good acoustics play a significant role.

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1. Introduction

In 2014 four pop venues have been opened that were consulted by Peutz. One in Turkey (Volkswagen Arena Istanbul) and three in the Netherlands (Venlo, Zwolle, Nijmegen). All four are in close vicinity of sound critical buildings, and in one case dwellings have even been build on top of the venue (Nijmegen). In all these cases a sufficient sound insulation is of major importance, which will be dealt with in the next chapters.

2. Volkswagen Arena (Black Box) Istanbul

The new Volkswagen Arena in Istanbul includes a large venue for pop concerts and congress. It has a volume of 68,000 m3, a height of 18m and 5,800 seats. The use for pop concerts has determined the design of the exterior sound insulation. Figure 1 shows the hall during a concert.

Figure 1. View towards stage during a pop event.

Due to regulations the noise exposure of the pop venue on surrounding buildings should not exceed the background noise levels with more than 5 dB(A) L_{eq} or 7 dB(C) L_{eq}. To fulfil these with an interior music level of 103 dB(A) house, sound insulations of $R'_{A,house} \geq 52$ dB for the roof and $R'_{A,house} \geq 55$ dB for the façade were necessary. To realize these values within the allowed weight, a double roof is implemented. This consists of an outer layer concrete on corrugated steel plates (430 kg/m^2) with a separately suspended ceiling of 40 kg/m^2 fibre boards on 0.6 m distance, with underneath it a sound absorptive ceiling. The façade consists of a solid wall (>400 kg/m^2 masonry/concrete) with a dry-lining wall of 30 kg/m2 on a cavity of 0.7 m on the inside.

Because Istanbul is a region with possible earth-quakes, the whole roof structure had to be sufficiently resistant against earth-quakes. For this reason the whole roof structure including all ceilings is mounted on large rubber bearings (900x900x300mm) that allow the roof to move sideways over maximum distance of 0.45 m. with special joints to prevent sound leakage. Figure 2 shows an edge detail of a cross-section of the roof and façade with an indication of the bearings.

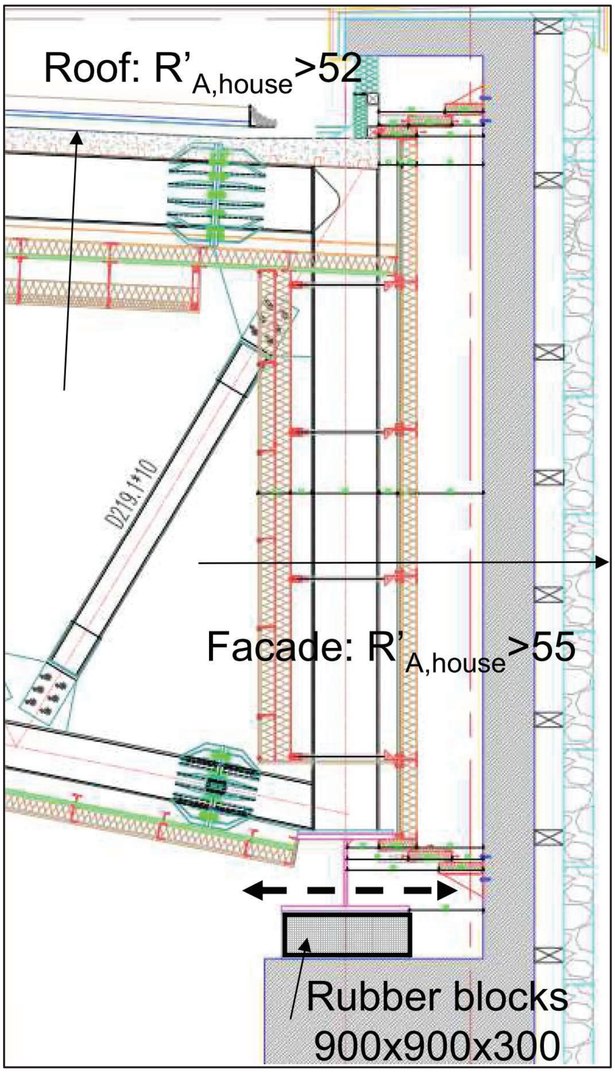

Figure 2. Edge detail of roof (on elastic bearings) and façade of the Volkswagen Arena in Istanbul.

In figure 3 gives a view of one damper placed in position under the steel structure during the construction phase.

Figure 3. View of a rubber damper of 900x900x300 mm under the roof structure.

Final delivery measurements in this project in Istanbul have shown that all sound insulation requirements for the exterior separations have been met.

3. Pop venue Hedon in Zwolle (NL)

The enlargement of the pop venue Hedon in Zwolle (NL) consisted of an enlargement of the main hall (3,100 m^3) as well as addition of a small hall (800 m^3), rehearsal rooms and loading dock. Figure 4 gives an impression of the new layout.

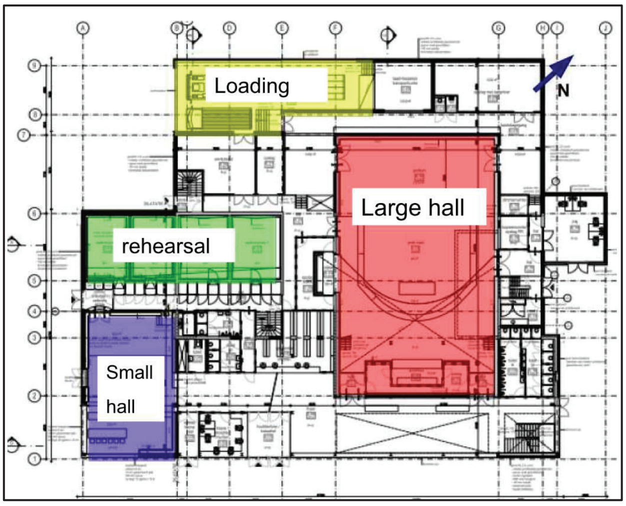

Figure 4. Ground floor plan of Hedon Zwolle (NL)

To reach a sufficient sound insulation between both halls a structural dilatation has been applied around the newly build small hall. To fulfil the legal demands at the surrounding dwellings at 40 m distance with an music level at the mixing desk of 103 dB(A) house, sound insulations of $R'_{A,house} \geq 57$ dB for the roof (new and existing) and façades of both halls have been aimed for. To realize these values the new roof is constructed of 600 kg/m^2 concrete with insulation, with on the inside a flexibly resilient suspended ceiling of 30 kg/m^2 gypsum boards on an air cavity of 0.3 m filled with 0,15 mm mineral wool. For the lighter, existing roof part of the large hall an larger air cavity of 0.7m is applied. The façade consists of 300 mm thick sand-lime bricks of 550 kg/m^2 with thermal insulation and plaster, with on the inside a free standing dry-lining wall of 30 kg/m^2 gypsum boards (3x12.5 mm) on an air cavity of 0.3 m filled with 0,15 mm mineral wool. Figure 5 shows a cross-section of the venue in Zwolle and figure 6 an interior view towards the balcony.

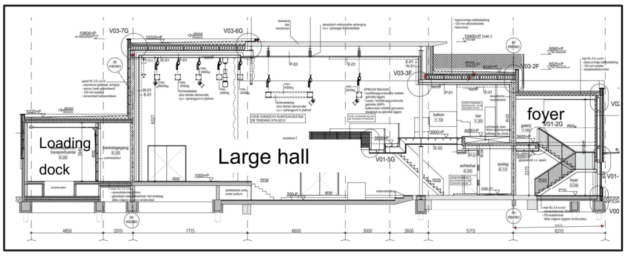

Figure 5. Cross-section over large pop hall Hedon Zwolle (NL)

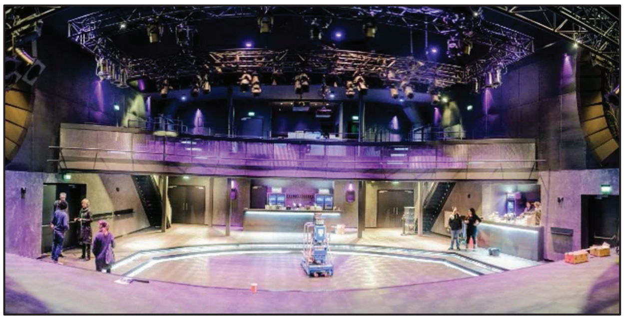

Figure 6. View inside large hall of Hedon in Zwolle (NL)

For economic reasons the ventilation equipment for the halls has been put on the roof which causes a lot of critical transits through the roof, that required attention and additional measures during the building phase. Delivery measurements showed that there remains a certain reduction of the sound insulation of the roof due to duct transits through the roof. The high sound insulation makes it however difficult to accurately measure the receiving noise levels outside above the background noise.
The venue is in full use since its opening and very successful.

4. Pop venue Grenswerk in Venlo (NL)

The new pop venue Grenswerk in Venlo (NL) contains a pop hall with a room volume of 3,300 m^3 on 1st level, as well as a loading dock and rehearsal rooms and studio on the ground floor. Figure 7 shows a cross-section, and figure 8 shows the 1st floor plan.

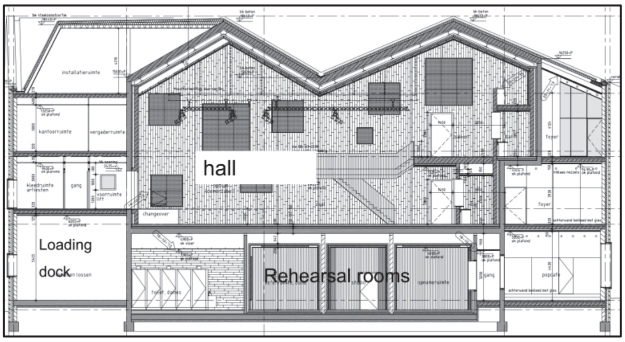

Figure 7. Cross section pop venue in Zwolle (NL)

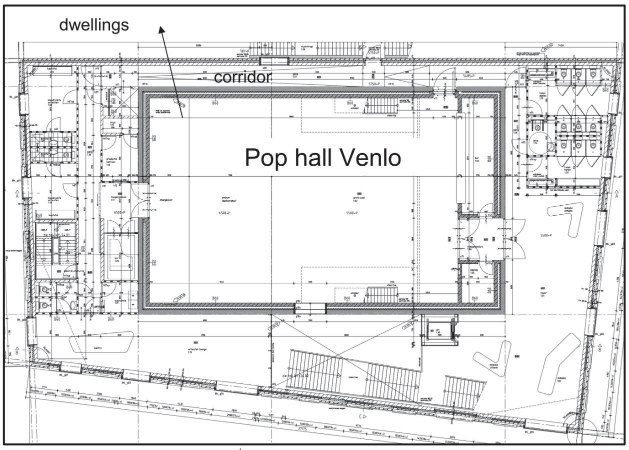

Figure 8. Plan of 1st floor of pop venue in Zwolle.

To fulfil the legal demands towards the nearby dwellings @2m from the façade with an interior music level of 103 dB(A) house, sound insulations of $R'_{A,house} \geq 61$ dB for the roof and $R'_{A,house} \geq 76$ dB for the façade were required. To realize these values a complete box-in-box structure for the pop hall was implemented with a self supporting inner box. The floor of the hall consists of a 150 mm concrete floor on 100 mm air cavity with elastic bearings on 350 mm concrete structural floor. The walls of the hall consist of a fully separated 1,300 kg/m^2 cavity wall of 250 mm concrete (inner box) on 200 mm air cavity with 100 mm mineral wool and a 300 mm concrete (outer box). The floor of the corridor towards the dwellings it flexibly mounted on the outer wall of the hall. Together with a width of 1,3 m of the corridor and a 600 kg/m^2 outside façade of the corridor, this delivers the required insulation of for the façade. The roof of the hall consists of a fully separately suspended ceiling of the inner box of 40 kg/m^2 gypsum boards on an air cavity of 0.5 m with 100 mm mineral wool, and a heavy outer roof of 800 kg/m^2 concrete. Figure 9 gives a view of the outside of the building, and figure 10 a view inside the hall.

Figure 9. Exterior of pop venue Venlo (NL).

Figure 10. Interior of pop hall Venlo (NL).

Delivery measurements showed that all acoustic dilatations and elastic bearings function optimally. Internal sound insulations towards the rehearsal rooms and studio of $D'_{A,pop} \geq 85$ dB were measured and an external sound insulation of the roof of at least $R'_{A,house} \geq 58$ dB. Higher sound isolation values of the roof or façade could not be measured due to limitations of the measuring equipment and the masking noise outside (signal/noise-ratio).
The new venue is in full use since its opening and proved to be very successful.

5. Pop venue Doornroosje Nijmegen(NL)

The brief in Nijmegen for the contractor Klokbouw-Zublin was to combine three buildings on a small footprint: a pop centre with two pop halls (1100 and 400 seats), a bicycle parking (4000 bicycles) and hundred 4-room dwellings for students. According to the brief both pop halls should be suitable for pop concerts with an equivalent sound level of 105 dB(A) house spectrum at the mixing desk, see figure 11.
The maximum allowable music levels in surrounding spaces were set as 40 dB(A) in the foyers and 30 dB(A) in the adjacent pop hall. Legal limits were a maximum music level of 30 dB(A) on the façade of dwellings and 15 dB(A) inside the dwellings. Based on these demands the following sound insulations should be met:
- $D'_{n,T,A,house} \geq 65$ dB between pop hall and foyers;
- $D'_{n,T,A,house} \geq 75$ dB between pop halls;
- $R'_{A,house} \geq 75$ dB for the roof of the pop hall;
- $D'_{n,T,A,house} \geq 75$ dB between pop hall and dwelling.

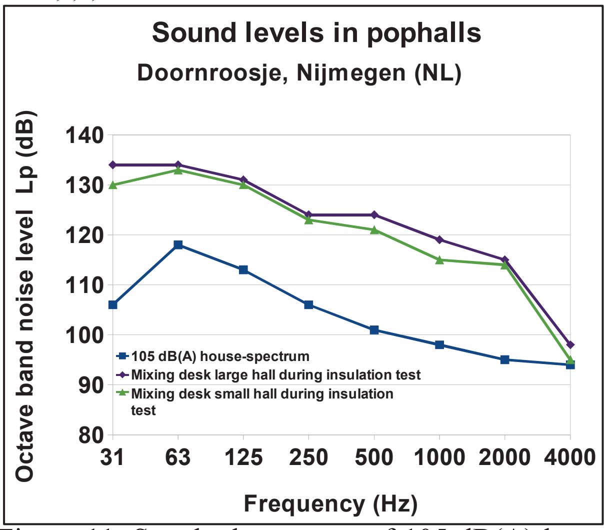

Figure 11. Standard spectrum of 105 dB(A) house music and 125 dB(A) noise level reached inside the pop halls during the insulation measurements.

The demands for pop concerts have determined the design of the sound insulation. Both pop halls have been built as a fully separated heavy boxes of concrete on elastic bearings placed on columns in the basement. All around the boxes a full separation is applied, see figure 12 and 13. Figure 12 shows a ground floor plan of the 3-storey pop centre with besides both pop halls also a café, foyers and a loading dock with a unique truck-rotation lift.

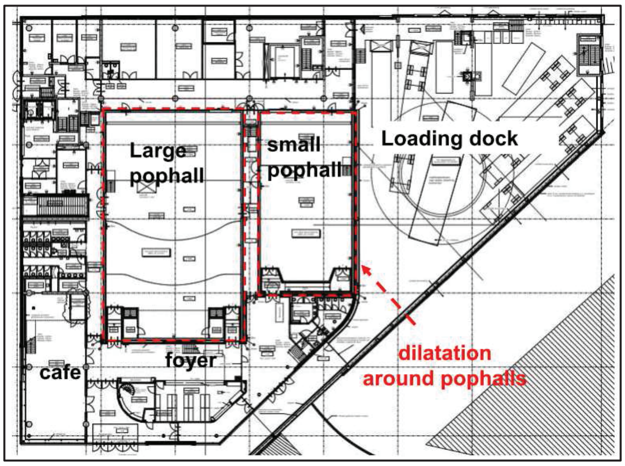

Figure 12. Ground floor plan of Doornroosje.

The walls of the box of the pop halls have a mass of 720 kg/m^2, the floors are 900 kg/m2 and the ceiling is 1,100 kg/m^2. In between the halls is a corridor of 2m width. Towards the foyers deep door locks are applied and a free standing dry-

lining wall of 40 kg/m^2 gypsum boards on 0.35 m air cavity filled with 0.15 mm mineral wool. Under the floor a flexibly resilient suspended ceiling of 30 kg/m^2 fibre board has been applied on 0.3m air cavity filled with 0,15 mm mineral wool.
In order to realize 100 4-chamber dwellings on the same footprint, these dwellings were projected in a ten storey high building above the three storey pop centre, as shown in figure 13 in a cross-section.

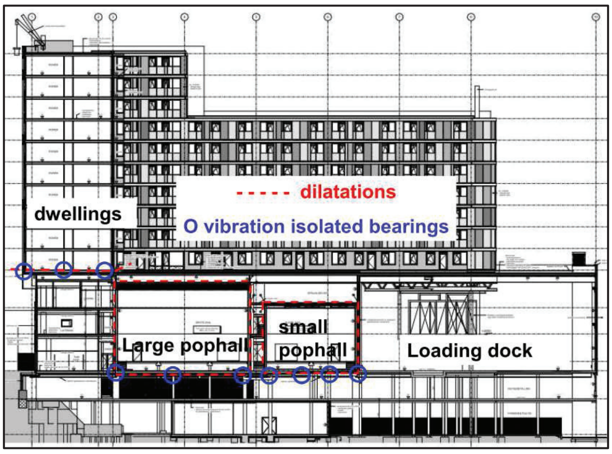

Figure 13. Cross-section through building of Doornroosje, with dwellings above the pop centre.

To realize a sufficient sound insulation towards the dwellings and to reduce railway vibrations an additional measure was taken by placing the total building of the dwellings on elastic bearings on the pop centre with a full dilatation in between, and by placing the dwellings aside from the pop halls. Figure 14 shows a photo of elastic bearings under the dwellings. The elastic bearings have a 10 Hz resonance frequency and a 16 MPa vertical loading capacity and consist of 4 layers of 20 mm rubber with 5 mm steel plates (size 125x125x95 mm).

Figure 14. Elastic bearings in position under dwellings on the pop centre during the construction phase.

One of the requirements from the principal for using these elastic bearings under the dwellings was that the pads could be interchanged at all times during the life of the building. For this reason a sufficiently high void space (0.9 m height) was designed between the lowest floor of the living building and the concrete roof of the pop centre, such that the supports were reachable after completion. Also a specific procedure for eventual replacement was designed by the supplier: In the design of the elastic bearings additional layers of high density fibre board were applied under the steel-rubber bearings, so that these could be demolished by drilling through. Subsequently these could be replaced by new rubber-steel pads that have been frozen under pre-stressed conditions.

To reach a sufficient sound reduction through the roof of the pop halls towards the facade of the dwellings above ($R'_{A,house} \geq 75$ dB), a large air cavity of 1.5 to 3 m was applied between the concrete ceiling of the pop halls and the outer roof. This roof has an additional function as a garden for the dwellings and has a total mass of 800 kg/m^2 (500 kg/m^2 concrete and 300 kg/m^2 soil-layers of the garden).

Delivery measurements of the sound insulations had to be performed before the PA-system of the pop hall itself was present. Therefore a special set was hired that produced a noise level of 125 dB(A) at the mixing desk (see figure 11). This provided a sufficient signal-noise ratio inside the dwellings (>10 dB) and gave reliable values for the sound insulations and proof that the demand ($D'_{A,house} \geq 90$ dB) was fulfilled. Figure 15 shows this set with 18 subwoofers and 6 array-speakers, that was being fed with pink noise for each separate octave band from 31 Hz to 4 kHz.

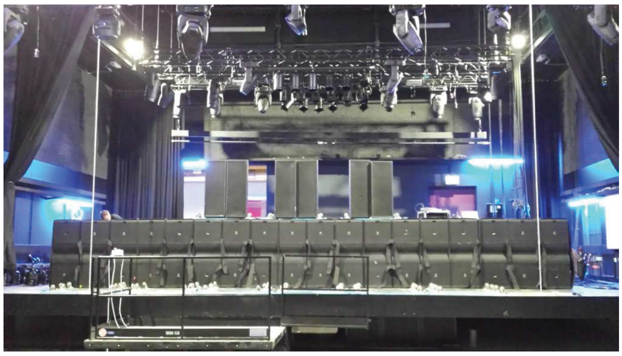

Figure 15. Measurement set up on the stage of the large pop hall with 18 subwoofers and 6 arrays.

The most relevant sound insulations measured are:
$D'_{n,T,A,house}$=99-108 dB from pop hall to dwellings, $D'_{n,T,A,house}$=76-77 dB between both pop halls, $R'_{A,house}$=76-79 dB for the roof of the pop halls, $D'_{n,T,A,house}$=65-68 dB from pophalls to the foyers. Figure 16 to 19 show measured insulation spectra.

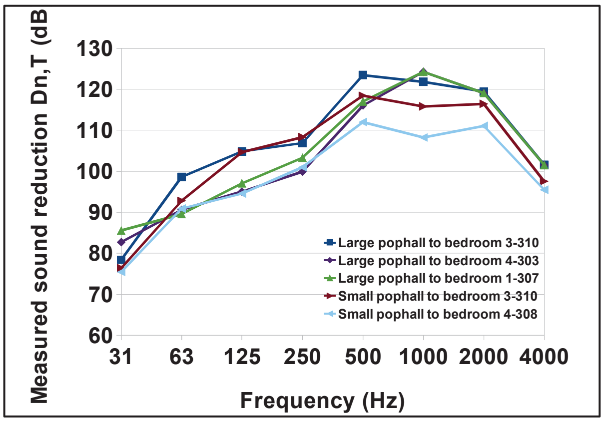

Figure 16. Measured $D_{n,T}$ between pop halls and sleeping rooms of adjacent dwellings.

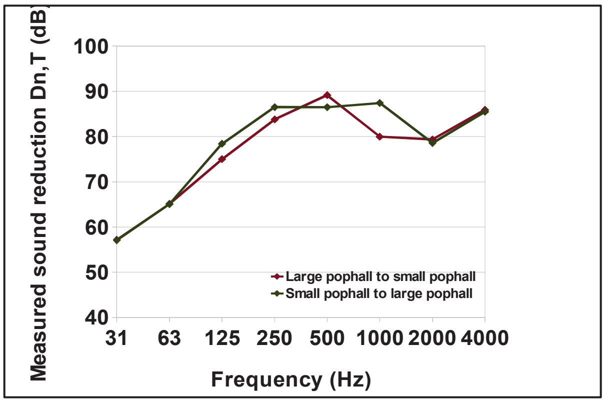

Figure 17. Measured $D_{n,T}$ between pop halls.

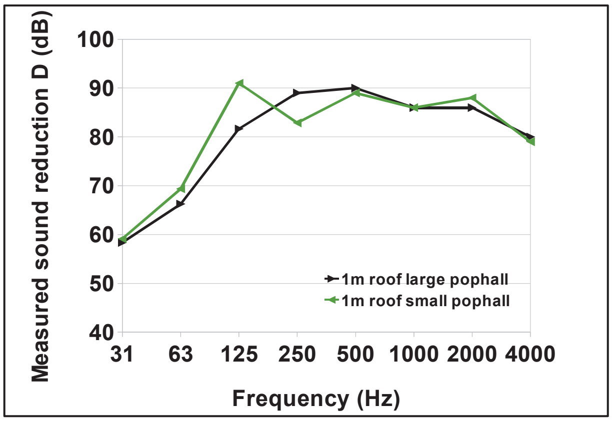

Figure 18. Measured D_{1m} of pop hall roof.

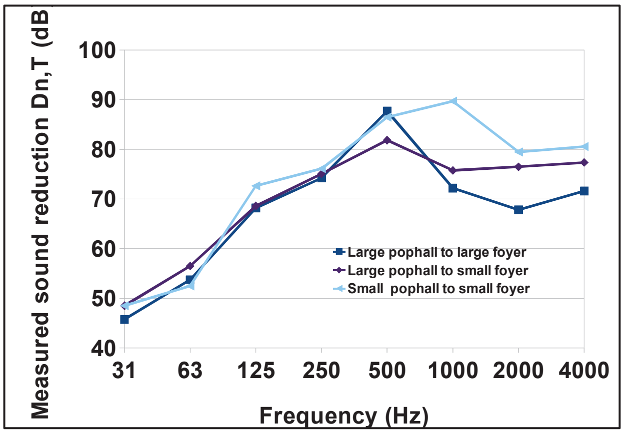

Figure 19. Measured $D_{n,T}$ towards the foyers.

Figure 20 shows a view towards the building seen from a platform of the adjacent train station.

Figure 20. View towards pop centre Doornroosje and Talia-housing above it from the North-West.

The delivery measurements of the sound insulations showed that the high sound insulation values aimed for have all been reached and even exceeded. The projected music levels during pop concerts of L_{Aeq}=105 dB(A) house can therefore be easily accommodated without any disturbance of people in the apartments above the pop centre.

6. Conclusions

Earth-quake risk as well as nearby dwellings have set specific demands for the design of the four pop venues dealt with in Istanbul, Zwolle (NL), Venlo (NL) and Nijmegen (NL). Each situation thereby has required its own specific design of sound insulation and related options like box-in-box, resilient bearings and dilatations.

A solid acoustic design proved to be of major importance to realise the sound insulation values aimed for, as well as accurate construction, execution and surveillance during the building phase. Having realized the sound insulations aimed for in these new venues plays an important factor in their success.

Doornroosje in Nijmegen is the first building in the Netherlands that shows that dwellings can be build above pop halls, and the first where it showed possible to realize and prove a sound insulation of $D_{A,house}$≥99dB to the dwellings by using a special setup with 125 dB(A) noise level.