Roeterseiland complex buildings A, B and C (REC ABC), Amsterdam

Study on the effective noise and vibration nuisance resulting from demolition and construction work being carried out on buildings B and C.

Reference
R037280aa.00003.eg
Version
03_016
Date
26 January 2012
Author:
R.J.A.M. Dekkers
E. Goudriaan

Contents

1 Introduction

In 2010, renovations started on a number of University of Amsterdam buildings for education, research and facilities within the Roeterseiland complex. These renovations include the demolition/stripping of various objects. Currently, demolition and construction activities are taking place on buildings B and C; these buildings will retain their concrete frames. Residents living on Sarphatistraat have complained about the noise resulting from the work being carried out. Among other things, these complaints resulted in a request by the municipal authorities on 29 November for more data, including an acoustic report providing information on relevant acoustic aspects of the performance of the demolition and construction work. The aim of the report is to reveal which measures can be taken to limit the exposure of Sarphatistraat residents to nuisance in the form of noise, vibrations and dust as much as possible.

The present report provides an understanding of the amount of noise that reaches the rear façade of the residences during demolition and construction activities, and of which measures can be/have been taken to limit the inconvenience caused.

2 Demolition and construction activities

The locations of buildings B and C are given in Figure 1 below. The general progression of the demolition and construction work through time in/on both buildings is as follows:

- Demolition work started some time ago, and is gradually moving from the south side of building B to the north side of building C.
- Construction will also move gradually from the south side of building B to the north side of building C, following the demolition activities.

Much of the demolition work in and around buildings B and C is already complete; all of the interior walls, balconies and facades have been removed, and part of building C (above the Nieuwe Achtergracht) has been demolished. Most of what remains of buildings B and C is now only a concrete shell, however various demolition activities still need to be carried out. After that, more construction work will need to be completed to furnish the buildings with new façades, internal walls and equipment.

Figure 1
Overview of University of Amsterdam buildings in the Roeterseiland complex

2.1 Demolition work

The remaining required *demolition* activities in/on buildings B and C will take place simultaneously on various floors, and in general consist of:

- removing sections of concrete using pneumatic breakers;
- milling work;
- grinding work;
- drilling work;
- chopping work;
- levelling work with a rammer.

Various other noise-producing vehicles and other mobile equipment are also used on-site, including cranes, digging machines and several power generators. These mobile sound sources are state-of-the-art (the generators, for example, are equipped with sound insulation) and they are not a determining factor in the assessment or the decibel levels of the demolition noise. The aspects that do count are the activities described above, which lead to noise levels being too high during the demolition work. It should be noted that high noise levels are inherent to the demolition process.

2.2 Construction work

The *construction* work in/on buildings B and C will also be performed simultaneously on various floors, and consist mainly of:

- pile-driving;
- installation of sheet piling;
- concreting (incl. bush hammering);
- drilling work;
- façade work;
- steel construction assembly, installation and disassembly.

The activities listed above are critical in determining noise levels in the residential area. It should be noted that the noise produced is inherent to the construction process.

For information on the additional mobile sound sources used during construction activities, please see the final paragraph of section 2.1.

3 Determining possible measures

The condition in the demolition permit (which was granted based on the demolition safety plan submitted by the University of Amsterdam) provides the basis for possible measures to be taken: "*Measures must be taken so that noise due to demolition activities that affects the local residents or the surrounding environment is reduced as much as reasonably possible".*

In consultation with the municipal authorities and the University of Amsterdam/BAM (the construction company), as of 6 December 2011 it was decided to commence demolition activities at 08:00 instead of 07:00. The noisiest demolition activities will also be completed by 17:00. This will limit the exposure of local residents to noise during the day; we expect that the bother experienced by local residents due to noise in particular will be reduced by shifting the times.

When determining methods for performing the work, inconvenience levels were also taken into consideration, as well as options for choosing less bothersome alternatives (e.g. sawing instead of chopping). Thought was given to why the ultimate performance method was chosen, which included considering the duration of the nuisance created (sometimes opting for short-term and loud instead of long-term and less loud). In construction, for example, the decision was made to use screw piles assembled in the ground instead of traditional driven piles, because the latter would have caused a great deal of inconvenience due to noise and vibrations.

3.1 Measures for the reduction and local insulation of sources

In light of the overview of the possible performance methods, and because the noise emissions are inherent to the demolition and construction activities, measures to reduce the source have proven difficult.

Also, because the positions of the sources change considerably, *local insulation of sources* has proven just as difficult. What is more, a local sound barrier (a barrier in the immediate vicinity of the source) will only have a limited effect. The constraints on the height and length of a local sound screen mean that the sound will pass "over and around" the barrier, limiting its effect, and as soon as the sources are located a short distance away from a local barrier, it will have almost no effect at all. The recesses in the floor will also allow the sound energy to travel through other storeys, further reducing the effectiveness of localised sound insulation.

4 Assessment framework

The following assessment frameworks shall apply to the evaluation of noise levels produced during the demolition and construction activities.

4.1 Demolition permit

A demolition permit was issued to the University of Amsterdam on 20 January 2011. Part of this permit was the demolition safety plan submitted by the University of Amsterdam, stating that the demolition activities were to take place on normal working days between 07:00 and 17:00.

The following execution provision was included in the demolition permit concerning noise:
"*Measures must be taken so that noise due to demolition activities that affects the local residents or the surrounding environment is reduced as much as reasonably possible".*

4.2 Construction activities permit

The permit for the stage 1 construction activities (reference *BWT 81-10-02-9* dated 16 December 2010) contains no such provisions pertaining to noise.

4.3 Additional requirements

The letter sent by the Municipality of Amsterdam (Construction and Residential Sector, reference *BWT 30-11-0369* dated 29 November 2011) requesting further information states that the Circular on Building Noise 2010 (*Circulaire Bouwlawaai 2010*) applies as the norm for the current demolition and reconstruction project. Based on this circular, the municipal authority specifies as a standard that the noise levels reaching the facades of residences due to the demolition activities must be limited to 80 dB(A).

4.4 Notes on the Circular on Building Noise

The Circular was published in November 2010 by the Ministry of Infrastructure and the Environment, and replaces the Circular on Building Noise from 1991. The Circular contains ministerial advice as to how municipal authorities could deal with noise due to construction work. Construction/demolition noise is a temporary effect that depends greatly on local circumstances. Due to the nature of the work, construction and demolition projects can generate a lot of noise. To a certain extent, the surrounding residents can be expected to tolerate the temporary inconvenience of construction and demolition noise. However, if noise levels exceed what is considered to be socially acceptable, it is recommended that the municipal authorities set regulations in order to restrict the inconvenience caused by the noise of the construction/demolition work.

The Circular on Building Noise assumes first of all that the construction/demolition work will be carried out during the day, and sets a daytime value. This daytime value is the value of the equivalent sound levels determined within the period running from 07:00 to 19:00. The preferred limit is a daytime value of 60 dB(A); the Circular advises against a daytime value of over 80 dB(A).

As stated above, when assessing noise levels the Circular on Building Noise uses an equivalent value for the sound levels. An equivalent value is an average value over a certain time period. This period may be a minute, five minutes, one hour, or even one day (12 hours). To illustrate, Figure 2 shows the changes in sound levels over a period of one hour. Figure 2 shows that the lowest value for the noise levels during the period under measurement was 57.5 dB(A) (at 10:04), and the highest value was 90 dB(A) (at 10.21). The equivalent value is therefore 77.1 dB(A).

Figure 2
Recorded noise levels over a one-hour period.

If the recorded equivalent values for noise levels are assessed in accordance with the Circular on Building Noise 2010, the noise levels at the façades must be used. If a measurement microphone is placed in front of the façade of a building, the microphone will also pick up the reflection of the sound coming from the façade itself, increasing the recorded noise levels. This increase must be corrected for by subtracting the effect of the reflection from the recorded noise level, which is equal to 2 dB(A).

5 Establishing effective noise levels

5.1 Measurements

5.1.1 Unmanned, continuous measurement of noise levels

In order to establish the effective noise levels at the rear façades of the residences on Sarphatistraat, an unmanned measurement set was installed on 1 December 2011. At three locations in line with the rear façades of the residences on Sarphatistraat, noise levels were registered and recorded 24 hours a day. These three locations are indicated in Figure 3 below.

Figure 3
Locations of the microphones for the unmanned measurements

Figures 4 and 5 show the measurement locations in greater detail. The microphones were placed approx. eight metres above the roof adjacent to the residences.

Figure 4
Measurement location 1

Measurement location 1

Figure 5
Measurement locations 2 and 3

Measurement location 2
Measurement location 3

Figures 6, 7 and 8 show the recorded daytime values of the effective equivalent noise levels at measurement locations 1, 2 and 3 for the period from 1-16 December. These values are *inclusive* of the reflection effect due to the façade wall behind the measurement point.

Figure 6
Recorded daytime equivalent noise level values at measurement location 1

Figure 7
Recorded daytime equivalent noise level values at measurement location 2

Figure 8
Recorded daytime equivalent noise level values at measurement location 3

The noise levels at measurement location 2 during the demolition work are higher than at location 1. This is due to the position of the demolition activities, i.e. the differences in distance between the activities and the two measurement points.
Measurement location 3 was further away from the demolition work carried out between 1 and 16 December than locations 1 and 2. Consequently the sound levels recorded at location 3 are lower than at locations 1 and 2.
It should be noted that no measurements could be taken on 12 December between 08:00 and 15:00 due to a power failure in the measurement system.

If the recorded equivalent daytime noise values are to be assessed using the Circular on Building Noise 2010 (in which the *incoming* noise level is the determining factor; see section 4.4), the recorded daytime values must be reduced by 2 dB in order to correct for the reflections adding to the measurements coming off the façade wall behind.

After this adjustment, the highest recorded daytime value for the *incoming* noise level is 80 dB(A), recorded by measurement location 2 on 7 December 2011. The lowest recorded daytime value for the *incoming* noise level at location 2 (after correction) is 72 dB(A), recorded on 16 December 2011.

5.1.2 Manned sound measurements

During the night of 1-2 December, supervised (manned) sound measurements were also carried out. From 22:30 until 08:30, both video and audio recordings were made of the surrounding conditions. It was established that no sources relevant to noise emissions were active on the demolition/construction site from 17:00 until 07:00[1].
On the morning of 2 December, the first employees of the sub-contractor(s) started arriving at around 06:30, and the work started at 07:00. Until 5 December, this was also the case for demolition work.

Starting on 6 December 2011, demolition work did not start until 08:00. Demolition activities do not finish any later than 17:00.

[1] The following sound sources were, however, in operation: an external central heating system, and an air channel on the eastern face of the lower levels of building A, used to funnel air out of the parking garage. However, the sound emitted by both sources is less than the construction/demolition noise produced during the day.

5.2 Calculating noise levels

In addition to the 24-hour recording of the effective noise levels, an acoustic calculation model for the demolition/construction activities was created. Using this calculation model, it is possible to create a prognosis of the noise emissions during the activities to come. For this purpose, the work yet to be completed by BAM Utiliteitsbouw has been specified as accurately as possible and divided according to position, nature and quantities.
Because the activities alter from day to day according to circumstances and demolition/construction progress, the calculations remain an estimate.

The demolition and construction activities generally progress through time from the south side of building B to the north side of building C.
This progression means that the activities will move further away from the residential area, resulting in a drop in noise over time.

5.2.1 Demolition

Figures available within LBP|SIGHT were used when determining the source volumes of the various sound sources for use in the calculation model.

Calculations have been made for the work in weeks 2 and 3 of 2012. During this period, the demolition activities will already be situated at a somewhat greater distance from the residential façades. The highest calculated daytime noise level was 75 dB(A) at measurement location 2. Because the demolition activities after week 3 will take place even further away from the Sarphatistraat residences, the noise levels in this area will be lower still. For this reason, no additional calculations were carried out.

5.2.2 Construction

As for the demolition activities, figures available within LBP|SIGHT were also used when determining the source volumes of the various construction sound sources for use in the calculation model. The highest calculated daytime noise level was 72 dB(A) at measurement point 2.

Anchors for the new façades will be installed increasingly further away in the months following January 2012, resulting in lower noise levels.

In week 50 of 2011, temporary sheet piling was driven by vibration in order to build a new sprinkler cellar on the east side of construction site B. This was accompanied by a great deal of noise emission. Extracting the sheet piling will cause almost the same amount of noise, but will take place at a much later stage. The highest calculated daytime noise level is 73 dB(A), at measurement point 2.

5.3 Assessment of noise levels

5.2.1 Demolition

As of week 2, the calculated noise levels due to *demolition* activities are not expected to be any higher than 75 dB(A).

The maximum permissible daytime volume of 80 dB(A) will not be exceeded.

5.3.2 Construction

As of week 2, the calculated noise levels due to *construction* activities are not expected to exceed 76 dB(A).

6 Determining possible additional measures

Section 3 stated that the available technologies, duration and the associated noise emissions were always taken into consideration when examining applicable techniques for demolition and construction activities. An examination of possible local sound barriers was also given.

One measure that has not yet been discussed is that of sound barriers which could be positioned either around the rear façades of the residences to reduce the incoming noise, or around buildings B and C.

In principle, emission levels in the residential area could be limited by erecting a sound barrier as close as possible to the homes, e.g. as short a distance as possible from the rear balconies of the homes on Sarphatistraat and to the gallery at the student accommodation. The barriers would need to be at least as high as the homes, and have enough sound insulation. Although erecting a barrier of this type would most likely be technically and legally feasible (this would need to be investigated, however), it is certainly quite drastic and could no longer be considered ‘reasonable’. In addition, due consideration would need to be given to the time required to design and build the sound barrier, as well as for the necessary procedures.

An alternative to a sound barrier around the rear of the residences could be realised by building one around buildings B and C, secured to the scaffolding. One advantage of this method is that it can be achieved sooner than barriers around the homes, although it would still require allowances for time in terms of design, realisation and procedures. A significant disadvantage, however, is that the sound sources outside the buildings would not be covered. These barriers could also possibly get in the way of the work on the façades, and raise objections from a safety perspective.

6.1 Monitoring permissible volume

Section 3 stated that *source measures* and *local insulation of the sources* are not practically feasible for the construction and demolition activities. Although the possible *intermediary* measures described in the previous section (erecting barriers) would most likely be technically and legally feasible (this would need to be investigated), they are certainly quite drastic and could no longer be considered ‘reasonable’. Additionally, the screening effect at the walls of the apartments on the uppermost floors would be limited.

It is for this reason that we propose an alternative method for limiting incoming noise at the facades in the residential area. Using the sound monitoring system installed on 1 December, the equivalent sound levels can be established at any time and checked to see whether the permissible daytime equivalent value of 80 dB(A) is being exceeded.
If the permissible level is in danger of being exceeded, the noise-causing activities can be either scheduled differently, concentrated, or discontinued for the day.

7 Nuisance due to vibrations

7.1.1 Demolition

To reduce vibration nuisance during demolition work, the existing expansion joints of the buildings to be demolished have been cleaned, reducing contact with surrounding structures. Reducing the falling distance of the sections to be demolished also prevents unnecessary vibration levels.
Because the concrete floors of both the ground floor and first floor of building B extend into the residential block of the homes on Sarphatistraat and are connected at a construction level, installing expansion joints to prevent vibrations is not technically feasible. The floors would need to be sawn free of each other, which in turn would affect the construction and its load-bearing capacity.

7.1.2 Construction

As stated previously, for *construction* activities the decision was made to use screw piles assembled in the ground instead of traditional driven piles, because the latter would have caused a great deal of inconvenience due to noise and vibrations. More vibrations are caused, however, due to the installation of sheet piling (carried out in week 50). Because of the expectation that obstacles would be present in the ground, the sheet piles were driven using a vibration hammer instead of a traditional pile-driver. It was not possible to dig test trenches 4.5 metres below ground level to check whether obstacles were present, as the adjacent supporting structure could have collapsed (due to the biased load on the existing poles as a result of the lateral earth pressure created).

Another factor is the expectation that the construction work will involve fewer vibration-causing activities than the demolition work. In order to manage the effective vibration levels, measurement equipment was installed in the residence at Sarphatistraat 133d on 25 January 2012, which will continuously measure vibration levels inside the residence.

8 Conclusions

The present study, including the sound measurements made from 1-16 December 2011, a list of the locations and intensity of the demolition and construction activities yet to take place and the calculations performed, has led to the following conclusions:

1. The daytime *demolition* work causes incoming noise levels of 74 to 80 dB(A) at the rear of the residences on Sarphatistraat.
2. It is expected that the *construction* activities will cause noise at slightly lower volumes.
3. The resulting noise emissions are inherent to the construction and demolition work, and measures at the source are not practicable.
4. When determining the chosen working methods, consideration was given to nuisance levels and to the option of using less bothersome alternatives.
5. Starting the demolition activities at 08:00 instead of 07:00 has limited daytime exposure.
6. Because the positions of the sources change considerably, local insulation of sources has proven to be difficult.
7. In principle, sound barriers could be erected around the residences which would result in a considerable noise reduction, especially for the homes on the lower levels. Although barriers of this type would most likely be technically and legally feasible (this would need to be investigated, however), it is certainly quite drastic and could no longer be considered 'reasonable'. Additionally, the screening effect at the walls of the apartments on the uppermost floors would be limited. Due consideration would also need to be given to the time required to design and build the sound barrier, and for the necessary procedures.
8. There are also objections to constructing sound barriers around buildings B and C, comparable to those mentioned under item 6 above.
9. An alternative method for ensuring that the permissible equivalent daytime value of 80 dB(A) is not exceeded at the residential façades is the continuation of the already effectuated sound monitoring activities, as part of which the limits are monitored automatically. If the permissible level is in danger of being exceeded, the noise-causing activities can be either scheduled differently, concentrated, or discontinued for the day.
10. In order to manage the effective vibration levels, measurement equipment was installed in the residence at Sarphatistraat 133d on 25 January 2012, which will continuously measure vibration levels in the residence. If the set threshold level is exceeded, the work can be adapted to effect a reduction in vibration levels.

11. Upon request, the authorities will be given access to the recorded sound level data.

LBP|SIGHT B.V.

E. Goudriaan

R.J.A.M. (Rob) Dekkers