Urban traffic noise impact zones as brown fields

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Abstract

Development of brown fields is an essential part of sustainable urban planning. After all, land is a scarce resource. Brown fields are not primarily associated with urban traffic noise impact zones, but they are at least similar. In the present study the development of brown fields means investigating the possibilities to reclaim land in urban noise impact zones that have been or would be sacrificed to traffic noise. Of course, the livability in these areas is not to be compromised.

Continuous apartment buildings along main roads can be used to provide noise reduction to the areas in the 'backyard' in the first place. In this way they protect land from excessive noise loads. Secondly they offer housing capacity themselves. A continuous atrium can be created by adding a second glass facade to one of the street facades. Research was aimed at the development of tools to stimulate this approach. A few simple methods are presented:

- to estimate the screening effect of the first-line buildings with respect to the hinterland,
- to assess the acceptability of passages (apertures) through the first-line buildings,
- to determine roughly the required measures in the street façades of the first-line dwellings, exposed to high noise levels.

Keywords: noise control, compact city, brown fields, urban planning.

1 Introduction

Sustainable building is part of sustainable development, "*that meets the needs of the present generation without compromising the ability of future generations to* *meet their own needs*" (Brundtland [1]). It demands consciousness of the limited resources of the earth, and its limited capacity to cope with pollution. Among many other things, this implies efficient land use in cities, and elsewhere. Along main roads in cities zones with high noise impact have been used only for low-grade buildings, because of practical or legal reasons. Although being an effective means of noise control, this must be considered now as a waste of land, we can no longer afford. Bordering these roads with continuous apartment buildings ('*canyonisation*') is proposed as a way to reclaim these zones. The buildings provide noise reduction to the areas in the 'backyard' in the first place. In this way they protect land from excessive noise loads. Secondly they offer housing capacity themselves.

Research was aimed at the development of tools to stimulate this approach. From the experience that acoustical aspects can play an important role, but are often neglected -presumably for lack of available methods in the conceptual design phase- the focus was set to acoustical tools.

The design process related to canyons embraces the following acoustically important questions.

1. How to achieve the required shielding?
2. Which special properties of the first-line buildings are required?
3. What is the influence of the termination of the first-line buildings?
4. What is the influence of apertures for passageways through a first-line building?

Several tools have been developed to facilitate the process, and answer the questions above:

- The shielding of a (continuous) building, expressed as the admissible traffic intensity on a road, yielding an acceptable sound load at a chosen position in the lee zone behind the building.
- A graph to estimate the consequences of the noise load on the façade, focused on the size and type of glazing.
- Additional tools, to determine the influence of apertures (passageways) in the buildings and the termination of the buildings on the shielding effect

In Figure 1 these topics and their relationships are shown. The grey fields are not discussed here, but can be found in the author's dissertation [2].

Noise is not the only pollutant caused by road traffic. Also gaseous and particulate matter ("fine dust", e.g. from diesel engines) is emitted by vehicles

At present no clear requirements for the design of urban canyons can be deduced from the issue of air quality, particularly not in early stages of design. Research shows that in general the expected air quality behind the canyon buildings is better than it would have been in the absence of the canyon buildings; after all, pollution from the vehicles is mixed in the canyon and released at greater height, where higher wind speeds enhance further dilution. Wind tunnel tests may be employed to optimise the specific canyon and hinterland buildings for air quality. This subject will not be discussed further on.

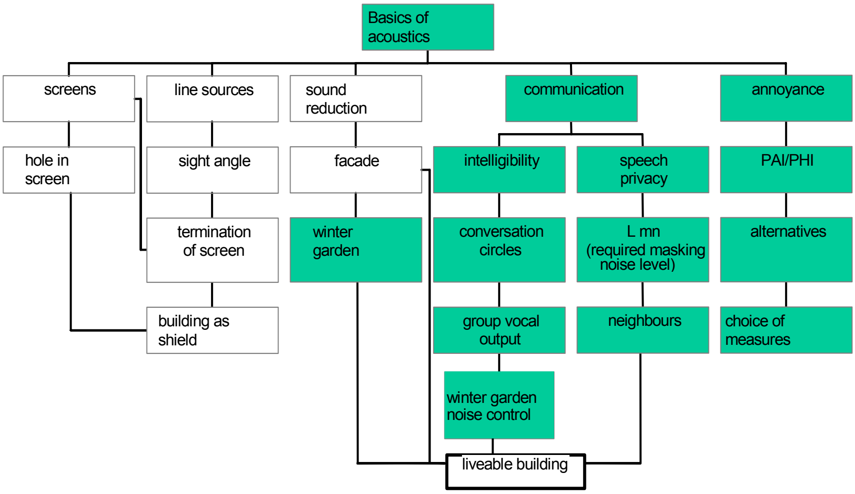

Figure 1: Items of acoustics involved in this study; grey fields are not treated in this paper.

2 Urban canyons

Noise control in general starts at the source: vehicles and pavements; in this study the sound production of road traffic is taken as given. Next the transmission of sound can be regarded. Noise barriers are the most applied measures to reduce noise transmission. In urban environments however, they are not very suitable. A much better choice is continuous buildings on one or both sides of the road; the latter case is called an urban canyon. The noise reduction can be very high, because the shielding buildings can easily be much higher than usual noise barriers. Another advantage is the environmental quality of the neighbourhood. High noise barriers are often associated with low-grade residential areas. Canyon buildings offer much more opportunities for an interesting view from the road than barriers. For the occupants of the canyon buildings, the view onto the road can be a positive point. Altogether sufficient reasons to advocate the principle of ‘canyonisation’ of roads as a way of sustainable noise control in urban environments.

3 Designing with noise loads

When a map for a district with roads and buildings (existing or designed) and suitable prognoses of traffic movements are available, calculations can be made of the sound levels to be expected at all relevant positions. Several computer programs can be employed to make the calculations, at chosen positions or as a noise map. Next these values will be judged against the established noise limits.

If noise limits are exceeded, possible measures have to be considered, and weighed.

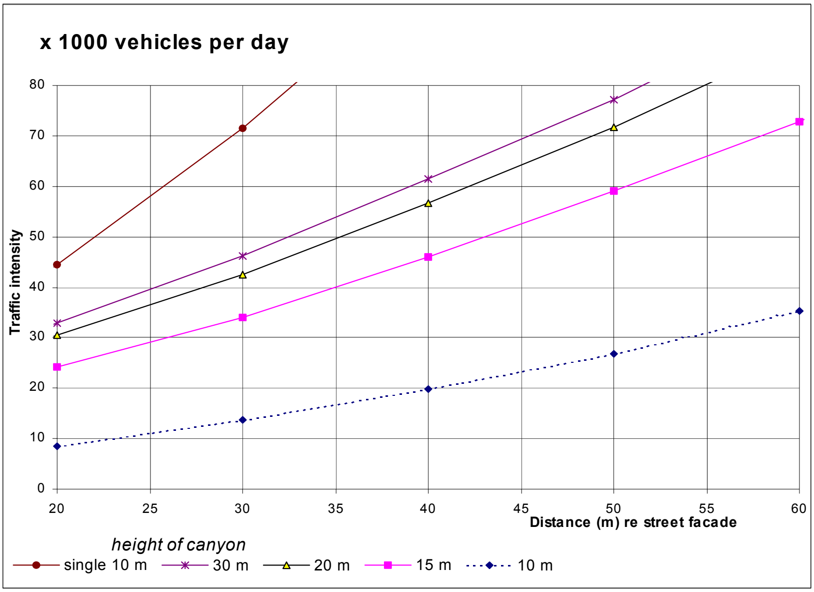

Figure 2: Allowable traffic intensity; for each choice of receiver position (distance from nearest façade facing canyon, height 10 m) and height of canyon buildings (10-30 m) the traffic intensity can be read that will cause a noise load L_{den}= 50 dB(A) at that position.

In an early stage of design however, this approach is not feasible. The necessary detailed data are absent (traffic intensities; urban design), but the freedom in design is large. What is needed is a simple method to estimate the characteristic quantities. For this purpose the reverse calculation process can be used. Goal is to comply with a set noise limit, here chosen as L_{den}= 50 dB(A), at a certain position. The height of the receiver position is set at 10 m; the height of the canyon i.e. the bordering buildings are variable. From these data the sound emission of a road in the canyon can be calculated, that is just allowable before exceeding the noise limit. This allowable sound emission can be expressed as traffic intensity, with a certain mean speed, and standard distribution of types of vehicles and subdivision in daytime, evening and night time.

Speeds were set at 70 km/h; in case of an urban highway 100 km/h for light vehicles like passenger cars and 80 km/h for others. Hourly intensities were 6-7.5 % in the daytime, 4 % in the evening and 1 % in night hours, with respect to the daily intensity (24 h). Characteristic distribution of type of vehicles 83 (80) % light, 12 (10) % medium and 5 (10) % heavy vehicles; numbers in parentheses apply to night-time. For the range of parameters in the Dutch situation, the resulting sound emissions vary plus or minus 1.5 dB(A). Standard pavement (asphalt) and a minimal width of the canyon (10 m) are assumed. Quiet asphalt or a wider canyon can reduce sound levels by some 3 dB(A); this would allow doubling of the allowable intensities.

In figure 2 the results are given for heights of canyon buildings of 10, 15, 20 and 30 m, and a single sided 10 m high continuous building; the latter also would apply to a canyon with two highly sound absorbing façades. On the vertical axis the allowable traffic intensity is found, for a chosen receiver position (fixed height 10 m; distance to façade nearest to canyon on horizontal axis) and height of canyon buildings (appropriate curve).

In this way, the limited information available in early stages of (urban) planning and design can be used to assess the potentials of a road canyon as a means to integrate roads in residential areas without serious noise annoyance. It is assumed that the allowable traffic intensity can be compared with rough estimates of traffic research.

4 Requirements of façades

In circumstances where a high sound load on the façade of the building is expected, starting points of the design of the façade should be:

- Ventilation of the building cannot take place through open windows or vents; instead a (mechanical) ventilation system that takes in air at the non-canyon façade has the extra advantage of better air quality
- The opaque parts of the façade are stony, such that their sound reduction index is much higher than the glazed parts; in practice an areal mass of 250 kg/m^2 or more
- Openable parts are limited in area and circumference, and supplied with almost perfect seals and the locks and hinges, necessary to effectuate them.

Standard values for room properties are taken: rectangular room, with depth (perpendicular to façade) 3 m, reverberation time 0.5 s.

Now the only remaining variables are the glazed area, expressed as the percentage of the area of the façade, the sound reduction of the glazing and the resulting standardised sound level difference $D_{2m,nT}$, as defined in European standard [3]. The latter links the outdoor sound level to the indoor sound level. Assuming a required indoor sound level L_{in}= 35 dB(A) the resulting standardised sound level difference is transformed into the admissible outdoor level. Both indoor and outdoor levels are expressed in the DEN-level (day-evening-night) as defined in the European Directive [4], or at least in the same metric.

For four typical examples of glazing, and percentages of glazing ranging from 0 to 100%, the admissible outdoor sound levels were calculated. The results are shown in Figure 3.

The typical variants of glazing are:

29, standard double glazing e.g. 6-12-4 mm, $R_{A,tr}$= 29 dB(A),
34, large air gap glazing e.g. 8-24-12 mm, $R_{A,tr}$= 34 dB(A),
39, laminated glazing with large air gap e.g. 12*-24-12*mm, $R_{A,tr}$= 39 dB(A),

43, double frame (very large air gap) e.g. 8*-120-14* mm, $R_{A,tr}$= 43 dB(A). (*laminated panes are designated with an asterisk*).

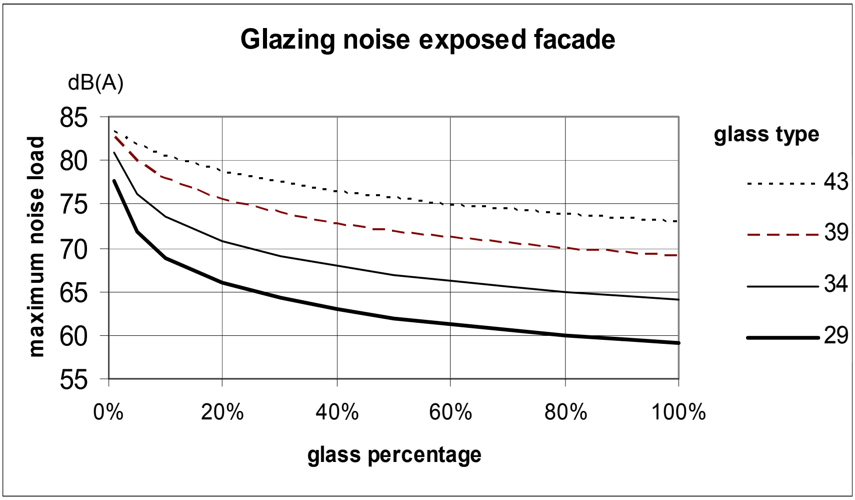

Figure 3: Admissible noise load as a function of the percentage of glass area in the façade; target value is an interior noise level of L_{den} = 35 dB(A). The glass type is parameter.

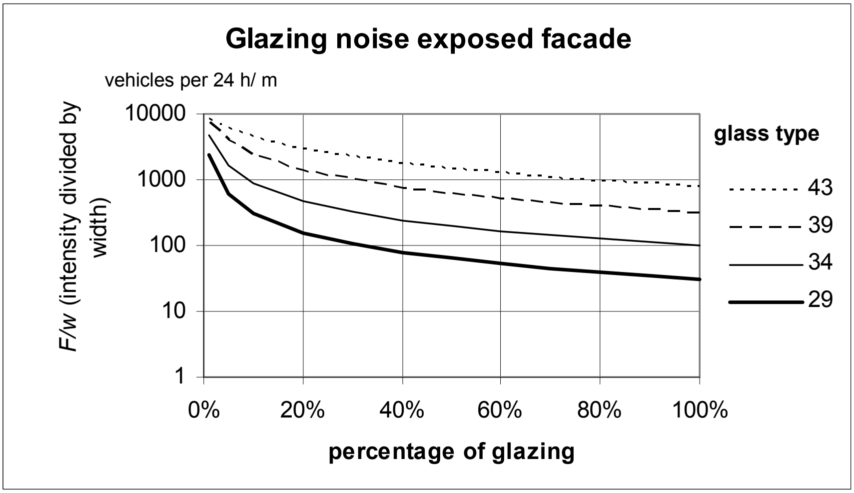

Figure 4: Admissible traffic intensity as a function of the glass percentage in the façade. The F/w value on the vertical axis must be multiplied by the width of the canyon in meters to find the admissible traffic intensity per 24 hours. The glass type is parameter.

Next we can calculate the admissible traffic intensity [*F*] in the canyon, associated with the noise loads on the façades. The procedure and default values are the same as in the previous chapter. However, the width of the canyon [*w*] is a relevant variable too. It appears to be possible to take this effect into account, by using the new variable *F/w*. The results are shown in Figure 4.

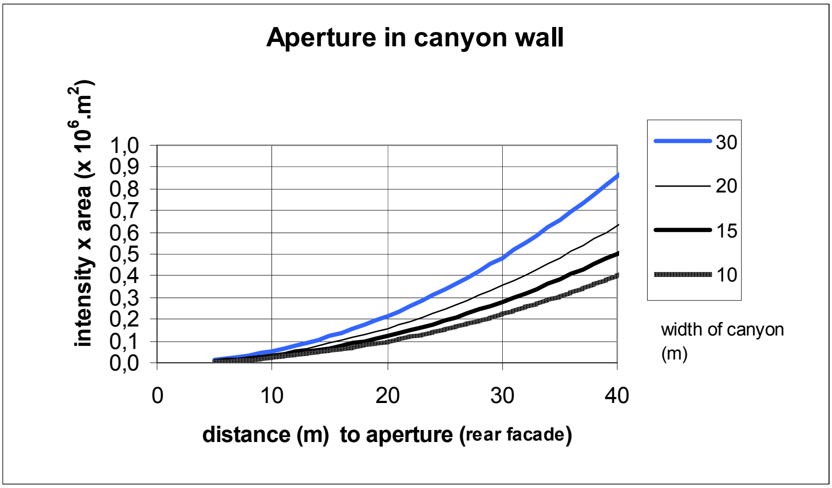

Figure 5: Influence of an aperture in a canyon building. For a given distance to the aperture in the building and width of the canyon, the allowable value of I x S (traffic intensity times area of aperture) can be read.

5 Apertures in canyon buildings

The canyon buildings should be continuous, without holes, openings etc. Some apertures for passageways may be necessary. The influence of such a hole can be calculated by simple means. In the street canyon a more or less diffuse sound field will exist; it is assumed perfectly diffuse, as is often done in practical acoustics. The sound intensity in this field, multiplied by the area of the aperture gives the sound power level at the entrance of the aperture. No attenuation in the passageway is assumed. Therefore the same sound power level is radiated into the lee zone behind the building. The width of the canyon (between the facades) is a parameter, varied between 10 and 30 m.

In the same way as described in chapter 3, the sound field in the canyon i.c. the sound intensity can be linked to the traffic intensity. The sound levels at certain distances from the aperture can be linked to the same noise limit of 50 dB(A). A variable that still has to be accounted for, is the area of the aperture. Because it has the same "linear" relationship to the sound power level as the traffic intensity, the most convenient or versatile way to incorporate it is to use the product of traffic intensity and area as one dependent variable. In Figure 5 the results are given in graphical form; they are not cumulated with the contribution of diffraction over the canyon (see chapter 3).

6 Conclusion

Sustainable development of cities requires compact planning, and an optimal use of ‘brown fields’. Noise impact zones along main roads in (sub)urban areas should not be excluded. Urban canyons, purposefully designed as instruments in reclaiming land from these zones have a great potential. A set of simple to use tools has been presented, that allows judgment of the viability of the urban canyon concept in the conceptual stage of specific plans, indeed.

References

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