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Environmental noise caused by building activities

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ABSTRACT

In The Netherlands regulations on noise of many kinds of traffic , industry, shooting-ranges, restaurants & bars, events are in force. Although noise originating from building sites is experienced as very bothersome there is no clear and no all-over system to limit that noise. Nowadays there is a strong movement to improve this situation. This contribution gives the backgrounds and insight in the Dutch situation. An interconnected system usable to municipalities is proposed. Means to limit the annoyance are handed over. Generally spoken an expected new system forces co-operation between contractors and authorities and make them more conscious. High levels are only admitted in situations in which authorities can argue why it is not not reasonable to ask contractors for extra reductions. However there will rest enough situations in which extreme limits are exceeded and inhabitants get the offer to leave their houses.

1. FRAMEWORK

A. Noise of building Activities

Our cities are constantly renewing. Cities are characterised by compactness and a mixture of working places, dwellings and traffic. It is nearly impossible not to disturb one of them when activities of building and demolishing begin. Constructing may be very noisy and deviates a lot from the normal surrounding sounds which are more or less steady and 'common'. The character of construction noise is often impulsive, intermittent and has more peaks of e.g. bumping and hammering. Another factor is the recognisability. Traffic noise in cities is diffused, there is no 'owner' or responsibility. In the contrary sounds of building activities are associated with the contractor and inhabitants point the local authorities as responsible on the hindrance of the builders. Environmental noise included.

The objective is to work in normal hours at daytime at the normal weekdays Monday - Friday. However In The Netherlands and other countries there is a pressure to build at other times as evenings, weekends and even at nights. This pressure originates in (a) physical circumstances and (b) in the way decisions to build are made.

Ad (a), many times it is quite impossible to build without disordering the course of traffic or to transport the materials needed at the building site. Building at more quiet hours is a relieve to the contractors and also to civil officers responsible for the flow through of traffic. However this 'solution' is not a relieve to those who live and want to sleep in the city.

Ad (b), making plans and taking decisions to build can take many years, cost a lot of money and is accompanied with commotion in local politics. Once decided the construction work must go on there is an eagerness to start and new difficulties such as annoyance of

construction noise are not very welcome. And the contractor is always in a hurry. This psycho-social framing is not beneficial to take outrageous measures to reduce environmental noise of building sites.[1]

Figure 1: Building activities in a main street of Rotterdam

The work field of the regional DCMR Environmental Protection Agency Rijnmond is the Greater Rotterdam area. The Section Noise of DCMR was faced on a large scale with environmental noise of building activities in the nineties. In those years the reconstruction took place of railways nearby a dwelling district of the village of Barendrecht. This lasted many years. A generation of children grew up under the ever present noise of piling. We made a search to see how to deal with these circumstances and it became clear that we had to find our own way. The developed systems to manage the noise came true to be valuable and the experiences were of great advantage to use in requests coming from other communities in our region. Other Dutch communities had to deal with similar problems. A need of help on a national scale grew.

B. Relevance

Construction noise comes up in Dutch surveys on environmental noises. Based at answers of inhabitants of Rotterdam (2003-2005) of severe annoyance originating from building sites there are following figures. The annoyance is twice worse to mass-events (e.g. concerts in open air) which are quite frequent. Compared with air-traffic the annoyance is the same but twice worse to noise of industry. Although investments to reduce noise of rail-traffic are enormous annoyance of construction noise is one and a half times that of railways. In Rotterdam the "*Noise of construction and demolition*" scores at annoyance: extreme 5%, very annoyed 6%, fairly annoyed 10%.

C. National Situation

In The Netherlands problems with environmental noise by building activities should be tackled by local authorities. In fact the municipalities are not kit out to handle these problems. Nowadays an old Circular letter exists with limiting building to daytime (not

weekend) with a limit of 60 dB(A) at façades outside. In practice many times these levels are exceeded. Than local authorities should discharge contractors. Resumed: the actual system is weak, unclear, not workable [2]. Consequently to contractors it is unpredictable what will happen. Reactions of inhabitants are violent. But we are renovating the system. One aspect will not alter: local authorities are responsible to take care for this acoustical well-being of their citizens. So the new system has to stimulate improvements there too.

2. CONSTRUCTION NOISE PASSES BY

A. Acoustical Climate, acoustical Weather

The sounds surrounding dwellings are part of the climate in which people live. Most of the sounds originate from sources which belong to that neighbourhood. Even if they are far away e.g. airports. That acoustical climate is - has to be - accepted. At a new noise in that area the judgements will be more severe, partly more negative. But once having the knowledge that the noise is temporary most of the initial opinions will mitigate. So does the annoyance if the noise doesn't affect the normal way of live too much. However resistance against the erected - or demolished construction and anxiety e.g. by vibrations will feed feelings of annoyance. Most times construction noise lasts for a few hours, days or weeks. In the live of inhabitants it may be an acoustical shower or tempest.
Fair exterior levels in acoustical climates are 55 or 50 dB(A) at daytime (WHO: serious / moderate annoyance) and 45 dB(A) night time to avoid sleep disturbance issues. The USA practise 60 to 65 Ldn with approximately 10% highly annoyed residential receptors.

B. Limits in acoustical Tempests

As the noise occurs for a longer time the irritation will grow. People come to a point wishing the acoustical tempest to be ended. So limits should depend on duration of noise.
Comparing what is 'normal' in Dutch circumstances and regulations a floating scale can be composed. Industrial noise - an acoustical climate - is used as an initial concept and the same limits and procedures should be used in cases of long lasting noise from building projects.

Table 1: Proposal of limits to use at construction noise. In LAeq, long time, daytime, outside, dwellings.

Duration	Indication	Target value	Right value	Frontier value	Process value	Ultimate value	
short	< 5d (wk)	60	65	70	75	80	
mid	< 15d (3w)	55	60	65	70	75	
long	< 65d (3m)	50	55	60	65	70	
very long	industrial	45	50	55	60	65	

The table is centred around a 65 / 65 centre-rule. It is to say there is a just allowable Leq by day of 65 dB(A) in cases with construction noise at maximum of 3 months = about 65 working days. If this period will be longer the whole period of noise should be judged 5 dB(A) more severe. There is a 'reward' if (a) the levels are lower and (b) the days with noise are lesser. The "concentrated clap" with concentration of noise in a short period is of preference. Thus attempting to shorten the time inhabitants are exposed to the noise.

C. Attitude of Authorities and Contractors

Many European societies are moving towards a more liberal climate. With a government at more distance but also introducing risks with a gap between authorities and civilians. The public authorities are obliged to force back their activities and take a role of enforcing and punishing while more and durable results are in reach when authorities are more participating. The same counts for environmental effects of building activities. If a system is developed in which contractors are forced to handle following rules R, at terms T, resulting in noise levels L, the system will fail unless a lot of energy is spent to stand the system itself. A more productive process will be one of coaching, insight, discussion, help, trust where possible and enforcement when necessary. In The Netherlands these systems are successful in cases of bother in neighbourhoods. Keywords are: flexible, respect, honest, clear. [3]

These thoughts backgrounded the proposals to manage construction noise in The Netherlands. Contractors and authorities as well are in benefice when they succeed to lower the noise levels. In ideal circumstances they work together to minimise the noise. Other methods of working, other traffic diversions, activities in daytimes instead of at night, technical reductions of noise lead to lower levels. Consequently both builder and civil servant do not need to spend their energy on time-consuming procedures.

Table 2: Predicted levels of noise (compare table 1) and the proportioned effort to those levels

Involved	Aspect	60-65	65-70	70-75	75-80	80+
Builder	Action	announce	inform	request	explain	dialogue
Builder	Ac.prognosis	none	some	motivating	detailed	special
Local authority	Action	administrate	test	in workflow	license	discuss
Local authority	Ac. level	low	any	experienced	good	excellent
Dispensation	Conditions	seldom	some	standard	mixed	tailormade

In fact there is not one limit and even not a maximum value. The lesser the noise the weaker the conditions. One of those is unburdening builders of noise-control. Exceeding the extreme level of 80 dB(A) (Leq, daytime, working days) joins with an offer to inhabitants to leave their houses and a guardian of these houses.

Purpose of this system is to stimulate and implement early thinking on environmental noise and force parties involved to get a ‘picture’ of the site and noisy periods. To image the noise around the site they need values as Leq, Lmax, number of events, character of noises, hours of activity, duration of sounds and possible resistance of the neighbourhood.

The aggravations at higher levels can be more and more frequent inform of (local) authorities, request dispensation and wait for decision, establishing a complaint-office, making loggings, periodical prognoses and monitoring reports.

3. ASPECTS OF TIME

The duration of environmental noise of building activities is already incorporated as written before but still there remain discussions of other aspects of time.

A. Day and Week

The normal hours of building activities 07-16 o'clock in The Netherlands do not correspond with patterns of being in bed of the inhabitants. A lot of people (adults) wish to sleep between 22 and 08 and want rest at 21 o'clock. So the morning hour and possible late

hours in case of working in overtime conflict.
In the evening and the early morning another physical phenomena plays a role. At those hours there is more risk meteorological favourable circumstances (mfc's) occur. Than the atmosphere is not turbulent but stable thus favouring better propagation of noise [4].
Taking in account the resistance of inhabitants against construction noise at early and late hours and also situations with presence of mfc it become clear why residents are astonished when piling has to start at 07.00 o'clock in time and is well audible far away. To start construction activities at least one hour later is helpfully. [5]
The weekends are more vulnerable too. Expressed in dB(A) (more equivalent of annoyance) the burden is +5 at Saturdays and +10 at Sundays. And in several Dutch communities rest at Sunday has to be respected.

B. Relaxation and Piling

There is not much research done at effects of annoyance related to duration of noise. Many people agree there is a preference to shorten the noise even if this becomes louder. The method of Concentrated Clap is stimulated. Of course up to certain limits. E.g. when piling is necessary work with more installations at once instead of more weeks of piling with one installation.
There is also the effect of relaxation. If noisy periods are followed by those of rest the caught stress wears out. And .... after such a relaxation period new noise is possible[9]. But in dependence of the completeness of that period of relaxation.
In fact the equivalence of rule of sound energy tells doubling the time makes 3 dB(A) extra. It is adopted the same is true on annoyance. However this rule of thumb is widespread foundations lack. In the contrary there are indications that doubling the time noise is heard gives about 5 dB(A) extra at a scale of annoyance.
At long term (weeks / year) and in situations without high levels of noise in normal working hours he annoyance of most people stand neutral to 3 or 4 months. After that period the annoyance is 'piling'. After three months critical situations arise.

4. RESOURCES

A. Annoyance

To make clear what the effects of annoyance of building noise are next relations have been

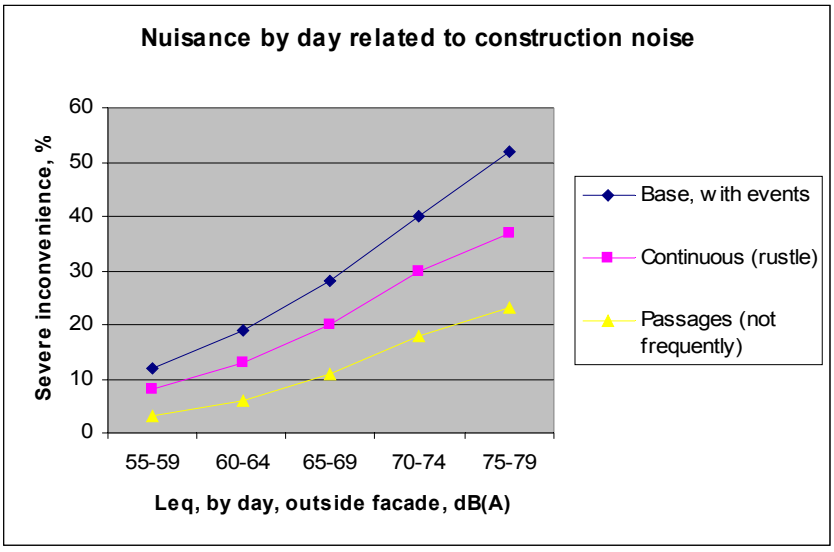

Figure 2: Nuisance by day

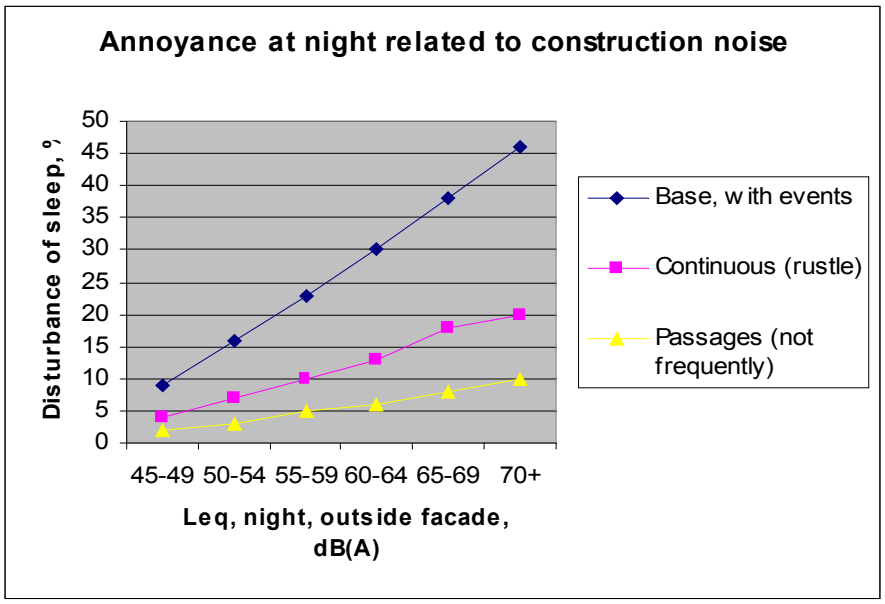

Figure 3: Annoyance at night

composed. There is a strong connection with the kind of noise. Peaks should be considered apart. In practice there is a base agreement some bother has to be beard. Thus in case of building noise only the grave symptoms are regarded.
An other aspect is the number of involved habitants. In practice not all houses are hit by the same levels of noise. To take these differences in account there are several methods [6] to count the overall annoyance.

B. Decibels of Annoyance

It would be nice to develop a system which let pass all elements contributing to annoyance and weigh those aspects. The end result would be a unity expressing that annoyance. This way of thinking burps up every few year. Nice examples are the Loudness level weighted Leq (LL-Leq)[10] and the Noise Perception Index (NPI)[8].
In fact this manner is partly already in use. Audible tonal. low frequent [7] and impulsive components in noise increase the calculated or measured value M in dB(A) with punishments P (5 to 12 dB(A)) resulting in a value of judgement J = M + P to compare with standards.
Also the differences of annoyance of the time of the day are incorporated. On day/night-levels Ldn, the European unity Lden and the Dutch Letm (max of Lday, Levening +5, Lnight+10) have a lookalike base. The kind of noise is influencing the nuisance too. Example: 60 dB(A) Leq shooting noise will not produce the same annoyance as 60 dB(A) Leq from modal industries. To express annoyance methods are in use with road traffic as a standard. E.g. at the same noise M of railways gets lower values J, while air traffic gets higher values J.
Because noise of road traffic is most spread and most familiar with a pragmatic approach is to express annoyances as equivalents of dB(A) highway noise, expressed as dBt. If necessary a distinction could be made in dBtd - to utter inconvenience at daytime - and dBtn - with the purpose to express sleep disturbance at night time.
In such a system the days, weeks or months that the building activities enrage the lives of inhabitants could be incorporated too.

C. Reasonableness

To decrease the noise several measures will be considered. Lesser noisy methods of constructing, other schemes of planning, uncommon machinery will cost extra money. In situations with very high levels those levels legitimate those measures but in lower levelled circumstances the number of concerned inhabitants and the levels they has to stand may taken in account. A screen to protect one farm against building noise lasting some days is not cost effective.

To reduce noise at source several possibilities will pass by. To take costs in account many approaches exists. Such as "As low as reasonable achievable ('alara') and halfway time value, htv".

A method to reduce noise itself is using other, better, more silent installations. In such discussions to reinforce use of these newer tools (with comparable terms as best practical means bpm and best technical means btm) availability and price are aspects. But also a more technical question of the real production of noise. This depends of the state and age of the source. New installations which just left the factory and tested in 'laboratory' circumstances will produce less noise than the same source after having been used in practice. Nowadays we have to deal with the similar discussions on real noise at subjects of silent road surfaces and new tyres. In discussions with contractors topics are discussed. "Why should I use another piling machine while this one is just 3 years old?".

These are reasons to propose a better way of defining those reductions of noise which incorporate the lifetime of the source. So in fact a price per dB profit is calculable. Define following source values expressed in dB:

a. New, tested under Ideal circumstances: itv, ideal-test values.

b. At Halfway Time, htv, values halfway the predicted life of the product. In practice this should be the values to deal with.

c. At Quart Time, qtv, values when a quarter of the lifetime of the product has passed. This will help in significance of reality of expectations about htv.

D. Others

Indications of acoustical effects of façades, distances, screens and lists of sources may give insight to all involved parties. One of them: the façades of houses.

In fact in cases of construction noise not the noise outside dwellings but inside houses is the base of all noise limits. People are supposed to find protection inside their houses and to close their windows in the hours of building. But the impact of façades varies a lot and it is not possible to measure them all. Because a lot of noise from building sites boards a lot of low frequent noise (lfn) special attention on lfn is necessary. Especially because most of the already (noise-)isolated houses did not take the aspect of lfn in account.

Proposal is to develop an acoustical standard façade with specifications in (third) octave bands. Those specifications present the reduction by the façade. It is to say the difference of free-field noise (falling in, no reflections incorporated) and noise inside rooms of the house. This standard façade should cover e.g. 85% of the houses in the area in question.

Inhabitants claiming they will get more noise while their façade is worse can let inspect their houses. But with a risk. If investigations point out the claim is not justified, they have to pay a portion of those inspections. At the other hand contractors could appear claiming the houses are 'better' than the default values with a goal to be allowed to make more noise. In those cases such a contractor will have to argue this point of view with calculations, measurements or other analysis. Inhabitants who do not co-operate in measurements of insulation as an initiative of the contractor lose possible advantages.

Also to regard is the possibility of inhabitants to break away from the noise. Houses with only rooms behind one noise loaded façade are aggravating and do not have the

advantages of this argument. Neither do situations in which the backside of the houses are loaded by construction noise while the front side is fired by heavy noise of rad traffic.

5. RECOMMENDATIONS

Environmental effects of construction noise has to be limited. Not only in decibels but primary in more free and more obliged types of activities. Policies on construction noise will be helpful to diminish the not-necessary part of the noises and stimulate another way of thinking on this kind of noise. Purchases and use of more silent machinery may be supported. Thus becoming more common and also favouring the circumstances of workers at building sites.
Pro-activity is a keyword in dealing with building noise.
Probably the effects of learning are huge if cities work together. Starting with international exchanges of local regulations, honest experiences and evaluations.

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6. There is a variety of methods to count houses (and/or inhabitants) weighted to the noise levels. The detailed methods are in use in constructing the European-maps (annoyed people in 5 dB-classes). It is also possible to do that grover. Examples: a) E.P.J. De Ruiter, The Population Annoyance Index, *DAGA, 2009* and b) H. Wolfert , P.A. Sloven, The 55-dwelling, in *Geluid, 1995 (in Dutch)* which result both in nearly the same figures.

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